Problem(70) --> Data file name : DC_01_Burbidge(1973)_30x89.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {  28 }
Part[   2] = {  20,  26 }
Part[   3] = {  26 }
Part[   4] = {   4,  26 }
Part[   5] = {  26,  27 }
Part[   6] = {  26 }
Part[   7] = {  26 }
Part[   8] = {  11,  19,  21,  22,  24,  30 }
Part[   9] = {   3,  19,  22,  26,  28,  30 }
Part[  10] = {  25 }
Part[  11] = {   7,  25,  26,  27,  28 }
Part[  12] = {  27 }
Part[  13] = {  26,  27,  28,  29 }
Part[  14] = {   3 }
Part[  15] = {  11,  17,  19,  22,  24 }
Part[  16] = {   1,  28 }
Part[  17] = {  20 }
Part[  18] = {  10 }
Part[  19] = {  25,  26 }
Part[  20] = {  22 }
Part[  21] = {  11,  17,  19,  21,  22,  24,  30 }
Part[  22] = {  11,  17,  19,  21,  22,  24,  30 }
Part[  23] = {   4 }
Part[  24] = {   3 }
Part[  25] = {  26,  28 }
Part[  26] = {  18 }
Part[  27] = {  23,  26,  28,  29 }
Part[  28] = {   7,  25,  27 }
Part[  29] = {   4,  26,  28 }
Part[  30] = {  11,  22 }
Part[  31] = {  26,  27,  28 }
Part[  32] = {  29 }
Part[  33] = {  22,  28 }
Part[  34] = {   1 }
Part[  35] = {   6,  20 }
Part[  36] = {   7,   8,  25,  26,  27 }
Part[  37] = {   3,  26 }
Part[  38] = {   4 }
Part[  39] = {   7 }
Part[  40] = {   3,   9,  11,  17,  19,  21,  24 }
Part[  41] = {   1,   7,  25,  26,  27,  28 }
Part[  42] = {  20,  26 }
Part[  43] = {   4,  26,  28 }
Part[  44] = {   3,  30 }
Part[  45] = {  26,  27 }
Part[  46] = {   3,  29 }
Part[  47] = {   4,  20,  30 }
Part[  48] = {   4,  25,  26,  27 }
Part[  49] = {   1,  26 }
Part[  50] = {  11,  17,  19 }
Part[  51] = {   4,  21,  30 }
Part[  52] = {  29 }
Part[  53] = {  26,  27,  28 }
Part[  54] = {  14,  20,  25,  26,  29 }
Part[  55] = {   3,   9,  11,  17,  21 }
Part[  56] = {  28,  29 }
Part[  57] = {   3,  26 }
Part[  58] = {   3,  14,  16 }
Part[  59] = {  23,  26,  28 }
Part[  60] = {  25,  27 }
Part[  61] = {  11,  16,  19 }
Part[  62] = {  11,  17,  20,  26 }
Part[  63] = {   3,   9,  11,  17,  21 }
Part[  64] = {   3,  14,  16,  19,  24,  28 }
Part[  65] = {   3,  26,  29 }
Part[  66] = {   3,  14,  17,  30 }
Part[  67] = {  11,  17,  19 }
```

```
Part[  68] = {   4,   9,  21,  26,  28 }
Part[  69] = {  14,  28,  30 }
Part[  70] = {   3,  14,  28,  30 }
Part[  71] = {  26,  27,  28 }
Part[  72] = {  10,  11,  17,  19,  21 }
Part[  73] = {   4,  22,  28 }
Part[  74] = {   8,  26 }
Part[  75] = {   9,  11,  17,  19,  21,  24 }
Part[  76] = {   1,   9,  14,  17,  19,  20,  24 }
Part[  77] = {  15,  20,  21,  26 }
Part[  78] = {  12,  17,  20,  21,  24,  26,  28,  30 }
Part[  79] = {  13,  24,  29 }
Part[  80] = {   3,   5,  11,  15,  22,  25,  30 }
Part[  81] = {  13,  24,  29,  30 }
Part[  82] = {   3,   4,  15,  16,  22,  25 }
Part[  83] = {   6,  16,  20,  26,  27,  28 }
Part[  84] = {   3,   5,  11,  15,  22,  25,  30 }
Part[  85] = {   4,  12,  15,  16,  21,  28 }
Part[  86] = {   3,  14,  17,  20,  21 }
Part[  87] = {  14,  15,  17,  19,  20,  21 }
Part[  88] = {   3,  14,  16,  19,  21,  24 }
Part[  89] = {   2,  14,  17,  19,  20,  21,  24,  26 }
```

< Block Diagonal Solution Matrix >

< Locations >

	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	3		
	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0		

< Machines >

	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	0	0	0	0	0	1	1	1	1	2			
< Parts >	3	4	7	9	1	4	5	6	7	9	0	1	2	4	5	6	7	8	9	0	1	2	5	6	8	0	2	3	8	3		
==========	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
(1) 1	*																	1														*
(2) 2	*									1						1																*
(3) 3	*															1																*
(4) 4	*	1														1																*
(5) 5	*															1	1															*
(6) 6	*															1																*
(7) 7	*															1																*
(8) 8	*			1				1			1	1	1							1												*
(9) 9	*	1							1			1			1		1		1														*
(10) 10	*													1																		*
(11) 11	*			1										1	1	1	1															*
(12) 12	*																1															*
(13) 13	*															1	1	1	1													*
(14) 14	*	1																														*
(15) 15	*			1				1	1			1	1																			*
(16) 16	*																	1			1											*
(17) 17	*									1																						*
(18) 19	*													1	1																	*
(19) 20	*											1																				*
(20) 21	*			1				1	1		1	1	1							1												*
(21) 22	*			1				1	1		1	1	1							1												*
(22) 23	*	1																														*
(23) 24	*	1																														*
(24) 25	*															1		1														*
(25) 27	*															1		1	1												1	*
(26) 28	*			1										1		1																*
(27) 29	*	1														1		1														*
(28) 30	*			1								1																				*
(29) 31	*															1	1	1														*
(30) 32	*																		1													*
(31) 33	*											1						1														*
(32) 35	*									1														1								*
(33) 36	*			1										1	1	1									1							*
(34) 37	*	1														1																*
(35) 38	*	1																														*
(36) 39	*			1																												*
(37) 40	*	1			1	1				1	1		1		1																	*

```
(  38)  41  *     1                       1 1 1 1     1                    *
(  39)  42  *                       1         1                            *
(  40)  43  *   1                             1   1                        *
(  41)  44  * 1                                     1                      *
(  42)  45  *                                 1 1                          *
(  43)  46  * 1                                        1                   *
(  44)  47  *   1                   1                     1                *
(  45)  48  *   1                           1 1 1                        *
(  46)  49  *                               1         1                  *
(  47)  50  *         1       1 1                                        *
(  48)  51  *   1                     1                 1                *
(  49)  52  *                                       1                    *
(  50)  53  *                               1 1 1                        *
(  51)  54  *           1         1       1 1     1                      *
(  52)  55  * 1     1 1       1     1                                    *
(  53)  56  *                                   1 1                      *
(  54)  57  * 1                           1                              *
(  55)  58  * 1         1   1                                            *
(  56)  59  *                               1   1                      1 *
(  57)  60  *                           1   1                            *
(  58)  61  *         1     1   1                                        *
(  59)  62  *         1       1   1         1                            *
(  60)  63  * 1     1 1       1     1                                    *
(  61)  64  * 1         1   1   1       1       1                        *
(  62)  65  * 1                               1     1                    *
(  63)  66  * 1         1     1                       1                  *
(  64)  67  *         1       1 1                                        *
(  65)  68  *   1   1                   1       1   1                    *
(  66)  69  *           1                           1   1                *
(  67)  70  * 1         1                           1   1                *
(  68)  71  *                               1 1 1                        *
(  69)  72  *         1       1 1   1                         1          *
(  70)  73  *   1                       1         1                      *
(  71)  74  *                               1               1            *
(  72)  75  *       1 1       1 1   1   1                                *
(  73)  76  *       1   1     1 1 1     1             1                  *
(  74)  77  *             1       1 1       1                            *
(  75)  78  *                 1   1 1   1   1   1   1           1        *
(  76)  79  *                         1         1               1     *
(  77)  80  * 1       1   1           1   1         1     1                *
(  78)  81  *                         1         1 1             1     *
(  79)  82  * 1 1         1 1         1   1                              *
(  80)  83  *               1     1         1 1 1           1            *
(  81)  84  * 1       1   1           1   1         1     1                *
(  82)  85  *   1         1 1       1           1               1        *
(  83)  86  * 1         1     1   1 1                                     *
(  84)  87  *           1 1   1 1 1 1                                     *
(  85)  88  * 1         1   1   1   1   1                                *
(  86)  89  *           1     1 1 1 1   1   1         1                  *
========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  87)  18  *                                                 1          *
(  88)  26  *                                                       1   *
(  89)  34  *                                       1                    *
========== * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
```

```
< Machine cells and Part families  >
============================================================
Machine Cell[ 1] = { 3, 4, 7, 9, 11, 14, 15, 16, 17, 19, 20, 21, 22, 24, 25, 26,
27, 28, 29, 30 }
Machine Cell[ 2] = { 1, 2, 5, 6, 8, 10, 12, 13, 18, 23 }
============================================================
Part  Family[ 1] = { 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17,
19, 20, 21, 22, 23, 24, 25, 27, 28, 29, 30, 31, 32, 33, 35, 36, 37, 38, 39, 40,
41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60,
61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80,
81, 82, 83, 84, 85, 86, 87, 88, 89 }
Part  Family[ 2] = { 18, 26, 34 }
============================================================

< Summary of the performance measures >
============================================================
```

```
No. of machines                                  = 30
No. of part types                                = 89
No. of cells                                     = 2
Machine cell size                                = 20
Total no. of 1's in the original MPIM : |A|      = 302
Matrix density                                   = 0.113
Total no. of within-block 1's                    = 284
No. of exceptional elements (EEs)                = 18
No. of voids                                     = 1466
Sum of EEs and voids                             = 1484
Group Cability Index (GCI)                       = 94.04 %
grouping efficiency (GE)                         = 57.14 %
Grouping efficacy (GF)                           = 16.06 %
Machine utilization (MU)                         = 16.23 %
No. of redundant machines (RMs)                  = 7
============================================================
```

Problem(71) --> Data file name : DC_02_Tarsuslugil(1979)_78x30.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {  10,  19,  26,  27,  29,  33,  37,  38,  42,  43,  44,  46,  50,  51,  52,  57,  62,
69,  71,  77,  78 }
Part[   2] = {   6,   7,  10,  19,  26,  29,  37,  38,  39,  40,  42,  46,  47,  54,  56,  62,  69,
71,  77,  78 }
Part[   3] = {   2,  25,  33,  35,  39,  40,  42,  48,  53,  56,  60,  70 }
Part[   4] = {   2,  25,  33,  35,  39,  40,  42,  48,  53,  56,  60,  70 }
Part[   5] = {   2,  25,  33,  35,  39,  40,  42,  49,  53,  56,  60,  70 }
Part[   6] = {   5,  14,  23,  28,  36,  46,  65,  68 }
Part[   7] = {   5,  14,  23,  28,  46,  47,  65,  70 }
Part[   8] = {   5,  12,  23,  34,  36,  68,  70,  72 }
Part[   9] = {   5,  23,  28,  31,  36,  46,  65,  67 }
Part[  10] = {   5,   9,  28,  31,  46,  65,  73 }
Part[  11] = {   8,   9,  10,  17,  22,  24,  31,  33,  58,  74 }
Part[  12] = {   1,   9,  10,  14,  15,  17,  18,  21,  22,  30,  33,  58,  64,  74 }
Part[  13] = {   4,   8,  10,  11,  14,  20,  32,  33,  74,  76 }
Part[  14] = {   4,   8,   9,  11,  13,  14,  22,  33,  46,  65,  77 }
Part[  15] = {   5,   6,   9,  12,  31,  36,  66,  68,  75 }
Part[  16] = {   3,   5,   6,   9,  12,  31,  33,  36,  66,  68,  75 }
Part[  17] = {   3,   6,  10,  11,  31,  41,  42,  46,  55,  56,  57,  58,  63 }
Part[  18] = {   6,  16,  32,  33,  44,  45,  55,  57,  61,  64,  74 }
Part[  19] = {   6,  16,  32,  33,  39,  44,  45,  47,  55,  57,  58,  61,  64,  74 }
Part[  20] = {   3,   6,  10,  11,  19,  41,  42,  46,  55,  56,  57,  58,  63 }
Part[  21] = {   3,   6,   7,  10,  11,  31,  33,  42,  46,  56,  58,  63,  78 }
Part[  22] = {   3,   6,   7,  10,  11,  14,  42,  46,  56,  58,  63,  78 }
Part[  23] = {   3,   6,   7,  10,  11,  14,  42,  46,  56,  58,  63,  78 }
Part[  24] = {   6,  10,  12,  31,  41,  42,  46,  54,  55,  56,  57,  58,  63,  78 }
Part[  25] = {   6,  10,  12,  30,  41,  42,  46,  54,  55,  56,  57,  58,  63,  78 }
Part[  26] = {   6,  10,  12,  31,  41,  42,  46,  56,  57,  58,  63,  78 }
Part[  27] = {   6,  10,  12,  31,  41,  42,  46,  56,  57,  58,  63,  78 }
Part[  28] = {   6,  10,  12,  41,  42,  56,  57,  58,  63,  78 }
Part[  29] = {   2,  25,  33,  35,  39,  42,  48,  49,  53,  56,  59,  60,  70 }
Part[  30] = {   2,  25,  33,  35,  39,  42,  48,  49,  53,  56,  59,  60,  70 }
```

< Block Diagonal Solution Matrix >

< Locations >

```
 000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
 000000000111111111122222222223333333333444444444455555555556666666666777777777
 123456789012345678901234567890123456789012345678901234567890123456789012345678
```

< Machines >

```
 000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
 112223344555566677000001111223333444555566667777000011112222233334444455666777
 396797837012427917356790124380146126567835682358124856780124523590458939014046
< Parts >    ********************************************************************************
(   1)   1  * 1111111 111 1 111     1          11  1        1               1   1           *
(   2)   2  * 11 111 1   11 111  11 1          11 1         1                 11            *
           *=============================================================================== *
(   3)   6  *                  1      111   1  1     1 1                                    *
(   4)   7  *        1         1      111      1     1                                  1   *
(   5)   8  *                  1     1 1   11          11                              1   *
(   6)   9  *              1   1       11 1 1  1     1                                    *
(   7)  10  *                  1  1     1 1    1     1   1                                 *
(   8)  14  *1                1    1 1 1        1     1        11      1   1              *
(   9)  15  *                   11 1  1    1 1          11  1                            *
(  10)  16  *                  111 1  1    1 1          11  1              1             *
(  11)  17  *                  1 1  11     1  11111111                                   *
(  12)  20  * 1                1 1  11        11111111                                   *
(  13)  21  *                  1 11 11     1   11 1 11      1              1             *
(  14)  22  *                  1 11 11 1       11 1 11      1                            *
(  15)  23  *                  1 11 11 1       11 1 11      1                            *
(  16)  24  *           1        1  1 1    1  11111111      1                            *
(  17)  25  *           1        1  1 1   1   11111111      1                            *
(  18)  26  *                    1  1 1    1  111 1111      1                            *
(  19)  27  *                    1  1 1    1  111 1111      1                            *
(  20)  28  *                    1  1 1       11  1111      1                            *
           *=============================================================================== *
(  21)   3  *                                 1  1          1          1 1111  1 1 1  1  *
(  22)   4  *                                 1  1          1          1 1111  1 1 1  1  *
(  23)   5  *                                 1  1          1          1 1111   11 1  1  *
(  24)  11  *                     11      1       1          1  1   11  1             1 *
(  25)  12  *                     11  1  1        1        1   1 11 11   1           1 1 *
(  26)  13  *                      11 1                      11    1    11            11*
(  27)  18  *                   1              1 1             1       11   11     11 1 *
(  28)  19  *        1          1                1 11           1       11 1 11     11 1 *
(  29)  29  *                                 1  1          1          1 111   11111  1  *
(  30)  30  *                                 1  1          1          1 111   11111  1  *
           ********************************************************************************
```

< Machine cells and Part families >

```
=============================================================
Machine Cell[ 1] = { 13, 19, 26, 27, 29, 37, 38, 43, 47, 50, 51, 52, 54, 62, 67, 69, 71, 77 }
Machine Cell[ 2] = { 3, 5, 6, 7, 9, 10, 11, 12, 14, 23, 28, 30, 31, 34, 36, 41, 42, 46, 55, 56, 57,
58, 63, 65, 66, 68, 72, 73, 75, 78 }
Machine Cell[ 3] = { 1, 2, 4, 8, 15, 16, 17, 18, 20, 21, 22, 24, 25, 32, 33, 35, 39, 40, 44, 45, 48,
```

49, 53, 59, 60, 61, 64, 70, 74, 76 }
==
Part Family[1] = { 1, 2 }
Part Family[2] = { 6, 7, 8, 9, 10, 14, 15, 16, 17, 20, 21, 22, 23, 24, 25, 26, 27, 28 }
Part Family[3] = { 3, 4, 5, 11, 12, 13, 18, 19, 29, 30 }
==

< Summary of the performance measures >
==
No. of machines   = 78
No. of part types   = 30
No. of cells   = 3
Machine cell size   = 30
Total no. of 1's in the original MPIM : |A| = 357
Matrix density   = 0.153
Total no. of within-block 1's   = 296
No. of exceptional elements (EEs)   = 61
No. of voids   = 580
Sum of EEs and voids   = 641
Group Cability Index (GCI)   = 82.91 %
grouping efficiency (GE)   = 64.81 %
Grouping efficacy (GF)   = 31.59 %
Machine utilization (MU)   = 33.79 %
No. of redundant machines (RMs)   = 2
==

Problem(72) --> Data file name : DC_03_WaghodekarSahu(1984)_5x7.cfp

< Machines visited by parts: Process route numbers(PRN) >
```
Part[   1] = {   1,   4 }
Part[   2] = {   2,   4,   5 }
Part[   3] = {   2,   3,   4 }
Part[   4] = {   2,   3,   4,   5 }
Part[   5] = {   1,   2,   3,   5 }
Part[   6] = {   1,   3,   5 }
Part[   7] = {   1 }
```

< Block Diagonal Solution Matrix >

	< Locations >				
	0	0	0	0	0
	0	0	0	0	0
	1	2	3	4	5
	< Machines >				
	0	0	0	0	0
	0	0	0	0	0
< Parts >	1	4	2	3	5
(1)	1	1	1		
(2)	7	1			
(3)	2		1	1	1
(4)	3		1	1	1
(5)	4		1	1	1
(6)	5	1		1	1
(7)	6	1		1	1

< Machine cells and Part families >
```
Machine Cell[ 1] = { 1, 4 }
Machine Cell[ 2] = { 2, 3, 5 }
```
```
Part  Family[ 1] = { 1, 7 }
Part  Family[ 2] = { 2, 3, 4, 5, 6 }
```

< Summary of the performance measures >
```
No. of machines                                = 5
No. of part types                              = 7
No. of cells                                   = 2
Machine cell size                              = 3
Total no. of 1's in the original MPIM : |A|    = 20
Matrix density                                 = 0.571
Total no. of within-block 1's                  = 15
No. of exceptional elements (EEs)              = 5
No. of voids                                   = 4
Sum of EEs and voids                           = 9
Group Cability Index (GCI)                     = 75.00 %
grouping efficiency (GE)                       = 73.85 %
Grouping efficacy (GF)                         = 62.50 %
Machine utilization (MU)                       = 78.95 %
No. of redundant machines (RMs)                = 0
```

Problem(73) --> Data file name : DC_04_Seifoddini(1989)_5x18.cfp

< Machines visited by parts: Process route numbers(PRN) >
```
============================================================
Part[   1] = {   1,   2,   4 }
Part[   2] = {   1,   4 }
Part[   3] = {   1,   2,   4 }
Part[   4] = {   2,   3,   5 }
Part[   5] = {   1,   4 }
Part[   6] = {   1,   2,   4 }
Part[   7] = {   2,   3 }
Part[   8] = {   1,   2,   4 }
Part[   9] = {   5 }
Part[  10] = {   2,   3,   5 }
Part[  11] = {   1,   2,   4 }
Part[  12] = {   1,   2,   4 }
Part[  13] = {   1,   2,   4 }
Part[  14] = {   1,   4 }
Part[  15] = {   2,   3,   5 }
Part[  16] = {   1,   4 }
Part[  17] = {   1,   4 }
Part[  18] = {   2,   3,   5 }
============================================================
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0
              0 0 0 0 0
              1 2 3 4 5
            < Machines >
              0 0 0 0 0
              0 0 0 0 0
< Parts >     1 2 4 3 5
=========== * * * * * * *
(   1)   1  * 1 1 1     *
(   2)   2  * 1   1     *
(   3)   3  * 1 1 1     *
(   4)   5  * 1   1     *
(   5)   6  * 1 1 1     *
(   6)   8  * 1 1 1     *
(   7)  11  * 1 1 1     *
(   8)  12  * 1 1 1     *
(   9)  13  * 1 1 1     *
(  10)  14  * 1   1     *
(  11)  16  * 1   1     *
(  12)  17  * 1   1     *
=========== * = = = = = *
(  13)   4  *   1   1 1 *
(  14)   7  *   1   1   *
(  15)   9  *         1 *
(  16)  10  *   1   1 1 *
(  17)  15  *   1   1 1 *
(  18)  18  *   1   1 1 *
=========== * * * * * * *
```

< Machine cells and Part families >

```
============================================================
Machine Cell[ 1] = { 1, 2, 4 }
Machine Cell[ 2] = { 3, 5 }
============================================================
Part  Family[ 1] = { 1, 2, 3, 5, 6, 8, 11, 12, 13, 14, 16, 17 }
Part  Family[ 2] = { 4, 7, 9, 10, 15, 18 }
============================================================
```

< Summary of the performance measures >

```
============================================================
No. of machines                              = 5
No. of part types                            = 18
No. of cells                                 = 2
Machine cell size                            = 3
Total no. of 1's in the original MPIM : |A| = 46
```

Matrix density	= 0.511
Total no. of within-block 1's	= 41
No. of exceptional elements (EEs)	= 5
No. of voids	= 7
Sum of EEs and voids	= 12
Group Cability Index (GCI)	= 89.13 %
grouping efficiency (GE)	= 86.76 %
Grouping efficacy (GF)	= 77.36 %
Machine utilization (MU)	= 85.42 %
No. of redundant machines (RMs)	= 0

==========

Problem(74) --> Data file name : DC_05_AskinSubramanian(1987)_14x23.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   6,   8 }
Part[   2] = {   4,   5,   7 }
Part[   3] = {   4,   5,   7 }
Part[   4] = {   2,   3,  10,  11 }
Part[   5] = {   2,   3,  11 }
Part[   6] = {   8,   9 }
Part[   7] = {   1,  13 }
Part[   8] = {   1,   7,  12,  13 }
Part[   9] = {  12,  13 }
Part[  10] = {   6,   8,   9,  14 }
Part[  11] = {   6,  14 }
Part[  12] = {   6,   8,   9 }
Part[  13] = {   9,  14 }
Part[  14] = {   6,   8 }
Part[  15] = {   6,   8,   9,  14 }
Part[  16] = {   6,   8 }
Part[  17] = {   4,   5,   7 }
Part[  18] = {  13 }
Part[  19] = {   4 }
Part[  20] = {   4,   5,   7 }
Part[  21] = {   3,  11 }
Part[  22] = {   4,   5,  13 }
Part[  23] = {  10 }
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 0 1 1 1 1 1
              1 2 3 4 5 6 7 8 9 0 1 2 3 4
            < Machines >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 1 1 0 0 1 0 1 1
< Parts >     4 5 7 6 8 9 0 4 2 3 1 1 2 3
=========== * * * * * * * * * * * * * * * *
(   1)   2  * 1 1 1                       *
(   2)   3  * 1 1 1                       *
(   3)  17  * 1 1 1                       *
(   4)  19  * 1                           *
(   5)  20  * 1 1 1                       *
(   6)  22  * 1 1                       1 *
=========== * = = = = = = = = = = = = = = *
(   7)   1  *       1 1                   *
(   8)   6  *         1 1                 *
(   9)  10  *       1 1 1   1             *
(  10)  11  *       1       1             *
(  11)  12  *       1 1 1                 *
(  12)  14  *       1 1                   *
(  13)  15  *       1 1 1   1             *
(  14)  16  *       1 1                   *
=========== * = = = = = = = = = = = = = = *
(  15)  13  *           1   1             *
(  16)  23  *             1               *
=========== * = = = = = = = = = = = = = = *
(  17)   4  *             1   1 1 1       *
(  18)   5  *                 1 1 1       *
(  19)  21  *                   1 1       *
=========== * = = = = = = = = = = = = = = *
(  20)   7  *                       1   1 *
(  21)   8  *     1                 1 1 1 *
(  22)   9  *                         1 1 *
(  23)  18  *                           1 *
=========== * * * * * * * * * * * * * * * *
```

< Machine cells and Part families >

```
Machine Cell[ 1] = { 4, 5, 7 }
```

```
Machine Cell[ 2] = { 6, 8, 9 }
Machine Cell[ 3] = { 10, 14 }
Machine Cell[ 4] = { 2, 3, 11 }
Machine Cell[ 5] = { 1, 12, 13 }
============================================================
Part  Family[ 1] = { 2, 3, 17, 19, 20, 22 }
Part  Family[ 2] = { 1, 6, 10, 11, 12, 14, 15, 16 }
Part  Family[ 3] = { 13, 23 }
Part  Family[ 4] = { 4, 5, 21 }
Part  Family[ 5] = { 7, 8, 9, 18 }
============================================================

< Summary of the performance measures >
============================================================
No. of machines                              = 14
No. of part types                            = 23
No. of cells                                 = 5
Machine cell size                            = 3
Total no. of 1's in the original MPIM : |A| = 58
Matrix density                               = 0.18
Total no. of within-block 1's                = 51
No. of exceptional elements (EEs)            = 7
No. of voids                                 = 16
Sum of EEs and voids                         = 23
Group Cability Index (GCI)                   = 87.93 %
grouping efficiency (GE)                     = 86.69 %
Grouping efficacy (GF)                       = 68.92 %
Machine utilization (MU)                     = 76.12 %
No. of redundant machines (RMs)              = 0
============================================================
```

Problem(75) --> Data file name : DC_06_Stanfel(1985)_14x24.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   4,   5,   7 }
Part[   2] = {   4,   5,   7 }
Part[   3] = {   2,   3,  10,  11 }
Part[   4] = {   2,   3,  11 }
Part[   5] = {   8,   9 }
Part[   6] = {   1,  13 }
Part[   7] = {   1,   7,  12,  13 }
Part[   8] = {  12,  13 }
Part[   9] = {   6,   8,   9,  14 }
Part[  10] = {   6,   8 }
Part[  11] = {   6,  14 }
Part[  12] = {   6,   8,   9 }
Part[  13] = {   9,  14 }
Part[  14] = {   6,   8 }
Part[  15] = {   6,   8,   9,  14 }
Part[  16] = {   6,   8 }
Part[  17] = {   4,   5,   7 }
Part[  18] = {  13 }
Part[  19] = {   4 }
Part[  20] = {   4,   5,   7 }
Part[  21] = {   3,  11 }
Part[  22] = {   6,   8 }
Part[  23] = {   4,   5,  13 }
Part[  24] = {  10,  11 }
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 0 1 1 1 1 1
              1 2 3 4 5 6 7 8 9 0 1 2 3 4
            < Machines >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 1 0 1 0 1 1 0 1
< Parts >     4 5 7 6 8 9 4 3 1 1 2 3 2 0
=========== * * * * * * * * * * * * * * * *
(   1)   1  * 1 1 1                       *
(   2)   2  * 1 1 1                       *
(   3)  17  * 1 1 1                       *
(   4)  19  * 1                           *
(   5)  20  * 1 1 1                       *
(   6)  23  * 1 1                     1   *
=========== * = = = = = = = = = = = = = = *
(   7)   5  *         1 1                 *
(   8)   9  *       1 1 1 1               *
(   9)  10  *       1 1                   *
(  10)  11  *       1     1               *
(  11)  12  *       1 1 1                 *
(  12)  13  *           1 1               *
(  13)  14  *       1 1                   *
(  14)  15  *       1 1 1 1               *
(  15)  16  *       1 1                   *
(  16)  22  *       1 1                   *
=========== * = = = = = = = = = = = = = = *
(  17)   4  *               1 1       1   *
(  18)  21  *               1 1           *
(  19)  24  *                 1         1 *
=========== * = = = = = = = = = = = = = = *
(  20)   6  *                   1   1     *
(  21)   7  *     1             1 1 1     *
(  22)   8  *                     1 1     *
(  23)  18  *                       1     *
=========== * = = = = = = = = = = = = = = *
(  24)   3  *               1 1       1 1 *
=========== * * * * * * * * * * * * * * * *
```

< Machine cells and Part families >

```
============================================================
Machine Cell[ 1] = { 4, 5, 7 }
Machine Cell[ 2] = { 6, 8, 9, 14 }
Machine Cell[ 3] = { 3, 11 }
Machine Cell[ 4] = { 1, 12, 13 }
Machine Cell[ 5] = { 2, 10 }
============================================================
Part  Family[ 1] = { 1, 2, 17, 19, 20, 23 }
Part  Family[ 2] = { 5, 9, 10, 11, 12, 13, 14, 15, 16, 22 }
Part  Family[ 3] = { 4, 21, 24 }
Part  Family[ 4] = { 6, 7, 8, 18 }
Part  Family[ 5] = { 3 }
============================================================

< Summary of the performance measures >
============================================================
No. of machines                              = 14
No. of part types                            = 24
No. of cells                                 = 5
Machine cell size                            = 4
Total no. of 1's in the original MPIM : |A|  = 61
Matrix density                               = 0.182
Total no. of within-block 1's                = 55
No. of exceptional elements (EEs)            = 6
No. of voids                                 = 23
Sum of EEs and voids                         = 29
Group Cability Index (GCI)                   = 90.16 %
grouping efficiency (GE)                     = 84.09 %
Grouping efficacy (GF)                       = 65.48 %
Machine utilization (MU)                     = 70.51 %
No. of redundant machines (RMs)              = 0
============================================================
```

Problem(76) --> Data file name : DC_07_McCormick(1972)_16x24.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   1,   3,   7,   8,  14 }
Part[   2] = {   6,  10,  12,  13 }
Part[   3] = {   1,   6,   8,  12 }
Part[   4] = {   1,   3,  14 }
Part[   5] = {  15 }
Part[   6] = {   1,   3,  14,  15 }
Part[   7] = {   1,   8,   9,  11,  13 }
Part[   8] = {   1,  13 }
Part[   9] = {  10,  11,  12,  15,  16 }
Part[  10] = {   1,   2,   8,  10 }
Part[  11] = {   1,  12,  13,  16 }
Part[  12] = {  14 }
Part[  13] = {   6,   8 }
Part[  14] = {  10,  11,  12,  14,  16 }
Part[  15] = {   1,   6 }
Part[  16] = {   3,   4 }
Part[  17] = {   2,   3,   6,  10,  16 }
Part[  18] = {   1,   6 }
Part[  19] = {   1,   3,   4,   7 }
Part[  20] = {  10,  11,  12,  15,  16 }
Part[  21] = {   5,   6 }
Part[  22] = {   1,   2,   8,  10 }
Part[  23] = {   1,   2,   8,  10 }
Part[  24] = {   7,   9,  10,  11,  12,  14,  16 }
```

< Block Diagonal Solution Matrix >

	< Locations >																
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
		1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6
	< Machines >																
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	1	1	1	1	0	1	1	1	0	0
< Parts >		1	2	6	8	5	7	0	1	2	6	9	3	4	5	3	4
==========	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
(1) 1	*	1			1		1						1		1		*
(2) 3	*	1		1	1				1								*
(3) 7	*	1			1			1			1	1					*
(4) 8	*	1										1					*
(5) 10	*	1	1		1		1										*
(6) 13	*			1	1												*
(7) 15	*	1			1												*
(8) 18	*	1			1												*
(9) 22	*	1	1		1		1										*
(10) 23	*	1	1		1		1										*
==========	*	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	*
(11) 21	*			1		1											*
==========	*	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	*
(12) 2	*			1				1				1					*
(13) 9	*						1	1	1	1				1			*
(14) 11	*	1								1	1		1				*
(15) 14	*						1	1	1	1				1			*
(16) 17	*		1	1			1			1					1		*
(17) 20	*						1	1	1	1				1			*
(18) 24	*					1	1	1	1	1	1		1				*
==========	*	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	*
==========	*	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	*
(19) 4	*	1											1		1		*
(20) 5	*													1			*
(21) 6	*	1											1	1	1		*
(22) 12	*												1				*
==========	*	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	*
(23) 16	*														1	1	*
(24) 19	*	1				1									1	1	*
==========	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

```
< Machine cells and Part families  >
============================================================
Machine Cell[ 1] = { 1, 2, 6, 8 }
Machine Cell[ 2] = { 5, 7 }
Machine Cell[ 3] = { 10, 11, 12, 16 }
Machine Cell[ 4] = { 9, 13 }  --> Residual cell
Machine Cell[ 5] = { 14, 15 }
Machine Cell[ 6] = { 3, 4 }
============================================================
Part  Family[ 1] = { 1, 3, 7, 8, 10, 13, 15, 18, 22, 23 }
Part  Family[ 2] = { 21 }
Part  Family[ 3] = { 2, 9, 11, 14, 17, 20, 24 }
Part  Family[ 4] --> Empty Part family
Part  Family[ 5] = { 4, 5, 6, 12 }
Part  Family[ 6] = { 16, 19 }
============================================================

< Summary of the performance measures >
============================================================
No. of machines                              = 16
No. of part types                            = 24
No. of cells                                 = 6
Machine cell size                            = 4
Total no. of 1's in the original MPIM : |A|  = 86
Matrix density                               = 0.224
Total no. of within-block 1's                = 55
No. of exceptional elements (EEs)            = 31
No. of voids                                 = 27
Sum of EEs and voids                         = 58
Group Cability Index (GCI)                   = 63.95 %
grouping efficiency (GE)                     = 78.40 %
Grouping efficacy (GF)                       = 48.67 %
Machine utilization (MU)                     = 67.07 %
No. of redundant machines (RMs)              = 3
============================================================
```

Problem(77) --> Data file name : DC_08_Srinivasan(1990)_16x30.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   2,   3 }
Part[   2] = {   4,   7,   8,  11,  12 }
Part[   3] = {   5,  13 }
Part[   4] = {   1,   2,   4,   7,   8,  12 }
Part[   5] = {   1,   9,  15 }
Part[   6] = {   5,  10,  14,  16 }
Part[   7] = {   1,   4,   7,   8,  11,  12,  16 }
Part[   8] = {   5,  10,  14,  16 }
Part[   9] = {   1,   4,   8,  11 }
Part[  10] = {   2,  13 }
Part[  11] = {   5,  10,  11,  14 }
Part[  12] = {   1,   7,   8,  11,  12 }
Part[  13] = {   3,  13 }
Part[  14] = {   5,  10,  14,  16 }
Part[  15] = {   5,  10,  14,  16 }
Part[  16] = {   2 }
Part[  17] = {  14 }
Part[  18] = {   1,   2,   4,   7,   8,  10,  11,  12 }
Part[  19] = {   9,  12 }
Part[  20] = {   2,  12,  13 }
Part[  21] = {   5,  10,  14 }
Part[  22] = {   1,   4,   7,   8,  12 }
Part[  23] = {   3,   6,   9,  15 }
Part[  24] = {   5,  10,  16 }
Part[  25] = {   3,   6,   7,   9,  15 }
Part[  26] = {   5,  10,  15,  16 }
Part[  27] = {   3,   6,   9,  14,  15,  16 }
Part[  28] = {   3,   8,   9 }
Part[  29] = {   3,   6,  13,  15 }
Part[  30] = {   1,   4,   7,  11,  13,  15 }
```

< Block Diagonal Solution Matrix >

```
             < Locations >
               0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
               0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1
               1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8
             < Machines >
               0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
               0 0 0 0 1 1 0 1 1 1 0 0 0 1 0 1 1 1
< Parts >      1 4 7 8 1 2 5 0 4 6 3 6 9 5 2 3 1 2
============ * * * * * * * * * * * * * * * * * * *
(   1)   2   *   1 1 1 1 1                       *
(   2)   4   * 1 1 1 1   1                   1   *
(   3)   7   * 1 1 1 1 1 1 1       1           1 *
(   4)   9   * 1 1   1 1                        1 *
(   5)  12   * 1   1 1 1 1                      1 *
(   6)  18   * 1 1 1 1 1 1   1             1   1 *
(   7)  19   *             1           1        1 *
(   8)  22   * 1 1 1 1   1                     1 1 *
(   9)  30   * 1 1 1   1                   1   1 1 *
============ * = = = = = = = = = = = = = = = = = *
(  10)   3   *             1                   1 1 *
(  11)   6   *             1 1 1 1             1 1 *
(  12)   8   *             1 1 1 1             1 1 *
(  13)  11   *         1   1 1 1               1 1 *
(  14)  14   *             1 1 1 1             1 1 *
(  15)  15   *             1 1 1 1             1 1 *
(  16)  17   *               1                 1 1 *
(  17)  21   *             1 1 1               1 1 *
(  18)  24   *             1 1   1             1 1 *
(  19)  26   *             1 1   1       1     1 1 *
============ * = = = = = = = = = = = = = = = = = *
(  20)   5   * 1                       1 1       1 *
(  21)  23   *                     1 1 1 1       1 *
(  22)  25   *     1               1 1 1 1       1 *
(  23)  27   *                 1 1 1 1 1 1       1 *
```

```
(  24)  28  *       1             1   1       *
(  25)  29  *                     1 1   1   1 *
=========== * = = = = = = = = = = = = = = = = *
(  26)   1  *                     1       1   *
(  27)  10  *                                 1 1 *
(  28)  13  *                     1             1 *
(  29)  16  *                                 1   *
(  30)  20  *           1                     1 1 *
=========== * * * * * * * * * * * * * * * * * * *

< Machine cells and Part families  >
============================================================
Machine Cell[ 1] = { 1, 4, 7, 8, 11, 12 }
Machine Cell[ 2] = { 5, 10, 14, 16 }
Machine Cell[ 3] = { 3, 6, 9, 15 }
Machine Cell[ 4] = { 2, 13 }
============================================================
Part  Family[ 1] = { 2, 4, 7, 9, 12, 18, 19, 22, 30 }
Part  Family[ 2] = { 3, 6, 8, 11, 14, 15, 17, 21, 24, 26 }
Part  Family[ 3] = { 5, 23, 25, 27, 28, 29 }
Part  Family[ 4] = { 1, 10, 13, 16, 20 }
============================================================

< Summary of the performance measures >
============================================================
No. of machines                              = 16
No. of part types                            = 30
No. of cells                                 = 4
Machine cell size                            = 6
Total no. of 1's in the original MPIM : |A| = 116
Matrix density                               = 0.242
Total no. of within-block 1's                = 97
No. of exceptional elements (EEs)            = 19
No. of voids                                 = 31
Sum of EEs and voids                         = 50
Group Cability Index (GCI)                   = 83.62 %
grouping efficiency (GE)                     = 85.19 %
Grouping efficacy (GF)                       = 65.99 %
Machine utilization (MU)                     = 75.78 %
No. of redundant machines (RMs)              = 0
============================================================
```

Problem(78) --> Data file name : DC_09_King(1980)_16x43.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   6,   7,   8,  10 }
Part[   2] = {   2,   6,   8,   9,  14,  16 }
Part[   3] = {   8,  11,  13 }
Part[   4] = {   9 }
Part[   5] = {   4,   5,  15 }
Part[   6] = {   6,  14 }
Part[   7] = {   3,   6,  16 }
Part[   8] = {   5,   6,   8 }
Part[   9] = {   4,   5,   8,  11 }
Part[  10] = {   2,   9,  16 }
Part[  11] = {   8,  12 }
Part[  12] = {   6,   8,  10 }
Part[  13] = {   6,   7,  10 }
Part[  14] = {   4,   5,   6,  15 }
Part[  15] = {   5,   8 }
Part[  16] = {   5 }
Part[  17] = {   3,   6,  14 }
Part[  18] = {   9,  16 }
Part[  19] = {   4,   5,   6,   8,  15 }
Part[  20] = {   8,  11 }
Part[  21] = {   4,   5,   8,  15 }
Part[  22] = {  12 }
Part[  23] = {   4,   5,   6,   8 }
Part[  24] = {   8,  11,  12,  13 }
Part[  25] = {   7,  10 }
Part[  26] = {  10 }
Part[  27] = {   8,  11,  12 }
Part[  28] = {   2,   8,   9 }
Part[  29] = {   4,   5 }
Part[  30] = {  11,  12 }
Part[  31] = {   8,  10 }
Part[  32] = {   2,   6,   9,  16 }
Part[  33] = {   5,   6,  15 }
Part[  34] = {   3,   6 }
Part[  35] = {   3,  14 }
Part[  36] = {   3 }
Part[  37] = {   1,   2,   6,   8,   9,  16 }
Part[  38] = {   2,   8,   9,  16 }
Part[  39] = {   6,  10 }
Part[  40] = {   2,   6,   9 }
Part[  41] = {   5,   8,  15 }
Part[  42] = {   1,   2,   6,   9,  16 }
Part[  43] = {   5,   6,   8,  15 }
```

< Block Diagonal Solution Matrix >

```
             < Locations >
               0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
               0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1
               1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6
             < Machines >
               0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
               0 0 0 1 1 0 0 0 1 1 0 0 0 1 1 1
< Parts >      3 6 7 0 4 4 5 8 1 5 1 2 9 6 2 3
============ * * * * * * * * * * * * * * * * *
(   1)   1  *   1 1 1       1                 *
(   2)   6  *   1     1                       *
(   3)   7  * 1 1                         1   *
(   4)  12  *   1   1       1                 *
(   5)  13  *   1 1 1                         *
(   6)  17  * 1 1     1                       *
(   7)  25  *     1 1                         *
(   8)  26  *       1                         *
(   9)  34  * 1 1                             *
(  10)  35  * 1       1                       *
(  11)  36  * 1                               *
(  12)  39  *   1   1                         *
```

```
========== * = = = = = = = = = = = = = = = = *
(  13)   3  *                 1 1                 1 *
(  14)   5  *           1 1       1                 *
(  15)   8  *   1         1 1                       *
(  16)   9  *           1 1 1 1                     *
(  17)  14  *   1       1 1       1                 *
(  18)  15  *             1 1                       *
(  19)  16  *             1                         *
(  20)  19  *   1       1 1 1     1                 *
(  21)  20  *               1 1                     *
(  22)  21  *           1 1 1     1                 *
(  23)  23  *   1       1 1 1                       *
(  24)  27  *               1 1               1     *
(  25)  29  *           1 1                         *
(  26)  31  *       1       1                       *
(  27)  33  *   1         1       1                 *
(  28)  41  *             1 1     1                 *
(  29)  43  *   1         1 1     1                 *
========== * = = = = = = = = = = = = = = = = *
(  30)   2  *   1     1     1         1 1 1         *
(  31)   4  *                             1         *
(  32)  10  *                           1 1 1       *
(  33)  18  *                             1 1       *
(  34)  28  *               1           1 1         *
(  35)  32  *   1                       1 1 1       *
(  36)  37  *   1           1       1 1 1 1         *
(  37)  38  *               1         1 1 1         *
(  38)  40  *   1                     1 1           *
(  39)  42  *   1                 1 1 1 1           *
========== * = = = = = = = = = = = = = = = = *
(  40)  11  *               1                 1     *
(  41)  22  *                                 1     *
(  42)  24  *               1 1               1 1 * 
(  43)  30  *                 1               1     *
========== * * * * * * * * * * * * * * * * * *
```

```
< Machine cells and Part families  >
============================================================
Machine Cell[ 1] = { 3, 6, 7, 10, 14 }
Machine Cell[ 2] = { 4, 5, 8, 11, 15 }
Machine Cell[ 3] = { 1, 2, 9, 16 }
Machine Cell[ 4] = { 12, 13 }
============================================================
Part  Family[ 1] = { 1, 6, 7, 12, 13, 17, 25, 26, 34, 35, 36, 39 }
Part  Family[ 2] = { 3, 5, 8, 9, 14, 15, 16, 19, 20, 21, 23, 27, 29, 31, 33, 41,
43 }
Part  Family[ 3] = { 2, 4, 10, 18, 28, 32, 37, 38, 40, 42 }
Part  Family[ 4] = { 11, 22, 24, 30 }
============================================================

< Summary of the performance measures >
============================================================
No. of machines                              = 16
No. of part types                            = 43
No. of cells                                 = 4
Machine cell size                            = 5
Total no. of 1's in the original MPIM : |A| = 126
Matrix density                               = 0.183
Total no. of within-block 1's                = 100
No. of exceptional elements (EEs)            = 26
No. of voids                                 = 93
Sum of EEs and voids                         = 119
Group Cability Index (GCI)                   = 79.37 %
grouping efficiency (GE)                     = 73.28 %
Grouping efficacy (GF)                       = 45.66 %
Machine utilization (MU)                     = 51.81 %
No. of redundant machines (RMs)              = 0
============================================================
```

Problem(78) --> Data file name : DC_09_King(1980)_16x43.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   6,   7,   8,  10 }
Part[   2] = {   2,   6,   8,   9,  14,  16 }
Part[   3] = {   8,  11,  13 }
Part[   4] = {   9 }
Part[   5] = {   4,   5,  15 }
Part[   6] = {   6,  14 }
Part[   7] = {   3,   6,  16 }
Part[   8] = {   5,   6,   8 }
Part[   9] = {   4,   5,   8,  11 }
Part[  10] = {   2,   9,  16 }
Part[  11] = {   8,  12 }
Part[  12] = {   6,   8,  10 }
Part[  13] = {   6,   7,  10 }
Part[  14] = {   4,   5,   6,  15 }
Part[  15] = {   5,   8 }
Part[  16] = {   5 }
Part[  17] = {   3,   6,  14 }
Part[  18] = {   9,  16 }
Part[  19] = {   4,   5,   6,   8,  15 }
Part[  20] = {   8,  11 }
Part[  21] = {   4,   5,   8,  15 }
Part[  22] = {  12 }
Part[  23] = {   4,   5,   6,   8 }
Part[  24] = {   8,  11,  12,  13 }
Part[  25] = {   7,  10 }
Part[  26] = {  10 }
Part[  27] = {   8,  11,  12 }
Part[  28] = {   2,   8,   9 }
Part[  29] = {   4,   5 }
Part[  30] = {  11,  12 }
Part[  31] = {   8,  10 }
Part[  32] = {   2,   6,   9,  16 }
Part[  33] = {   5,   6,  15 }
Part[  34] = {   3,   6 }
Part[  35] = {   3,  14 }
Part[  36] = {   3 }
Part[  37] = {   1,   2,   6,   8,   9,  16 }
Part[  38] = {   2,   8,   9,  16 }
Part[  39] = {   6,  10 }
Part[  40] = {   2,   6,   9 }
Part[  41] = {   5,   8,  15 }
Part[  42] = {   1,   2,   6,   9,  16 }
Part[  43] = {   5,   6,   8,  15 }
```

< Block Diagonal Solution Matrix >

```
             < Locations >
               0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
               0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1
               1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6
             < Machines >
               0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
               0 0 1 0 0 0 1 1 1 1 0 1 0 0 0 1
< Parts >      1 3 4 4 5 8 5 1 2 3 7 0 2 6 9 6
=========== * * * * * * * * * * * * * * * * * *
(   1)  17  *   1 1                         1     *
(   2)  34  *   1                           1     *
(   3)  35  *   1 1                               *
(   4)  36  *   1                                 *
=========== * = = = = = = = = = = = = = = = = = *
(   5)   5  *       1 1   1                       *
(   6)   8  *         1 1                   1     *
(   7)   9  *       1 1 1   1                     *
(   8)  14  *       1 1   1                 1     *
(   9)  15  *         1 1                         *
(  10)  16  *         1                           *
(  11)  19  *       1 1 1 1                 1     *
```

```
(  12)  21  *       1 1 1 1                     *
(  13)  23  *       1 1 1                 1     *
(  14)  29  *       1 1                         *
(  15)  31  *           1             1         *
(  16)  33  *         1   1               1     *
(  17)  41  *         1 1 1                     *
(  18)  43  *         1 1 1                 1     *
========== * = = = = = = = = = = = = = = = = = *
(  19)   3  *           1   1   1               *
(  20)  11  *           1     1                 *
(  21)  20  *           1   1                   *
(  22)  22  *               1                   *
(  23)  24  *           1   1 1 1               *
(  24)  27  *           1   1 1                 *
(  25)  30  *               1 1                 *
========== * = = = = = = = = = = = = = = = = = *
(  26)   1  *           1           1 1   1     *
(  27)  13  *                       1 1   1     *
(  28)  25  *                       1 1         *
(  29)  26  *                         1         *
(  30)  39  *                         1   1     *
========== * = = = = = = = = = = = = = = = = = *
(  31)   2  *     1     1               1 1 1 1 *
(  32)   4  *                                 1 *
(  33)   6  *     1                         1   *
(  34)   7  *   1                           1   1 *
(  35)  10  *                             1   1 1 *
(  36)  12  *           1             1   1     *
(  37)  18  *                                 1 1 *
(  38)  28  *           1               1   1   *
(  39)  32  *                           1 1 1 1 *
(  40)  37  * 1         1               1 1 1 1 *
(  41)  38  *           1               1   1 1 *
(  42)  40  *                           1 1 1   *
(  43)  42  * 1                         1 1 1 1 *
========== * * * * * * * * * * * * * * * * * * *
```

```
< Machine cells and Part families  >
============================================================
Machine Cell[ 1] = { 1, 3, 14 }
Machine Cell[ 2] = { 4, 5, 8, 15 }
Machine Cell[ 3] = { 11, 12, 13 }
Machine Cell[ 4] = { 7, 10 }
Machine Cell[ 5] = { 2, 6, 9, 16 }
============================================================
Part  Family[ 1] = { 17, 34, 35, 36 }
Part  Family[ 2] = { 5, 8, 9, 14, 15, 16, 19, 21, 23, 29, 31, 33, 41, 43 }
Part  Family[ 3] = { 3, 11, 20, 22, 24, 27, 30 }
Part  Family[ 4] = { 1, 13, 25, 26, 39 }
Part  Family[ 5] = { 2, 4, 6, 7, 10, 12, 18, 28, 32, 37, 38, 40, 42 }
============================================================

< Summary of the performance measures >
============================================================
No. of machines                              = 16
No. of part types                            = 43
No. of cells                                 = 5
Machine cell size                            = 4
Total no. of 1's in the original MPIM : |A|  = 126
Matrix density                               = 0.183
Total no. of within-block 1's                = 96
No. of exceptional elements (EEs)            = 30
No. of voids                                 = 55
Sum of EEs and voids                         = 85
Group Cability Index (GCI)                   = 76.19 %
grouping efficiency (GE)                     = 78.99 %
Grouping efficacy (GF)                       = 53.04 %
Machine utilization (MU)                     = 63.58 %
No. of redundant machines (RMs)              = 1
============================================================
```

Problem(78) --> Data file name : DC_09_King(1980)_16x43.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   6,   7,   8,  10 }
Part[   2] = {   2,   6,   8,   9,  14,  16 }
Part[   3] = {   8,  11,  13 }
Part[   4] = {   9 }
Part[   5] = {   4,   5,  15 }
Part[   6] = {   6,  14 }
Part[   7] = {   3,   6,  16 }
Part[   8] = {   5,   6,   8 }
Part[   9] = {   4,   5,   8,  11 }
Part[  10] = {   2,   9,  16 }
Part[  11] = {   8,  12 }
Part[  12] = {   6,   8,  10 }
Part[  13] = {   6,   7,  10 }
Part[  14] = {   4,   5,   6,  15 }
Part[  15] = {   5,   8 }
Part[  16] = {   5 }
Part[  17] = {   3,   6,  14 }
Part[  18] = {   9,  16 }
Part[  19] = {   4,   5,   6,   8,  15 }
Part[  20] = {   8,  11 }
Part[  21] = {   4,   5,   8,  15 }
Part[  22] = {  12 }
Part[  23] = {   4,   5,   6,   8 }
Part[  24] = {   8,  11,  12,  13 }
Part[  25] = {   7,  10 }
Part[  26] = {  10 }
Part[  27] = {   8,  11,  12 }
Part[  28] = {   2,   8,   9 }
Part[  29] = {   4,   5 }
Part[  30] = {  11,  12 }
Part[  31] = {   8,  10 }
Part[  32] = {   2,   6,   9,  16 }
Part[  33] = {   5,   6,  15 }
Part[  34] = {   3,   6 }
Part[  35] = {   3,  14 }
Part[  36] = {   3 }
Part[  37] = {   1,   2,   6,   8,   9,  16 }
Part[  38] = {   2,   8,   9,  16 }
Part[  39] = {   6,  10 }
Part[  40] = {   2,   6,   9 }
Part[  41] = {   5,   8,  15 }
Part[  42] = {   1,   2,   6,   9,  16 }
Part[  43] = {   5,   6,   8,  15 }
```

< Block Diagonal Solution Matrix >

```
             < Locations >
               0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
               0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1
               1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6
             < Machines >
               0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
               0 1 0 0 0 1 0 1 1 1 0 0 0 1 0 1
< Parts >      3 4 4 5 8 5 7 0 1 2 2 6 9 6 1 3
=========== * * * * * * * * * * * * * * * * * *
(   1)  17  * 1 1                     1         *
(   2)  34  * 1                       1         *
(   3)  35  * 1 1                               *
(   4)  36  * 1                                 *
=========== * = = = = = = = = = = = = = = = = *
(   5)   5  *     1 1   1                       *
(   6)   8  *       1 1                 1       *
(   7)   9  *     1 1 1       1               *
(   8)  11  *         1           1             *
(   9)  12  *         1     1             1     *
(  10)  14  *     1 1   1               1       *
(  11)  15  *       1 1                         *
```

```
(  12)  16  *       1                           *
(  13)  19  *     1 1 1 1             1         *
(  14)  20  *         1       1                 *
(  15)  21  *     1 1 1 1                       *
(  16)  23  *     1 1 1               1         *
(  17)  29  *     1 1                           *
(  18)  31  *         1     1                   *
(  19)  33  *       1   1               1       *
(  20)  41  *       1 1 1                       *
(  21)  43  *       1 1 1               1       *
========== * = = = = = = = = = = = = = = = = = *
(  22)   1  *         1   1 1           1       *
(  23)  13  *             1 1           1       *
(  24)  25  *             1 1                   *
(  25)  26  *               1                   *
========== * = = = = = = = = = = = = = = = = = *
(  26)   3  *         1       1               1 *
(  27)  22  *                   1               *
(  28)  24  *         1       1 1             1 *
(  29)  27  *         1       1 1               *
(  30)  30  *                 1 1               *
========== * = = = = = = = = = = = = = = = = = *
(  31)   2  *   1     1           1 1 1 1       *
(  32)   4  *                         1         *
(  33)   6  *   1                     1         *
(  34)   7  * 1                       1   1     *
(  35)  10  *                       1   1 1     *
(  36)  18  *                           1 1     *
(  37)  28  *         1             1   1       *
(  38)  32  *                       1 1 1 1     *
(  39)  37  *         1             1 1 1 1 1   *
(  40)  38  *         1             1   1 1     *
(  41)  39  *               1         1         *
(  42)  40  *                       1 1 1       *
(  43)  42  *                       1 1 1 1 1   *
========== * = = = = = = = = = = = = = = = = = *
========== * * * * * * * * * * * * * * * * * * *
```

```
< Machine cells and Part families  >
============================================================
Machine Cell[ 1] = { 3, 14 }
Machine Cell[ 2] = { 4, 5, 8, 15 }
Machine Cell[ 3] = { 7, 10 }
Machine Cell[ 4] = { 11, 12 }
Machine Cell[ 5] = { 2, 6, 9, 16 }
Machine Cell[ 6] = { 1, 13 }  --> Residual cell
============================================================
Part  Family[ 1] = { 17, 34, 35, 36 }
Part  Family[ 2] = { 5, 8, 9, 11, 12, 14, 15, 16, 19, 20, 21, 23, 29, 31, 33,
41, 43 }
Part  Family[ 3] = { 1, 13, 25, 26 }
Part  Family[ 4] = { 3, 22, 24, 27, 30 }
Part  Family[ 5] = { 2, 4, 6, 7, 10, 18, 28, 32, 37, 38, 39, 40, 42 }
Part  Family[ 6] --> Empty Part family
============================================================

< Summary of the performance measures >
============================================================
No. of machines                              = 16
No. of part types                            = 43
No. of cells                                 = 6
Machine cell size                            = 4
Total no. of 1's in the original MPIM : |A| = 126
Matrix density                               = 0.183
Total no. of within-block 1's                = 94
No. of exceptional elements (EEs)            = 32
No. of voids                                 = 52
Sum of EEs and voids                         = 84
Group Cability Index (GCI)                   = 74.60 %
grouping efficiency (GE)                     = 79.24 %
Grouping efficacy (GF)                       = 52.81 %
```

```
Machine utilization (MU)                    = 64.38 %
No. of redundant machines (RMs)             = 2
============================================================
```

Problem(79) --> Data file name : DC_10_Carrie(1973)_18x24.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   8,  15 }
Part[   2] = {   3,   4,   5,   7,  10 }
Part[   3] = {   6,   8,   9 }
Part[   4] = {   5,   8,  16,  17 }
Part[   5] = {   3,   4,   5,   6,   7 }
Part[   6] = {   4,   7,  12 }
Part[   7] = {  11,  12,  15 }
Part[   8] = {   3,   4,   5,   6,  13 }
Part[   9] = {   3,   4,   5,   6,  13 }
Part[  10] = {   1,   5,   6,   8 }
Part[  11] = {   5,  18 }
Part[  12] = {   3,   4,   5,   7,  10 }
Part[  13] = {   1,  12,  15 }
Part[  14] = {  11,  12,  13 }
Part[  15] = {   3,   4,   5,   6,  15 }
Part[  16] = {   5,  18 }
Part[  17] = {   3,   4,   5,   6,  15 }
Part[  18] = {  11,  12,  14,  15 }
Part[  19] = {  10,  12,  13 }
Part[  20] = {   8,  14 }
Part[  21] = {  11,  12,  14 }
Part[  22] = {   4,  12,  13 }
Part[  23] = {   1,   2,   5,   6,   8 }
Part[  24] = {   5,   6,   8,   9 }
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1
              1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
            < Machines >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 1 1 1 1 1 0 0 0 0 1 1 1 1 1
< Parts >     3 4 5 6 7 1 2 3 4 5 8 9 1 2 0 8 6 7 9 0
=========== * * * * * * * * * * * * * * * * * * * * *
(   1)   2  * 1 1 1   1                   1       *
(   2)   5  * 1 1 1 1 1                               *
(   3)   6  *   1     1   1                           *
(   4)   8  * 1 1 1 1       1                        *
(   5)   9  * 1 1 1 1       1                        *
(   6)  10  *     1 1               1   1            *
(   7)  11  *     1                             1     *
(   8)  12  * 1 1 1   1                       1       *
(   9)  15  * 1 1 1 1           1                    *
(  10)  16  *     1                             1     *
(  11)  17  * 1 1 1 1           1                    *
=========== * = = = = = = = = = = = = = = = = = = = *
(  12)   1  *                   1 1                  *
(  13)   7  *           1 1     1                    *
(  14)  13  *             1     1     1              *
(  15)  14  *           1 1 1                        *
(  16)  18  *           1 1   1 1                    *
(  17)  19  *             1 1               1       *
(  18)  21  *           1 1   1                      *
(  19)  22  *   1         1 1                        *
=========== * = = = = = = = = = = = = = = = = = = = *
(  20)   3  *       1             1 1                *
(  21)  20  *                 1   1                  *
(  22)  24  *     1 1             1 1                *
=========== * = = = = = = = = = = = = = = = = = = = *
(  23)  23  *     1 1             1   1 1            *
=========== * = = = = = = = = = = = = = = = = = = = *
=========== * = = = = = = = = = = = = = = = = = = = *
(  24)   4  *     1               1           1 1    *
=========== * * * * * * * * * * * * * * * * * * * *
```

```
< Machine cells and Part families  >
============================================================
Machine Cell[ 1] = { 3, 4, 5, 6, 7 }
Machine Cell[ 2] = { 11, 12, 13, 14, 15 }
Machine Cell[ 3] = { 8, 9 }
Machine Cell[ 4] = { 1, 2 }
Machine Cell[ 5] = { 10, 18 }  --> Residual cell
Machine Cell[ 6] = { 16, 17 }
============================================================
Part  Family[ 1] = { 2, 5, 6, 8, 9, 10, 11, 12, 15, 16, 17 }
Part  Family[ 2] = { 1, 7, 13, 14, 18, 19, 21, 22 }
Part  Family[ 3] = { 3, 20, 24 }
Part  Family[ 4] = { 23 }
Part  Family[ 5] --> Empty Part family
Part  Family[ 6] = { 4 }
============================================================

< Summary of the performance measures >
============================================================
No. of machines                              = 18
No. of part types                            = 24
No. of cells                                 = 6
Machine cell size                            = 5
Total no. of 1's in the original MPIM : |A|  = 88
Matrix density                               = 0.204
Total no. of within-block 1's                = 64
No. of exceptional elements (EEs)            = 24
No. of voids                                 = 41
Sum of EEs and voids                         = 65
Group Cability Index (GCI)                   = 72.73 %
grouping efficiency (GE)                     = 76.81 %
Grouping efficacy (GF)                       = 49.61 %
Machine utilization (MU)                     = 60.95 %
No. of redundant machines (RMs)              = 2
============================================================
```

Problem(80) --> Data file name : DC_11_MosierTaube(1985b)_20x20.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   1,   7,  18,  20 }
Part[   2] = {   2,  13 }
Part[   3] = {   2,   3,   5,  15,  20 }
Part[   4] = {   3,   8,  11,  12,  17,  20 }
Part[   5] = {   2,  11,  15,  16,  17 }
Part[   6] = {   1,   4,   6,   7,   8,   9 }
Part[   7] = {   2,   6,   7,  17,  18 }
Part[   8] = {   2,   3,  15,  18,  20 }
Part[   9] = {   1,   4,   7,   8,   9,  15 }
Part[  10] = {   2,   4,   8,  10,  13,  19 }
Part[  11] = {   1,   3,  10,  12,  13,  16 }
Part[  12] = {  12 }
Part[  13] = {   1,   2,   3,   5,  10,  11,  13,  14 }
Part[  14] = {   3,   6,   7,   8,   9,  11,  12,  14,  16,  17,  19 }
Part[  15] = {   2,   5,   8,  10,  11,  17 }
Part[  16] = {   1,   3,   7,   9,  13,  15,  16,  17,  18 }
Part[  17] = {   2,  12,  13,  14 }
Part[  18] = {   3,   7,   8,  11,  12,  13,  14 }
Part[  19] = {   7,   9,  10,  11,  14,  20 }
Part[  20] = {   2,   7,   8 }
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 2
              1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
            < Machines >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 1 1 1 1 2 0 0 0 0 0 1 1 0 1 0 1 1 1
< Parts >     2 5 0 1 3 4 0 1 4 6 7 9 6 7 3 2 8 9 5 8
=========== * * * * * * * * * * * * * * * * * * * * *
(   1)   2  * 1       1                             *
(   2)   3  * 1 1         1               1       1   *
(   3)   4  *       1     1             1 1 1 1       *
(   4)   5  * 1     1                 1 1         1   *
(   5)  10  * 1   1   1       1                 1 1     *
(   6)  11  *     1   1     1         1   1 1         *
(   7)  13  * 1 1 1 1 1 1   1             1           *
(   8)  15  * 1 1 1 1                   1     1       *
(   9)  17  * 1       1 1                   1         *
(  10)  18  *       1 1 1         1       1 1 1       *
(  11)  19  *     1 1   1 1       1 1                 *
(  12)  20  * 1                   1             1     *
=========== * = = = = = = = = = = = = = = = = = = = = *
(  13)   1  *             1 1     1                 1 *
(  14)   6  *               1 1 1 1 1           1     *
(  15)   7  * 1                 1 1     1           1 *
(  16)   9  *               1 1   1 1         1   1   *
(  17)  14  *       1   1       1 1 1 1 1 1 1 1 1     *
(  18)  16  *         1     1     1 1 1 1 1       1 1 *
=========== * = = = = = = = = = = = = = = = = = = = = *
(  19)  12  *                               1         *
=========== * = = = = = = = = = = = = = = = = = = = = *
=========== * = = = = = = = = = = = = = = = = = = = = *
(  20)   8  * 1           1               1       1 1 *
=========== * * * * * * * * * * * * * * * * * * * * *
```

< Machine cells and Part families >

```
============================================================
Machine Cell[ 1] = { 2, 5, 10, 11, 13, 14, 20 }
Machine Cell[ 2] = { 1, 4, 6, 7, 9, 16, 17 }
Machine Cell[ 3] = { 3, 12 }
Machine Cell[ 4] = { 8, 19 }  --> Residual cell
Machine Cell[ 5] = { 15, 18 }
============================================================
Part  Family[ 1] = { 2, 3, 4, 5, 10, 11, 13, 15, 17, 18, 19, 20 }
```

```
Part  Family[ 2] = { 1, 6, 7, 9, 14, 16 }
Part  Family[ 3] = { 12 }
Part  Family[ 4] --> Empty Part family
Part  Family[ 5] = { 8 }
============================================================

< Summary of the performance measures >
============================================================
No. of machines                              = 20
No. of part types                            = 20
No. of cells                                 = 5
Machine cell size                            = 7
Total no. of 1's in the original MPIM : |A|  = 111
Matrix density                               = 0.278
Total no. of within-block 1's                = 62
No. of exceptional elements (EEs)            = 49
No. of voids                                 = 68
Sum of EEs and voids                         = 117
Group Cability Index (GCI)                   = 55.86 %
grouping efficiency (GE)                     = 64.77 %
Grouping efficacy (GF)                       = 34.64 %
Machine utilization (MU)                     = 47.69 %
No. of redundant machines (RMs)              = 3
============================================================
```

Problem(81) --> Data file name : DC_12_Kumar(1986)_20x23.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   1,   3,   4,   5,   6,   8,  12,  13,  14,  15,  18,  19 }
Part[   2] = {   3,   6,   9,  10,  12 }
Part[   3] = {   1,   4,   8,  18,  19,  20 }
Part[   4] = {   5,  13 }
Part[   5] = {   2,   9,  11,  16,  19 }
Part[   6] = {  10,  17 }
Part[   7] = {   3,   7,   9,  10,  11,  16,  17 }
Part[   8] = {   7,  10 }
Part[   9] = {   7,  10 }
Part[  10] = {   1,   5,   6,   9,  12,  13,  18 }
Part[  11] = {   1,   3,   5,  12 }
Part[  12] = {   4,   8,  14,  15,  20 }
Part[  13] = {   2,   8,  17 }
Part[  14] = {   2,  16 }
Part[  15] = {   1,   2,   3,   5,   6,   8,  12,  13,  14,  17,  18,  20 }
Part[  16] = {   8,  10,  14,  20 }
Part[  17] = {   4,  10 }
Part[  18] = {   3,   9,  12,  13,  15,  16,  17 }
Part[  19] = {   9,  15,  17 }
Part[  20] = {  12,  13,  16 }
Part[  21] = {   1,   4,   9,  15 }
Part[  22] = {   1,   3,   4,   6,   8,   9,  10,  14,  15,  20 }
Part[  23] = {   1,   4,   9,  15 }
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 2
              1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
            < Machines >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 1 0 0 0 0 1 1 1 0 1 1 1 0 0 0 1 1 1 2
< Parts >     7 0 1 3 5 6 2 3 7 2 6 8 9 4 8 9 1 4 5 0
=========== * * * * * * * * * * * * * * * * * * * * *
(   1)   6  *   1             1                       *
(   2)   7  * 1 1   1         1   1         1 1       *
(   3)   8  * 1 1                                     *
(   4)   9  * 1 1                                     *
(   5)  17  *   1                       1             *
=========== * = = = = = = = = = = = = = = = = = = = = *
(   6)   1  *     1 1 1 1 1 1       1 1 1 1     1 1   *
(   7)   2  *   1   1   1 1                   1       *
(   8)   4  *         1     1                         *
(   9)  10  *     1   1 1 1 1       1       1         *
(  10)  11  *     1 1 1   1                           *
(  11)  15  *     1 1 1 1 1 1 1 1   1     1     1   1 *
(  12)  18  *       1     1 1 1   1         1     1   *
(  13)  20  *             1 1     1                   *
=========== * = = = = = = = = = = = = = = = = = = = = *
(  14)   5  *                   1 1   1     1 1       *
(  15)  13  *                 1 1         1           *
(  16)  14  *                   1 1                   *
=========== * = = = = = = = = = = = = = = = = = = = = *
=========== * = = = = = = = = = = = = = = = = = = = = *
(  17)   3  *     1                 1 1 1 1         1 *
(  18)  12  *                         1 1     1 1 1 *
(  19)  16  *   1                       1     1   1 *
(  20)  19  *                 1           1     1   *
(  21)  21  *     1                     1   1     1   *
(  22)  22  *   1 1 1   1                 1 1 1   1 1 1 *
(  23)  23  *     1                     1   1     1   *
=========== * * * * * * * * * * * * * * * * * * * * *
```

< Machine cells and Part families >

```
============================================================
Machine Cell[ 1] = { 7, 10 }
```

```
Machine Cell[ 2] = { 1, 3, 5, 6, 12, 13, 17 }
Machine Cell[ 3] = { 2, 16 }
Machine Cell[ 4] = { 18, 19 }  --> Residual cell
Machine Cell[ 5] = { 4, 8, 9, 11, 14, 15, 20 }
============================================================
Part  Family[ 1] = { 6, 7, 8, 9, 17 }
Part  Family[ 2] = { 1, 2, 4, 10, 11, 15, 18, 20 }
Part  Family[ 3] = { 5, 13, 14 }
Part  Family[ 4] --> Empty Part family
Part  Family[ 5] = { 3, 12, 16, 19, 21, 22, 23 }
============================================================

< Summary of the performance measures >
============================================================
No. of machines                              = 20
No. of part types                            = 23
No. of cells                                 = 5
Machine cell size                            = 7
Total no. of 1's in the original MPIM : |A| = 113
Matrix density                               = 0.246
Total no. of within-block 1's                = 71
No. of exceptional elements (EEs)            = 42
No. of voids                                 = 50
Sum of EEs and voids                         = 92
Group Cability Index (GCI)                   = 62.83 %
grouping efficiency (GE)                     = 73.14 %
Grouping efficacy (GF)                       = 43.56 %
Machine utilization (MU)                     = 58.68 %
No. of redundant machines (RMs)              = 3
============================================================
```

Problem(82) --> Data file name : DC_13_BoeCheng(1991)_20x35.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   1,   3,   7,   8,  17 }
Part[   2] = {   2,   4,  13,  14,  18 }
Part[   3] = {   3,   7,  17 }
Part[   4] = {  11,  12,  15,  16,  19 }
Part[   5] = {   3,   5,   7,   8,  17 }
Part[   6] = {   1,  11,  12,  15,  16 }
Part[   7] = {   4,   7,  14,  18 }
Part[   8] = {   6,   9,  10,  20 }
Part[   9] = {   8,  11,  12,  15,  16,  19 }
Part[  10] = {   2,  14 }
Part[  11] = {   1,  11,  12,  15,  19 }
Part[  12] = {   2,   4,   7,  13,  14,  16,  18 }
Part[  13] = {   2,   4,  13,  14,  18 }
Part[  14] = {   1,   5,   6,   9,  10,  20 }
Part[  15] = {   1,   3,   7,   8,  17 }
Part[  16] = {  10 }
Part[  17] = {   5,   7,   8,  17 }
Part[  18] = {   1,   2,  14,  16 }
Part[  19] = {   2,   6,   7,   9,  10,  20 }
Part[  20] = {   1,   7,   8,  17,  18 }
Part[  21] = {  11,  12,  15,  19 }
Part[  22] = {   6,   7,  10 }
Part[  23] = {   1,   5,   7,   8,   9,  20 }
Part[  24] = {   1,   2,   4,   7,  13,  14,  18 }
Part[  25] = {   1,   6,  17 }
Part[  26] = {   5,   7,  10,  16,  20 }
Part[  27] = {   4,  14 }
Part[  28] = {  15,  19 }
Part[  29] = {   3,   7 }
Part[  30] = {   1,   6,   7,  15,  16,  19 }
Part[  31] = {   2,   3,   7,  14,  18 }
Part[  32] = {   1,   7,   9,  16,  19 }
Part[  33] = {  11,  12 }
Part[  34] = {   1 }
Part[  35] = {   1,   8,   9,  17 }
```

< Block Diagonal Solution Matrix >

```
             < Locations >
               0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
               0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 2
               1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
             < Machines >
               0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
               0 0 0 0 1 1 1 1 1 1 0 1 2 0 0 1 1 1 0 0
< Parts >      1 3 7 8 7 1 2 5 6 9 6 0 0 2 4 3 4 8 5 9
============ * * * * * * * * * * * * * * * * * * * * *
(   1)   1   * 1 1 1 1 1                               *
(   2)   3   *   1 1   1                               *
(   3)   5   *   1 1 1 1                           1   *
(   4)  15   * 1 1 1 1 1                               *
(   5)  17   *     1 1 1                           1   *
(   6)  20   * 1   1 1 1                         1     *
(   7)  23   * 1   1 1                   1           1 1 *
(   8)  25   * 1       1           1                  *
(   9)  29   *   1 1                                   *
(  10)  34   * 1                                       *
(  11)  35   * 1     1 1                             1 *
============ * = = = = = = = = = = = = = = = = = = = = *
(  12)   4   *           1 1 1 1 1                     *
(  13)   6   * 1         1 1 1 1                       *
(  14)   9   *       1   1 1 1 1 1                     *
(  15)  11   * 1         1 1 1   1                     *
(  16)  21   *           1 1 1   1                     *
(  17)  28   *               1   1                     *
(  18)  30   * 1   1         1 1 1 1                   *
(  19)  32   * 1   1           1 1                   1 *
```

```
(  20)  33  *           1 1                             *
========== * = = = = = = = = = = = = = = = = = = = = = *
(  21)   8  *                     1 1 1               1 *
(  22)  14  * 1                   1 1 1           1 1 *
(  23)  16  *                       1                 *
(  24)  19  *     1                 1 1 1 1         1 *
(  25)  22  *     1                 1 1               *
(  26)  26  *     1           1       1 1         1     *
========== * = = = = = = = = = = = = = = = = = = = = = *
(  27)   2  *                             1 1 1 1 1     *
(  28)   7  *     1                         1   1 1     *
(  29)  10  *                             1     1       *
(  30)  12  *     1           1           1 1 1 1 1     *
(  31)  13  *                             1 1 1 1 1     *
(  32)  18  * 1               1           1     1       *
(  33)  24  * 1   1                       1 1 1 1 1     *
(  34)  27  *                               1   1       *
(  35)  31  *   1 1                       1     1 1     *
========== * = = = = = = = = = = = = = = = = = = = = = *
========== * * * * * * * * * * * * * * * * * * * * * *

< Machine cells and Part families  >
============================================================
Machine Cell[ 1] = { 1, 3, 7, 8, 17 }
Machine Cell[ 2] = { 11, 12, 15, 16, 19 }
Machine Cell[ 3] = { 6, 10, 20 }
Machine Cell[ 4] = { 2, 4, 13, 14, 18 }
Machine Cell[ 5] = { 5, 9 }  --> Residual cell
============================================================
Part  Family[ 1] = { 1, 3, 5, 15, 17, 20, 23, 25, 29, 34, 35 }
Part  Family[ 2] = { 4, 6, 9, 11, 21, 28, 30, 32, 33 }
Part  Family[ 3] = { 8, 14, 16, 19, 22, 26 }
Part  Family[ 4] = { 2, 7, 10, 12, 13, 18, 24, 27, 31 }
Part  Family[ 5] --> Empty Part family
============================================================

< Summary of the performance measures >
============================================================
No. of machines                              = 20
No. of part types                            = 35
No. of cells                                 = 5
Machine cell size                            = 5
Total no. of 1's in the original MPIM : |A| = 149
Matrix density                               = 0.213
Total no. of within-block 1's                = 112
No. of exceptional elements (EEs)            = 37
No. of voids                                 = 51
Sum of EEs and voids                         = 88
Group Cability Index (GCI)                   = 75.17 %
grouping efficiency (GE)                     = 80.91 %
Grouping efficacy (GF)                       = 56.00 %
Machine utilization (MU)                     = 68.71 %
No. of redundant machines (RMs)              = 2
============================================================
```

Problem(83) --> Data file name : DC_14_ChandraRaja(1989)_5_24x40.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {  13,  15,  21,  22 }
Part[   2] = {   3,  20,  24 }
Part[   3] = {  14,  21,  23,  24 }
Part[   4] = {   8,  12,  15,  18 }
Part[   5] = {   5,   8,  12,  15,  18 }
Part[   6] = {   9,  10 }
Part[   7] = {  17 }
Part[   8] = {   4,  16 }
Part[   9] = {   1,  21 }
Part[  10] = {   5,   6,  11,  21 }
Part[  11] = {   4,  18,  20 }
Part[  12] = {   3,   5,  13,  20 }
Part[  13] = {   2,  11,  19,  23 }
Part[  14] = {   1,   2,   5,  14,  15,  19 }
Part[  15] = {   3,  11,  20 }
Part[  16] = {  13,  14,  21,  22 }
Part[  17] = {   1,  13,  17,  22 }
Part[  18] = {   6,  12,  18 }
Part[  19] = {   4,  16,  20 }
Part[  20] = {  10,  12,  17 }
Part[  21] = {   4,  16 }
Part[  22] = {   2,   5,  11,  12 }
Part[  23] = {   3,  11,  20 }
Part[  24] = {   3,  10,  12 }
Part[  25] = {   7,  14,  20 }
Part[  26] = {   6,   8,  10,  15,  16 }
Part[  27] = {  12,  15,  18,  19 }
Part[  28] = {   4 }
Part[  29] = {   9,  17 }
Part[  30] = {   6,   8,  18,  22 }
Part[  31] = {  17,  20 }
Part[  32] = {   1,   7,  16,  23,  24 }
Part[  33] = {   1,   2,   9,  21 }
Part[  34] = {   3,   8,  20 }
Part[  35] = {   5,  11,  13,  16,  19 }
Part[  36] = {   2,   5,  16,  19 }
Part[  37] = {  15,  16 }
Part[  38] = {   4,   6 }
Part[  39] = {   8,   9 }
Part[  40] = {   7,   9,  19 }
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
              1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8
            < Machines >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              1 1 0 2 0 2 0 1 0 1 0 0 1 1 2 2 1 2 0 0 1 1 0 1 1 1 1 1
< Parts >     0 2 3 0 1 1 4 6 9 7 2 5 1 9 3 4 3 2 6 8 5 8 7 4 5 6 7 8
=========== * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
(   1)  20  * 1 1               1                                     *
(   2)  24  * 1 1 1                                                   *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(   3)   2  *     1 1                           1                     *
(   4)  11  *       1     1                                   1       *
(   5)  12  *     1 1                 1           1                   *
(   6)  15  *     1 1                   1                             *
(   7)  23  *     1 1                   1                             *
(   8)  31  *       1           1                                     *
(   9)  34  *     1 1                                   1             *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  10)   9  *         1 1                                             *
(  11)  33  *         1 1     1   1                                   *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  12)   8  *             1 1                                         *
```

```
(  13)  19  *       1     1 1                                       *
(  14)  21  *             1 1                                       *
(  15)  28  *             1                                         *
(  16)  37  *               1                           1           *
(  17)  38  *             1                         1               *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  18)   6  * 1               1                                     *
(  19)   7  *                   1                                   *
(  20)  29  *                 1 1                                   *
(  21)  39  *                 1                       1             *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  22)  10  *           1           1 1           1                 *
(  23)  13  *                     1   1 1 1                         *
(  24)  14  *         1           1 1   1             1     1     1 *
(  25)  22  *   1                 1 1 1                             *
(  26)  35  *               1       1 1 1     1                     *
(  27)  36  *               1     1 1   1                           *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  28)   3  *           1                 1 1                   1   *
(  29)  32  *         1     1               1 1               1     *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  30)   1  *           1                       1 1     1           *
(  31)  16  *           1                       1 1           1   *
(  32)  17  *         1         1               1 1               *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  33)   4  *   1                                   1 1 1         *
(  34)   5  *   1                   1               1 1 1         *
(  35)  18  *   1                                 1     1         *
(  36)  26  * 1             1                     1 1 1           *
(  37)  27  *   1                       1             1 1         *
(  38)  30  *                                   1 1 1   1         *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  39)  25  *       1                                       1 1   *
(  40)  40  *                 1         1                   1     *
=========== * * * * * * * * * * * * * * * * * * * * * * * * * * * *
```

```
< Machine cells and Part families  >
============================================================
Machine Cell[ 1] = { 10, 12 }
Machine Cell[ 2] = { 3, 20 }
Machine Cell[ 3] = { 1, 21 }
Machine Cell[ 4] = { 4, 16 }
Machine Cell[ 5] = { 9, 17 }
Machine Cell[ 6] = { 2, 5, 11, 19 }
Machine Cell[ 7] = { 23, 24 }
Machine Cell[ 8] = { 13, 22 }
Machine Cell[ 9] = { 6, 8, 15, 18 }
Machine Cell[10] = { 7, 14 }
============================================================
Part  Family[ 1] = { 20, 24 }
Part  Family[ 2] = { 2, 11, 12, 15, 23, 31, 34 }
Part  Family[ 3] = { 9, 33 }
Part  Family[ 4] = { 8, 19, 21, 28, 37, 38 }
Part  Family[ 5] = { 6, 7, 29, 39 }
Part  Family[ 6] = { 10, 13, 14, 22, 35, 36 }
Part  Family[ 7] = { 3, 32 }
Part  Family[ 8] = { 1, 16, 17 }
Part  Family[ 9] = { 4, 5, 18, 26, 27, 30 }
Part  Family[10] = { 25, 40 }
============================================================

< Summary of the performance measures >
============================================================
No. of machines                              = 24
No. of part types                            = 40
No. of cells                                 = 10
Machine cell size                            = 4
Total no. of 1's in the original MPIM : |A| = 131
Matrix density                               = 0.136
Total no. of within-block 1's                = 80
No. of exceptional elements (EEs)            = 51
```

```
No. of voids                                  = 24
Sum of EEs and voids                          = 75
Group Cability Index (GCI)                    = 61.07 %
grouping efficiency (GE)                      = 85.48 %
Grouping efficacy (GF)                        = 51.61 %
Machine utilization (MU)                      = 76.92 %
No. of redundant machines (RMs)               = 0
============================================================
```

Problem(84) --> Data file name : DC_15_ChandraRaja(1989)_6_24x40.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {  13,  15,  21,  22 }
Part[   2] = {   3,  20,  24 }
Part[   3] = {  21,  23,  24 }
Part[   4] = {   8,  12,  18 }
Part[   5] = {   5,   8,  15,  18 }
Part[   6] = {   9,  10 }
Part[   7] = {  17 }
Part[   8] = {   4,  16 }
Part[   9] = {   1,  10,  19,  21 }
Part[  10] = {   5,   6,  11,  21 }
Part[  11] = {   4,  14,  18,  20 }
Part[  12] = {   3,   5,   9,  13,  20,  23 }
Part[  13] = {   2,   7,  19,  23 }
Part[  14] = {   2,  14,  15,  19 }
Part[  15] = {   3,  11,  20 }
Part[  16] = {   8,  13,  14,  22 }
Part[  17] = {   1,  13,  17 }
Part[  18] = {   6,  12,  18 }
Part[  19] = {   1,  16,  20 }
Part[  20] = {  10,  12,  17 }
Part[  21] = {   4,  16 }
Part[  22] = {   2,   5,  11,  12 }
Part[  23] = {   3,  11,  20 }
Part[  24] = {   3,  10,  12 }
Part[  25] = {   7,  14,  20 }
Part[  26] = {   6,   8,  10,  15,  16 }
Part[  27] = {  12,  15,  18,  19 }
Part[  28] = {   4,   7 }
Part[  29] = {   9,  17 }
Part[  30] = {   6,   8,  18,  22 }
Part[  31] = {   1,  17,  20 }
Part[  32] = {   7,  16,  23,  24 }
Part[  33] = {   1,   2,   9,  21 }
Part[  34] = {   3,   8,  20,  24 }
Part[  35] = {   5,  13,  19 }
Part[  36] = {   2,   5,  19 }
Part[  37] = {  15,  16 }
Part[  38] = {   4,   6,   8 }
Part[  39] = {   8,   9,  16 }
Part[  40] = {   7,   9,  19 }
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2
              1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8
            < Machines >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 1 0 1 2 0 0 1 0 1 1 1 2 2 2 0 1 0 2 1 1 0 1 1 2 2 2
< Parts >     2 7 9 3 4 0 6 8 5 1 0 7 3 2 3 4 4 6 9 1 2 8 5 1 3 3 4 4
=========== * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
(   1)  13  * 1 1 1                         1                         *
(   2)  14  * 1   1   1       1                                       *
(   3)  36  * 1   1                                             1     *
(   4)  40  *   1 1                                     1             *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(   5)   2  *       1   1                     1                       *
(   6)  11  *         1 1                       1         1           *
(   7)  12  *       1   1             1   1       1       1   1       *
(   8)  15  *       1   1                                     1 1     *
(   9)  23  *       1   1                                     1 1     *
(  10)  25  *   1     1 1                                             *
(  11)  34  *       1   1   1               1                         *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  12)   5  *               1 1                             1 1       *
(  13)  26  *             1 1 1   1             1                     *
```

```
(  14)  30  *             1 1           1                1     *
(  15)  37  *                 1                 1              *
(  16)  38  *             1 1                       1          *
(  17)  39  *               1                     1 1          *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = *
(  18)   7  *                         1                        *
(  19)   9  *     1             1 1                   1        *
(  20)  17  *                   1   1 1                        *
(  21)  20  *                     1 1                   1      *
(  22)  29  *                       1             1            *
(  23)  31  *           1         1   1                        *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = *
(  24)   1  *                   1       1 1           1        *
(  25)  16  *         1     1           1 1                    *
(  26)  35  *     1                     1                  1   *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = *
(  27)   3  *                               1 1       1        *
(  28)  32  *   1                           1 1   1            *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = *
(  29)   8  *                                   1 1            *
(  30)  19  *           1       1                 1            *
(  31)  21  *                                   1 1            *
(  32)  28  *   1                               1              *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = *
(  33)   6  *                     1                 1          *
(  34)  33  * 1                   1                 1 1        *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = *
(  35)   4  *               1                           1 1    *
(  36)  18  *             1                             1 1    *
(  37)  24  *       1             1                     1      *
(  38)  27  *     1           1                         1 1    *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = *
(  39)  10  *             1                           1     1 1 *
(  40)  22  * 1                                         1   1 1 *
=========== * * * * * * * * * * * * * * * * * * * * * * * * * *
```

```
< Machine cells and Part families  >
============================================================
Machine Cell[ 1] = { 2, 7, 19 }
Machine Cell[ 2] = { 3, 14, 20 }
Machine Cell[ 3] = { 6, 8, 15 }
Machine Cell[ 4] = { 1, 10, 17 }
Machine Cell[ 5] = { 13, 22 }
Machine Cell[ 6] = { 23, 24 }
Machine Cell[ 7] = { 4, 16 }
Machine Cell[ 8] = { 9, 21 }
Machine Cell[ 9] = { 12, 18 }
Machine Cell[10] = { 5, 11 }
============================================================
Part  Family[ 1] = { 13, 14, 36, 40 }
Part  Family[ 2] = { 2, 11, 12, 15, 23, 25, 34 }
Part  Family[ 3] = { 5, 26, 30, 37, 38, 39 }
Part  Family[ 4] = { 7, 9, 17, 20, 29, 31 }
Part  Family[ 5] = { 1, 16, 35 }
Part  Family[ 6] = { 3, 32 }
Part  Family[ 7] = { 8, 19, 21, 28 }
Part  Family[ 8] = { 6, 33 }
Part  Family[ 9] = { 4, 18, 24, 27 }
Part  Family[10] = { 10, 22 }
============================================================

< Summary of the performance measures >
============================================================
No. of machines                              = 24
No. of part types                            = 40
No. of cells                                 = 10
Machine cell size                            = 3
Total no. of 1's in the original MPIM : |A| = 131
Matrix density                               = 0.136
Total no. of within-block 1's                = 73
No. of exceptional elements (EEs)            = 58
```

```
No. of voids                                  = 30
Sum of EEs and voids                          = 88
Group Cability Index (GCI)                    = 55.73 %
grouping efficiency (GE)                      = 82.05 %
Grouping efficacy (GF)                        = 45.34 %
Machine utilization (MU)                      = 70.87 %
No. of redundant machines (RMs)               = 0
============================================================
```

Problem(85) --> Data file name : DC_16_ChandraRaja(1989)_7_24x40.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {  15,  21,  22 }
Part[   2] = {   7,  20,  24 }
Part[   3] = {  11,  13,  21,  23 }
Part[   4] = {   8,  12,  18 }
Part[   5] = {   5,   8,  15,  18 }
Part[   6] = {   5,   9,  10 }
Part[   7] = {  17,  22 }
Part[   8] = {   4,  14,  24 }
Part[   9] = {   1,  10,  19,  21 }
Part[  10] = {   5,   6,  11,  21 }
Part[  11] = {   4,  14,  18,  20 }
Part[  12] = {   3,   5,   9,  13,  20,  23 }
Part[  13] = {   2,   7,  19,  23 }
Part[  14] = {   2,  14,  15,  19 }
Part[  15] = {   3,  11,  20 }
Part[  16] = {   8,  13,  14,  22 }
Part[  17] = {   1,  13,  17 }
Part[  18] = {   6,  12,  18 }
Part[  19] = {   1,  16,  20 }
Part[  20] = {  10,  12,  17 }
Part[  21] = {   4,  23 }
Part[  22] = {   2,   5,  11,  12 }
Part[  23] = {   3,  11 }
Part[  24] = {   3,  10,  12 }
Part[  25] = {   7,  14,  20 }
Part[  26] = {   6,   8,  10,  15,  16 }
Part[  27] = {  12,  15,  18,  19 }
Part[  28] = {   4,   7 }
Part[  29] = {  17 }
Part[  30] = {   6,   8,  18,  22 }
Part[  31] = {   1,  17,  20 }
Part[  32] = {   7,  16,  23,  24 }
Part[  33] = {   1,   2,   9,  21 }
Part[  34] = {   3,   8,  24 }
Part[  35] = {   5,  13,  19 }
Part[  36] = {  16,  19,  23 }
Part[  37] = {  15,  16 }
Part[  38] = {   4,   6,   8 }
Part[  39] = {   8,   9,  16 }
Part[  40] = {   2,   9,  19 }
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 3 4
              1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 1 2 1 1
            < Machines >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 1 0 1 1 0 2 2 0 1 1 2 0 1 1 1 0 2 0 1 2 0 1 1 2 1 2
< Parts >     6 8 8 2 5 9 1 0 1 3 1 7 2 9 6 0 2 7 4 5 3 3 4 4 1 1 1 1
=========== * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
(   1)   4  *   1 1                             1                     *
(   2)   5  *   1 1   1                                 1             *
(   3)  18  * 1   1                               1                   *
(   4)  26  * 1 1     1                       1 1                     *
(   5)  30  * 1 1 1                       1                           *
(   6)  38  * 1 1                                                 1   *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(   7)  13  *       1   1                         1       1         *
(   8)  14  *       1 1 1                                       1   *
(   9)  27  *     1   1 1                           1               *
(  10)  37  *         1                       1                     *
(  11)  40  *       1   1                   1                       *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  12)   1  *         1       1       1                             *
(  13)   9  *           1 1   1             1                       *
```

```
(  14)  10  * 1              1   1                  1         *
(  15)  19  *            1 1             1                   *
(  16)  31  *            1 1         1                       *
(  17)  33  *       1    1   1         1                      *
=========== * = = = = = = = = = = = = = = = = = = = = = = = *
(  18)  15  *              1   1 1                           *
(  19)  22  *       1            1           1     1          *
(  20)  23  *                  1 1                           *
(  21)  34  *   1              1                 1           *
=========== * = = = = = = = = = = = = = = = = = = = = = = = *
(  22)   7  *                      1 1                       *
(  23)  17  *            1         1                 1       *
(  24)  29  *                      1                         *
=========== * = = = = = = = = = = = = = = = = = = = = = = = *
(  25)  36  *          1                 1             1     *
(  26)  39  *   1                    1 1                     *
=========== * = = = = = = = = = = = = = = = = = = = = = = = *
(  27)   6  *                        1   1       1           *
(  28)  20  *                      1       1 1               *
(  29)  24  *                  1           1 1               *
=========== * = = = = = = = = = = = = = = = = = = = = = = = *
(  30)   2  *              1                     1 1         *
(  31)  25  *              1                     1         1 *
(  32)  32  *                          1     1 1     1     *
=========== * = = = = = = = = = = = = = = = = = = = = = = = *
(  33)   3  *                1   1                   1 1     *
(  34)  12  *              1   1       1           1 1 1     *
(  35)  16  *   1                    1               1     1 *
(  36)  21  *                                        1 1   *
(  37)  35  *          1                           1 1       *
=========== * = = = = = = = = = = = = = = = = = = = = = = = *
(  38)   8  *                                  1       1 1 *
(  39)  11  *     1         1                            1 1 *
(  40)  28  *                                1         1   *
=========== * * * * * * * * * * * * * * * * * * * * * * * *

< Machine cells and Part families  >
============================================================
Machine Cell[ 1] = { 6, 8, 18 }
Machine Cell[ 2] = { 2, 15, 19 }
Machine Cell[ 3] = { 1, 20, 21 }
Machine Cell[ 4] = { 3, 11 }
Machine Cell[ 5] = { 17, 22 }
Machine Cell[ 6] = { 9, 16 }
Machine Cell[ 7] = { 10, 12 }
Machine Cell[ 8] = { 7, 24 }
Machine Cell[ 9] = { 5, 13, 23 }
Machine Cell[10] = { 4, 14 }
============================================================
Part  Family[ 1] = { 4, 5, 18, 26, 30, 38 }
Part  Family[ 2] = { 13, 14, 27, 37, 40 }
Part  Family[ 3] = { 1, 9, 10, 19, 31, 33 }
Part  Family[ 4] = { 15, 22, 23, 34 }
Part  Family[ 5] = { 7, 17, 29 }
Part  Family[ 6] = { 36, 39 }
Part  Family[ 7] = { 6, 20, 24 }
Part  Family[ 8] = { 2, 25, 32 }
Part  Family[ 9] = { 3, 12, 16, 21, 35 }
Part  Family[10] = { 8, 11, 28 }
============================================================

< Summary of the performance measures >
============================================================
No. of machines                              = 24
No. of part types                            = 40
No. of cells                                 = 10
Machine cell size                            = 3
Total no. of 1's in the original MPIM : |A| = 131
Matrix density                               = 0.136
Total no. of within-block 1's                = 70
No. of exceptional elements (EEs)            = 61
```

No. of voids = 32
Sum of EEs and voids = 93
Group Cability Index (GCI) = 53.44 %
grouping efficiency (GE) = 80.76 %
Grouping efficacy (GF) = 42.94 %
Machine utilization (MU) = 68.63 %
No. of redundant machines (RMs) = 0
==========

Problem(86) --> Data file name : DC_17_McCormick(1972)_27x27.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   1,   2,   4,   5,   7,   8,  13,  18,  22 }
Part[   2] = {   1,   2,   4,   7,   8,  13,  16,  19,  22 }
Part[   3] = {   3,   4,   5,   7,   8,  14,  16,  19 }
Part[   4] = {   1,   2,   3,   4,  13,  14,  17 }
Part[   5] = {   1,   3,   5,   7,   8,   9,  10,  16,  19,  21,  22 }
Part[   6] = {   6,   9,  10,  17,  20,  23,  26,  27 }
Part[   7] = {   1,   2,   3,   5,   7,   8,   9,  10,  11,  13,  14,  16,  22 }
Part[   8] = {   1,   2,   3,   5,   7,   8,   9,  10,  16 }
Part[   9] = {   5,   6,   7,   8,   9,  10 }
Part[  10] = {   5,   6,   7,   8,   9,  10,  11,  12,  13,  14,  19 }
Part[  11] = {   7,  10,  11,  12,  20,  25 }
Part[  12] = {  10,  11,  12,  13,  14,  19 }
Part[  13] = {   2,   4,   7,  10,  12,  13,  16,  19,  22 }
Part[  14] = {   3,   4,   7,  10,  12,  14,  16,  19 }
Part[  15] = {  15,  16,  17,  18,  21,  22,  27 }
Part[  16] = {   2,   3,   4,   5,   7,   8,  13,  14,  15,  16,  17,  18,  19,
21,  22 }
Part[  17] = {   6,  15,  16,  17,  20,  21,  23,  27 }
Part[  18] = {   1,   2,  15,  16,  22,  25 }
Part[  19] = {   2,   3,   4,   5,  10,  12,  13,  14,  16,  19,  22 }
Part[  20] = {   6,  11,  17,  20,  21,  24,  26 }
Part[  21] = {   5,  15,  16,  17,  20,  21,  24,  26,  27 }
Part[  22] = {   1,   2,   5,   7,  13,  15,  16,  18,  19,  22 }
Part[  23] = {   6,  17,  23,  27 }
Part[  24] = {  20,  21,  24,  26,  27 }
Part[  25] = {  11,  18,  25,  27 }
Part[  26] = {   6,  20,  21,  24,  26 }
Part[  27] = {   6,  15,  17,  21,  23,  24,  25,  27 }
```

< Block Diagonal Solution Matrix >

```
             < Locations >
               0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
               0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2
               1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9
             < Machines >
               0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
               0 0 0 0 0 0 1 1 1 1 1 2 0 1 1 1 2 2 2 2 2 2 2 0 1 0 1
< Parts >      1 2 4 5 7 8 0 3 4 6 9 2 6 1 5 7 0 1 3 4 5 6 7 3 2 9 8
============ * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
(   1)   1   * 1 1 1 1 1 1   1       1                                 1 *
(   2)   2   * 1 1 1   1 1   1   1 1 1                                 *
(   3)   3   *     1 1 1 1     1 1 1                       1           *
(   4)   4   * 1 1 1           1 1               1         1           *
(   5)   5   * 1     1 1 1 1     1 1 1               1     1   1       *
(   6)   7   * 1 1   1 1 1 1 1 1 1   1   1               1   1       *
(   7)   8   * 1 1   1 1 1 1     1                     1   1   1       *
(   8)   9   *       1 1 1 1           1                     1   1       *
(   9)  10   *       1 1 1 1 1 1   1   1 1                   1 1   1       *
(  10)  12   *             1 1 1   1     1                   1     1       *
(  11)  13   *   1 1   1   1 1   1 1 1                       1     1       *
(  12)  14   *     1   1   1   1 1 1                       1 1     1       *
(  13)  16   *   1 1 1 1 1   1 1 1 1 1     1 1   1           1     1 1   *
(  14)  18   * 1 1                 1   1     1           1             1       *
(  15)  19   *   1 1 1     1 1 1 1 1 1                       1 1     1       *
(  16)  22   * 1 1   1 1     1   1 1 1     1                         1 1   *
============ * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  17)   6   *           1           1     1 1   1     1 1     1   1       *
(  18)  11   *       1   1             1     1       1       1     1       *
(  19)  15   *                 1   1     1 1   1         1       1 1   *
(  20)  17   *                 1     1   1 1 1 1 1       1         1       *
(  21)  20   *                   1 1   1 1 1   1   1             1       *
(  22)  21   *     1           1       1 1 1 1   1   1 1           1       *
(  23)  23   *                   1     1     1       1           1       *
(  24)  24   *                         1 1   1   1 1             1       *
(  25)  25   *                     1               1   1       1 1   *
(  26)  26   *                   1       1 1   1   1           1       *
```

```
(  27)  27  *                          1   1 1   1 1 1 1   1         *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
=========== * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

< Machine cells and Part families  >
============================================================
Machine Cell[ 1] = { 1, 2, 4, 5, 7, 8, 10, 13, 14, 16, 19, 22 }
Machine Cell[ 2] = { 6, 11, 15, 17, 20, 21, 23, 24, 25, 26, 27 }
Machine Cell[ 3] = { 3, 12 }  --> Residual cell
Machine Cell[ 4] = { 9, 18 }  --> Residual cell
============================================================
Part  Family[ 1] = { 1, 2, 3, 4, 5, 7, 8, 9, 10, 12, 13, 14, 16, 18, 19, 22 }
Part  Family[ 2] = { 6, 11, 15, 17, 20, 21, 23, 24, 25, 26, 27 }
Part  Family[ 3] --> Empty Part family
Part  Family[ 4] --> Empty Part family
============================================================

< Summary of the performance measures >
============================================================
No. of machines                          = 27
No. of part types                        = 27
No. of cells                             = 4
Machine cell size                        = 12
Total no. of 1's in the original MPIM : |A| = 219
Matrix density                           = 0.3
Total no. of within-block 1's            = 173
No. of exceptional elements (EEs)        = 46
No. of voids                             = 140
Sum of EEs and voids                     = 186
Group Cability Index (GCI)               = 79.00 %
grouping efficiency (GE)                 = 72.11 %
Grouping efficacy (GF)                   = 48.19 %
Machine utilization (MU)                 = 55.27 %
No. of redundant machines (RMs)          = 4
============================================================
```

Problem(87) --> Data file name : DC_18_Carrie(1973)_28x46.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   8,   9,  10,  11,  14,  15,  19 }
Part[   2] = {   1,   2,   8,   9,  10,  11,  15 }
Part[   3] = {   8,  10,  15,  19,  22 }
Part[   4] = {   1,   8,   9,  10,  23 }
Part[   5] = {   8,   9,  10,  19,  23 }
Part[   6] = {   5,   8,   9,  19,  21 }
Part[   7] = {   1,   5,   8,   9,  21 }
Part[   8] = {   8,  19,  20,  21 }
Part[   9] = {   8,   9,  19,  20 }
Part[  10] = {  17,  19,  20,  21 }
Part[  11] = {   5,  19,  21,  22 }
Part[  12] = {   1,   8,  10,  16 }
Part[  13] = {   3,   6,   7,   8,   9,  11,  13 }
Part[  14] = {   3,   4,   5,   8,   9,  27 }
Part[  15] = {   3,   4,   8,   9,  10 }
Part[  16] = {   3,   6,   8,   9,  10 }
Part[  17] = {   3,   5,   6,   8,  18,  26 }
Part[  18] = {   3,   4,   5,   8,  28 }
Part[  19] = {   3,   4,   5,  10,  18 }
Part[  20] = {   3,   4,   5,   8,  18 }
Part[  21] = {   3,   4,   5,   6,  18 }
Part[  22] = {   3,   4,   5,  24,  27 }
Part[  23] = {   3,   4,   5,   8,  24 }
Part[  24] = {   3,   4,   8,   9,  13,  15,  24 }
Part[  25] = {   3,   4,   5,   6,  11,  20,  24 }
Part[  26] = {   3,   6,   7,   8,  27 }
Part[  27] = {   3,   6,   7,  12,  24 }
Part[  28] = {   3,   4,   5,   7 }
Part[  29] = {   3,   5,   6,   7 }
Part[  30] = {   3,   4,   7,   9 }
Part[  31] = {   3,   4,   6,  26 }
Part[  32] = {  20,  21,  22 }
Part[  33] = {   5,  14,  21 }
Part[  34] = {   3,  11,  25 }
Part[  35] = {   3,   6,  25 }
Part[  36] = {   4,  19,  20 }
Part[  37] = {   3,   7,  19 }
Part[  38] = {   1,   2,  16 }
Part[  39] = {   9,  11,  12,  13,  14 }
Part[  40] = {   9,  11,  12,  13,  25 }
Part[  41] = {   8,  11,  13,  14 }
Part[  42] = {  12,  13,  21,  24 }
Part[  43] = {  11,  13,  24 }
Part[  44] = {  11,  14,  16,  17 }
Part[  45] = {   9,  11,  16,  17 }
Part[  46] = {   8,  24,  25 }
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2
              1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
            < Machines >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 1 0 0 1 1 1 2 0 0 1 1 0 2 2 2 1 2 2 2 1 1 1 2 0 2 2 2
< Parts >     3 4 5 8 1 2 1 2 3 4 8 9 0 5 7 7 1 2 9 0 3 6 6 7 4 8 6 5 3 4
=========== * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
(   1)  14  * 1 1 1                 1 1         1                         *
(   2)  17  * 1   1 1               1                           1       1 *
(   3)  18  * 1 1 1                 1                                 1   *
(   4)  19  * 1 1 1 1                     1                             *
(   5)  20  * 1 1 1 1               1                                   *
(   6)  21  * 1 1 1 1                                                 1 * *
(   7)  22  * 1 1 1               1             1                       *
(   8)  23  * 1 1 1               1 1                                   *
(   9)  25  * 1 1 1         1     1                       1             1 *
```

```
(  10)  28  * 1 1 1                         1                           *
(  11)  29  * 1   1                         1                       1   *
(  12)  30  * 1 1                       1   1                           *
(  13)  31  * 1 1                                               1       1   *
(  14)  37  * 1                             1       1                   *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  15)  38  *         1 1                                       1       *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  16)  27  * 1             1   1         1                           1   *
(  17)  39  *             1 1 1     1                           1       *
(  18)  40  *             1 1 1     1                               1   *
(  19)  41  *             1   1   1                           1       *
(  20)  42  *               1 1 1             1                       *
(  21)  43  *             1   1 1                                     *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  22)   1  *             1       1 1 1 1         1           1       *
(  23)   2  *         1 1 1       1 1 1 1                             *
(  24)   3  *                     1   1 1       1 1                   *
(  25)   4  *         1           1 1 1                   1             *
(  26)   5  *                     1 1 1               1   1             *
(  27)   6  *     1               1 1           1   1                   *
(  28)   7  *     1   1           1 1           1                       *
(  29)  12  *         1           1   1                       1         *
(  30)  13  * 1           1   1   1 1     1                       1   *
(  31)  15  * 1 1                 1 1 1                               *
(  32)  16  * 1                   1 1 1                           1   *
(  33)  24  * 1 1               1 1 1 1   1                             *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  34)  26  * 1                   1       1 1                     1   *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  35)  11  *     1                           1 1 1                   *
(  36)  32  *                                 1 1   1                 *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  37)   8  *                     1           1   1 1                 *
(  38)   9  *                     1 1             1 1                 *
(  39)  10  *                                 1   1 1       1         *
(  40)  36  *   1                               1 1                   *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  41)  44  *             1                               1 1 1       *
(  42)  45  *             1         1                     1 1         *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  43)  33  *     1                           1               1       *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  44)  34  * 1           1                                       1   *
(  45)  35  * 1                                                1 1   *
(  46)  46  *                   1 1                             1   *
=========== * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
```

```
< Machine cells and Part families  >
============================================================
Machine Cell[ 1] = { 3, 4, 5, 18 }
Machine Cell[ 2] = { 1, 2 }
Machine Cell[ 3] = { 11, 12, 13, 24 }
Machine Cell[ 4] = { 8, 9, 10, 15 }
Machine Cell[ 5] = { 7, 27 }
Machine Cell[ 6] = { 21, 22 }
Machine Cell[ 7] = { 19, 20 }
Machine Cell[ 8] = { 23, 26 }  --> Residual cell
Machine Cell[ 9] = { 16, 17 }
Machine Cell[10] = { 14, 28 }
Machine Cell[11] = { 6, 25 }
============================================================
Part  Family[ 1] = { 14, 17, 18, 19, 20, 21, 22, 23, 25, 28, 29, 30, 31, 37 }
Part  Family[ 2] = { 38 }
Part  Family[ 3] = { 27, 39, 40, 41, 42, 43 }
Part  Family[ 4] = { 1, 2, 3, 4, 5, 6, 7, 12, 13, 15, 16, 24 }
Part  Family[ 5] = { 26 }
Part  Family[ 6] = { 11, 32 }
Part  Family[ 7] = { 8, 9, 10, 36 }
Part  Family[ 8] --> Empty Part family
```

```
Part  Family[ 9] = { 44, 45 }
Part  Family[10] = { 33 }
Part  Family[11] = { 34, 35, 46 }
============================================================

< Summary of the performance measures >
============================================================
No. of machines                              = 28
No. of part types                            = 46
No. of cells                                 = 11
Machine cell size                            = 4
Total no. of 1's in the original MPIM : |A|  = 211
Matrix density                               = 0.164
Total no. of within-block 1's                = 115
No. of exceptional elements (EEs)            = 96
No. of voids                                 = 41
Sum of EEs and voids                         = 137
Group Cability Index (GCI)                   = 54.50 %
grouping efficiency (GE)                     = 82.62 %
Grouping efficacy (GF)                       = 45.63 %
Machine utilization (MU)                     = 73.72 %
No. of redundant machines (RMs)              = 3
============================================================
```

Problem(88) --> Data file name : DC_19_KumarVannelli(1987)_30x41.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   8,  19,  20,  29,  30 }
Part[   2] = {  10,  23 }
Part[   3] = {   9,  19,  20,  29,  30 }
Part[   4] = {  14,  25 }
Part[   5] = {   5,  14 }
Part[   6] = {   6,  16 }
Part[   7] = {   4,  17 }
Part[   8] = {   8,  27,  28 }
Part[   9] = {   8,  29 }
Part[  10] = {   1,  11,  21,  22 }
Part[  11] = {   2,  12 }
Part[  12] = {   2,   3,  10,  12,  21,  22,  23 }
Part[  13] = {   9,  29 }
Part[  14] = {   8,  18 }
Part[  15] = {   4,  27 }
Part[  16] = {   7,  17,  18,  26 }
Part[  17] = {   5,  15 }
Part[  18] = {   2,  12,  13,  14 }
Part[  19] = {  12 }
Part[  20] = {  10 }
Part[  21] = {   9,  19,  20,  29,  30 }
Part[  22] = {  19,  20,  30 }
Part[  23] = {   3,  10,  12,  22,  23 }
Part[  24] = {   4,  12 }
Part[  25] = {   4,  13 }
Part[  26] = {   6,  14 }
Part[  27] = {   7,  17,  18,  26 }
Part[  28] = {   4,  16 }
Part[  29] = {   8,  28 }
Part[  30] = {  19,  29 }
Part[  31] = {   1,   3,  21,  22,  23 }
Part[  32] = {   1,   2,   3,  21,  22 }
Part[  33] = {   1,   2,  11,  21 }
Part[  34] = {   5,   7,  18,  26 }
Part[  35] = {   4,  28 }
Part[  36] = {   5,   7,  17,  26 }
Part[  37] = {  14,  15 }
Part[  38] = {  13,  24 }
Part[  39] = {   1,   2,   3,  10,  11,  12,  22,  23 }
Part[  40] = {   3,  12,  21,  22 }
Part[  41] = {   1,   2,  11 }
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 3
              1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
            < Machines >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 1 0 2 0 1 0 2 0 1 1 2 1 2 3 0 1 1 2 1 2 0 0 1 2 2 0 2 1 2
< Parts >     2 2 9 9 5 5 8 8 6 6 3 4 9 0 0 7 7 8 6 0 3 1 3 1 1 2 4 7 4 5
============ * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
(   1)  11  * 1 1                                                           *
(   2)  18  * 1 1                   1                                   1   *
(   3)  19  *   1                                                           *
(   4)  24  *   1                                                       1   *
============ * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(   5)   9  *       1     1                                                 *
(   6)  13  *     1 1                                                       *
============ * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(   7)   5  *         1                                                 1   *
(   8)  17  *         1 1                                                   *
============ * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(   9)   8  *             1 1                                           1   *
(  10)  14  *             1                       1                         *
(  11)  29  *             1 1                                               *
```

```
(  12)  35  *               1                                       1       *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  13)   6  *                 1 1                                           *
(  14)  26  *                 1                                       1   *
(  15)  28  *                   1                                     1     *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  16)  25  *                     1                                   1     *
(  17)  38  *                     1 1                                       *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  18)   1  *       1     1           1 1 1                                 *
(  19)   3  *     1 1                 1 1 1                                 *
(  20)  21  *     1 1                 1 1 1                                 *
(  21)  22  *                         1 1 1                                 *
(  22)  30  *       1                 1                                     *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  23)   7  *                               1                       1       *
(  24)  16  *                           1 1 1 1                             *
(  25)  27  *                           1 1 1 1                             *
(  26)  34  *         1                 1   1 1                             *
(  27)  36  *         1                 1 1   1                             *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  28)   2  *                                   1 1                         *
(  29)  20  *                                   1                           *
(  30)  23  *   1                               1 1   1     1               *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  31)  10  *                                       1   1 1 1               *
(  32)  12  * 1 1                               1 1   1   1 1               *
(  33)  31  *                                     1 1 1   1 1               *
(  34)  32  * 1                                     1 1   1 1               *
(  35)  33  * 1                                     1   1 1                 *
(  36)  39  * 1 1                               1 1 1 1 1   1               *
(  37)  40  *   1                                     1   1 1               *
(  38)  41  * 1                                     1   1                   *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  39)  15  *                                                   1 1         *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  40)   4  *                                                       1 1 *
(  41)  37  *           1                                           1   *
=========== * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
```

```
< Machine cells and Part families  >
============================================================
Machine Cell[ 1] = { 2, 12 }
Machine Cell[ 2] = { 9, 29 }
Machine Cell[ 3] = { 5, 15 }
Machine Cell[ 4] = { 8, 28 }
Machine Cell[ 5] = { 6, 16 }
Machine Cell[ 6] = { 13, 24 }
Machine Cell[ 7] = { 19, 20, 30 }
Machine Cell[ 8] = { 7, 17, 18, 26 }
Machine Cell[ 9] = { 10, 23 }
Machine Cell[10] = { 1, 3, 11, 21, 22 }
Machine Cell[11] = { 4, 27 }
Machine Cell[12] = { 14, 25 }
============================================================
Part  Family[ 1] = { 11, 18, 19, 24 }
Part  Family[ 2] = { 9, 13 }
Part  Family[ 3] = { 5, 17 }
Part  Family[ 4] = { 8, 14, 29, 35 }
Part  Family[ 5] = { 6, 26, 28 }
Part  Family[ 6] = { 25, 38 }
Part  Family[ 7] = { 1, 3, 21, 22, 30 }
Part  Family[ 8] = { 7, 16, 27, 34, 36 }
Part  Family[ 9] = { 2, 20, 23 }
Part  Family[10] = { 10, 12, 31, 32, 33, 39, 40, 41 }
Part  Family[11] = { 15 }
Part  Family[12] = { 4, 37 }
============================================================

< Summary of the performance measures >
============================================================
```

```
No. of machines                                  = 30
No. of part types                                = 41
No. of cells                                     = 12
Machine cell size                                = 5
Total no. of 1's in the original MPIM : |A|      = 128
Matrix density                                   = 0.104
Total no. of within-block 1's                    = 90
No. of exceptional elements (EEs)                = 38
No. of voids                                     = 31
Sum of EEs and voids                             = 69
Group Cability Index (GCI)                       = 70.31 %
grouping efficiency (GE)                         = 85.48 %
Grouping efficacy (GF)                           = 56.60 %
Machine utilization (MU)                         = 74.38 %
No. of redundant machines (RMs)                  = 0
============================================================
```

Problem(89) --> Data file name : DC_20_Stanfel(1985)_Figure_5_30x50.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   1,   4,   5,   9,  11,  13 }
Part[   2] = {   2,   3,   5,   9 }
Part[   3] = {   2,   5,   9,  12 }
Part[   4] = {   3,   7,  10,  11 }
Part[   5] = {   1,   6,   8,  13 }
Part[   6] = {   1,   3,   9,  10,  13 }
Part[   7] = {   4,   5,   8,  10,  11,  12 }
Part[   8] = {   1,   3,  12 }
Part[   9] = {   2,   6,   7,  10,  13 }
Part[  10] = {   5,  10 }
Part[  11] = {   3,   5,  10 }
Part[  12] = {   7,   8 }
Part[  13] = {   6,   7,   8 }
Part[  14] = {   6,   8,  12 }
Part[  15] = {   6,   8,  12 }
Part[  16] = {   6,   8,  12 }
Part[  17] = {   2,   9,  13 }
Part[  18] = {   1,   4,  10,  11 }
Part[  19] = {  14,  16 }
Part[  20] = {  14,  15,  17 }
Part[  21] = {  14,  16 }
Part[  22] = {  15,  16 }
Part[  23] = {  14,  16,  17 }
Part[  24] = {  15,  17 }
Part[  25] = {  14,  15,  17 }
Part[  26] = {  14,  16 }
Part[  27] = {  15,  16 }
Part[  28] = {  18,  19,  20 }
Part[  29] = {  19,  20,  23 }
Part[  30] = {  18,  21,  22 }
Part[  31] = {  19,  21,  23 }
Part[  32] = {  20,  21,  22 }
Part[  33] = {  19,  21,  23 }
Part[  34] = {  18,  19,  22 }
Part[  35] = {  20,  22,  23 }
Part[  36] = {  18,  20,  21 }
Part[  37] = {  18,  20,  22 }
Part[  38] = {  19,  21,  23 }
Part[  39] = {  24,  28,  29,  30 }
Part[  40] = {  27,  29,  30 }
Part[  41] = {  25,  27,  29 }
Part[  42] = {  24,  25,  30 }
Part[  43] = {  26,  28 }
Part[  44] = {  24,  27,  30 }
Part[  45] = {  25,  28,  29 }
Part[  46] = {  26,  30 }
Part[  47] = {  27,  28 }
Part[  48] = {  24,  29,  30 }
Part[  49] = {  25,  26,  27 }
Part[  50] = {  25,  29 }
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 3
              1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
            < Machines >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 1 1 1 1 2 2 2 2 2 0 0 1 2 2 0 0 1 1 2 2 2 3 0 0 1 1 0 1
< Parts >     6 8 2 4 6 9 1 3 5 7 9 1 3 0 6 8 4 5 1 8 0 2 4 0 2 9 5 7 7 3
=========== * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
(   1)   5  * 1 1                     1                                                   1 *
(   2)  12  *   1                                                                     1   *
(   3)  13  * 1 1                                                                     1   *
(   4)  14  * 1 1 1                                                                       *
(   5)  15  * 1 1 1                                                                       *
```

```
(   6)  16  * 1 1 1                                                       *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(   7)  19  *       1 1                                                   *
(   8)  21  *       1 1                                                   *
(   9)  22  *         1                                             1     *
(  10)  23  *       1 1                                               1   *
(  11)  26  *       1 1                                                   *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  12)  29  *           1   1                       1                     *
(  13)  31  *           1 1 1                                             *
(  14)  33  *           1 1 1                                             *
(  15)  38  *           1 1 1                                             *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  16)  40  *                   1 1                         1             *
(  17)  41  *                 1 1 1                                       *
(  18)  45  *                 1   1         1                             *
(  19)  49  *                 1 1       1                                 *
(  20)  50  *                 1   1                                       *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  21)   4  *                       1 1         1                   1   *
(  22)   6  *                     1 1 1                       1       1 *
(  23)   8  *     1               1 1                                     *
(  24)  10  *                       1       1                           *
(  25)  11  *                       1 1     1                           *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  26)  43  *                           1 1                             *
(  27)  46  *                           1               1               *
(  28)  47  *                   1         1                             *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  29)   1  *                     1       1 1 1               1       1 *
(  30)   7  *   1 1                   1     1 1 1                       *
(  31)  18  *                     1   1     1   1                       *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  32)  28  *           1                       1 1                     *
(  33)  30  *             1                     1   1                   *
(  34)  32  *             1                       1 1                   *
(  35)  34  *           1                       1   1                   *
(  36)  35  *               1                     1 1                   *
(  37)  36  *             1                       1 1                   *
(  38)  37  *                                     1 1 1                 *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  39)  39  *                     1       1           1 1               *
(  40)  42  *                   1                     1 1               *
(  41)  44  *                     1                   1 1               *
(  42)  48  *                       1                 1 1               *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  43)   2  *                         1       1           1 1           *
(  44)   3  *     1                           1           1 1           *
(  45)  17  *                                           1 1       1   *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  46)  20  *       1                                       1 1         *
(  47)  24  *                                               1 1         *
(  48)  25  *       1                                       1 1         *
(  49)  27  *         1                                     1           *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  50)   9  * 1                       1                   1       1 1 *
=========== * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

< Machine cells and Part families  >
============================================================
Machine Cell[ 1] = { 6, 8, 12 }
Machine Cell[ 2] = { 14, 16 }
Machine Cell[ 3] = { 19, 21, 23 }
Machine Cell[ 4] = { 25, 27, 29 }
Machine Cell[ 5] = { 1, 3, 10 }
Machine Cell[ 6] = { 26, 28 }
Machine Cell[ 7] = { 4, 5, 11 }
Machine Cell[ 8] = { 18, 20, 22 }
Machine Cell[ 9] = { 24, 30 }
Machine Cell[10] = { 2, 9 }
Machine Cell[11] = { 15, 17 }
```

```
Machine Cell[12] = { 7, 13 }
============================================================
Part  Family[ 1] = { 5, 12, 13, 14, 15, 16 }
Part  Family[ 2] = { 19, 21, 22, 23, 26 }
Part  Family[ 3] = { 29, 31, 33, 38 }
Part  Family[ 4] = { 40, 41, 45, 49, 50 }
Part  Family[ 5] = { 4, 6, 8, 10, 11 }
Part  Family[ 6] = { 43, 46, 47 }
Part  Family[ 7] = { 1, 7, 18 }
Part  Family[ 8] = { 28, 30, 32, 34, 35, 36, 37 }
Part  Family[ 9] = { 39, 42, 44, 48 }
Part  Family[10] = { 2, 3, 17 }
Part  Family[11] = { 20, 24, 25, 27 }
Part  Family[12] = { 9 }
============================================================

< Summary of the performance measures >
============================================================
No. of machines                              = 30
No. of part types                            = 50
No. of cells                                 = 12
Machine cell size                            = 3
Total no. of 1's in the original MPIM : |A|  = 154
Matrix density                               = 0.103
Total no. of within-block 1's                = 105
No. of exceptional elements (EEs)            = 49
No. of voids                                 = 25
Sum of EEs and voids                         = 74
Group Cability Index (GCI)                   = 68.18 %
grouping efficiency (GE)                     = 88.60 %
Grouping efficacy (GF)                       = 58.66 %
Machine utilization (MU)                     = 80.77 %
No. of redundant machines (RMs)              = 0
============================================================
```

Problem(90) --> Data file name : DC_21_Stanfel(1985)_Figure_6_30x50.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   3,   8,  19,  25 }
Part[   2] = {   5,   6,  10,  13 }
Part[   3] = {   5,  10,  13 }
Part[   4] = {   3,   8,  25 }
Part[   5] = {  17,  18,  20,  21 }
Part[   6] = {  18,  20,  23 }
Part[   7] = {  17,  20,  21 }
Part[   8] = {   1,   9,  11,  13 }
Part[   9] = {   1,  11,  13 }
Part[  10] = {  15,  26,  28 }
Part[  11] = {   5,  13 }
Part[  12] = {  15,  17,  20 }
Part[  13] = {  22,  24,  26,  27 }
Part[  14] = {  21,  28 }
Part[  15] = {  22,  24,  27 }
Part[  16] = {   3,  25,  30 }
Part[  17] = {   2,   4,   6,  26,  29 }
Part[  18] = {  15,  28 }
Part[  19] = {   2,   7,  12,  14 }
Part[  20] = {   2,  12,  14,  26 }
Part[  21] = {   1,   9,  16,  19,  23 }
Part[  22] = {   4,   6,   9 }
Part[  23] = {  10,  11,  12,  29 }
Part[  24] = {  10,  12,  29 }
Part[  25] = {  11,  12,  29 }
Part[  26] = {  18,  19,  20 }
Part[  27] = {  18,  20 }
Part[  28] = {   7,  17,  19 }
Part[  29] = {   7,   8,  20 }
Part[  30] = {   7,  17,  19 }
Part[  31] = {  14,  16,  23,  26 }
Part[  32] = {   4,  14,  16 }
Part[  33] = {   4,   8,  25 }
Part[  34] = {   1,   3,   4,  23,  24,  26,  27 }
Part[  35] = {  16,  21,  26,  30 }
Part[  36] = {   9,  11,  25 }
Part[  37] = {  10,  17 }
Part[  38] = {   2 }
Part[  39] = {   3,   6,  10,  16,  21,  23,  30 }
Part[  40] = {  13,  15,  25,  28 }
Part[  41] = {   7,   9,  11,  24 }
Part[  42] = {   8 }
Part[  43] = {   1,   4,  19,  27 }
Part[  44] = {  12,  13,  14,  17 }
Part[  45] = {   8,  21,  25,  28 }
Part[  46] = {   2,  10,  15,  19,  23 }
Part[  47] = {  10,  19 }
Part[  48] = {   6,  14 }
Part[  49] = {   3,   9 }
Part[  50] = {  15,  17,  19 }
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 3
              1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
            < Machines >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 1 1 1 2 2 0 1 1 2 2 1 2 1 3 2 2 2 0 0 2 0 0 1 0 0 0 1 1 2
< Parts >     5 3 0 9 3 6 7 7 8 0 1 2 9 6 0 2 4 7 3 8 5 1 9 1 2 4 6 4 5 8
=========== * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
(   1)   2  * 1 1 1                                                       1       *
(   2)   3  * 1 1 1                                                               *
(   3)  11  * 1 1                                                                 *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(   4)  37  *     1         1                                                     *
```

```
(   5)  46  *     1 1 1                                                 1       1   *
(   6)  47  *     1 1                                                               *
(   7)  50  *       1       1                                                     1   *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(   8)  31  *         1 1                   1                                 1     *
(   9)  34  *         1 1                           1 1 1     1       1             *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  10)   5  *               1 1 1 1                                               *
(  11)   6  *         1       1 1                                                 *
(  12)   7  *               1   1 1                                               *
(  13)  12  *               1   1                                             1   *
(  14)  26  *       1         1 1                                                 *
(  15)  27  *                 1 1                                                 *
(  16)  28  *       1     1 1                                                     *
(  17)  29  *             1   1                   1                               *
(  18)  30  *       1     1 1                                                     *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  19)  23  *     1                 1 1                       1                   *
(  20)  24  *     1                 1 1                                           *
(  21)  25  *                       1 1                       1                   *
(  22)  44  *   1           1       1                                     1       *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  23)  35  *           1         1     1 1                                       *
(  24)  39  *     1   1           1     1 1       1                       1       *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  25)  13  *           1                     1 1 1                               *
(  26)  15  *                                 1 1 1                               *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  27)   1  *       1                               1 1 1                         *
(  28)   4  *                                       1 1 1                         *
(  29)  16  *                           1           1   1                         *
(  30)  33  *                                         1 1         1               *
(  31)  42  *                                         1                           *
(  32)  45  *                     1                   1 1                   1 1   *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  33)   8  *   1                                         1 1 1                   *
(  34)   9  *   1                                         1   1                   *
(  35)  21  *       1 1                   1                 1 1                   *
(  36)  36  *                                       1     1 1                     *
(  37)  41  *             1                   1           1 1                     *
(  38)  43  *       1                               1       1       1             *
(  39)  49  *                                       1       1                     *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  40)  17  *           1             1                       1 1 1               *
(  41)  19  *             1         1                         1     1             *
(  42)  20  *           1           1                         1     1             *
(  43)  22  *                                               1     1 1             *
(  44)  32  *                         1                       1   1               *
(  45)  38  *                                                 1                   *
(  46)  48  *                                                     1 1             *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  47)  10  *           1                                                   1 1   *
(  48)  14  *                     1                                           1   *
(  49)  18  *                                                               1 1   *
(  50)  40  *   1                                   1                       1 1   *
=========== * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

< Machine cells and Part families  >
============================================================
Machine Cell[ 1] = { 5, 13 }
Machine Cell[ 2] = { 10, 19 }
Machine Cell[ 3] = { 23, 26 }
Machine Cell[ 4] = { 7, 17, 18, 20, 21 }
Machine Cell[ 5] = { 12, 29 }
Machine Cell[ 6] = { 16, 30 }
Machine Cell[ 7] = { 22, 24, 27 }
Machine Cell[ 8] = { 3, 8, 25 }
Machine Cell[ 9] = { 1, 9, 11 }
Machine Cell[10] = { 2, 4, 6, 14 }
Machine Cell[11] = { 15, 28 }
============================================================
```

```
Part  Family[ 1] = { 2, 3, 11 }
Part  Family[ 2] = { 37, 46, 47, 50 }
Part  Family[ 3] = { 31, 34 }
Part  Family[ 4] = { 5, 6, 7, 12, 26, 27, 28, 29, 30 }
Part  Family[ 5] = { 23, 24, 25, 44 }
Part  Family[ 6] = { 35, 39 }
Part  Family[ 7] = { 13, 15 }
Part  Family[ 8] = { 1, 4, 16, 33, 42, 45 }
Part  Family[ 9] = { 8, 9, 21, 36, 41, 43, 49 }
Part  Family[10] = { 17, 19, 20, 22, 32, 38, 48 }
Part  Family[11] = { 10, 14, 18, 40 }
============================================================

< Summary of the performance measures >
============================================================
No. of machines                              = 30
No. of part types                            = 50
No. of cells                                 = 11
Machine cell size                            = 5
Total no. of 1's in the original MPIM : |A|  = 167
Matrix density                               = 0.111
Total no. of within-block 1's                = 101
No. of exceptional elements (EEs)            = 66
No. of voids                                 = 55
Sum of EEs and voids                         = 121
Group Cability Index (GCI)                   = 60.48 %
grouping efficiency (GE)                     = 79.92 %
Grouping efficacy (GF)                       = 45.50 %
Machine utilization (MU)                     = 64.74 %
No. of redundant machines (RMs)              = 0
============================================================
```

Problem(90) --> Data file name : DC_22_KingNakornchai(1982)_30x90.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {  28 }
Part[   2] = {  20,  26 }
Part[   3] = {  26 }
Part[   4] = {   4,  26 }
Part[   5] = {  26,  27 }
Part[   6] = {  26 }
Part[   7] = {  26 }
Part[   8] = {  11,  19,  21,  22,  24,  30 }
Part[   9] = {   3,  19,  22,  26,  28,  30 }
Part[  10] = {  25 }
Part[  11] = {   7,  25,  26,  27,  28 }
Part[  12] = {  27 }
Part[  13] = {  26,  27,  28 }
Part[  14] = {   3,  29 }
Part[  15] = {  11,  17,  19,  22,  24 }
Part[  16] = {   1,  28 }
Part[  17] = {  20 }
Part[  18] = {  10 }
Part[  19] = {  25,  26 }
Part[  20] = {  22 }
Part[  21] = {  11,  17,  19,  21,  22,  24,  30 }
Part[  22] = {  11,  17,  19,  21,  22,  24,  30 }
Part[  23] = {   4 }
Part[  24] = {   3 }
Part[  25] = {  26,  28 }
Part[  26] = {  18 }
Part[  27] = {  23,  26,  28,  29 }
Part[  28] = {   7,  25,  27 }
Part[  29] = {   4,  26,  28 }
Part[  30] = {  11,  22 }
Part[  31] = {  26,  27,  28 }
Part[  32] = {  29 }
Part[  33] = {  22,  28 }
Part[  34] = {   1 }
Part[  35] = {   6,  20 }
Part[  36] = {   7,   8,  25,  26,  27 }
Part[  37] = {   3,  26 }
Part[  38] = {   4 }
Part[  39] = {   7 }
Part[  40] = {   3,   9,  11,  17,  19,  21,  24 }
Part[  41] = {   1,   7,  25,  26,  27,  28 }
Part[  42] = {  20,  26 }
Part[  43] = {   4,  26,  28 }
Part[  44] = {   3 }
Part[  45] = {  30 }
Part[  46] = {  26,  27 }
Part[  47] = {   3,  29 }
Part[  48] = {   4,  20,  30 }
Part[  49] = {   4,  25,  26,  27 }
Part[  50] = {   1,  26 }
Part[  51] = {  11,  17,  19 }
Part[  52] = {   4,  21,  30 }
Part[  53] = {  29 }
Part[  54] = {  26,  27,  28 }
Part[  55] = {  14,  20,  25,  26,  29 }
Part[  56] = {   3,   9,  11,  17,  21 }
Part[  57] = {  28,  29 }
Part[  58] = {   3,  26 }
Part[  59] = {   3,  14,  16 }
Part[  60] = {  23,  26,  28 }
Part[  61] = {  25,  27 }
Part[  62] = {  11,  16,  19 }
Part[  63] = {  11,  17,  20,  26 }
Part[  64] = {   3,   9,  11,  17,  21 }
Part[  65] = {   3,  14,  16,  19,  24,  28 }
Part[  66] = {   3,  26,  29 }
Part[  67] = {   3,  14,  17,  30 }
```

```
Part[  68] = {  11,  17,  19 }
Part[  69] = {   4,   9,  21,  26,  28 }
Part[  70] = {  14,  28,  30 }
Part[  71] = {   3,  14,  28,  30 }
Part[  72] = {  26,  27,  28 }
Part[  73] = {  10,  11,  17,  19,  21 }
Part[  74] = {   4,  22,  28 }
Part[  75] = {   8,  26 }
Part[  76] = {   9,  11,  17,  19,  21,  24 }
Part[  77] = {   1,   9,  14,  17,  19,  20,  24 }
Part[  78] = {  15,  20,  21,  26 }
Part[  79] = {  12,  17,  20,  21,  24,  26,  28,  30 }
Part[  80] = {  13,  24,  29 }
Part[  81] = {   3,   5,  11,  15,  22,  25,  30 }
Part[  82] = {  13,  24,  29,  30 }
Part[  83] = {   3,   4,  15,  16,  22,  25 }
Part[  84] = {   6,  16,  20,  26,  27,  28 }
Part[  85] = {   3,   5,  11,  15,  22,  25,  30 }
Part[  86] = {   4,  12,  15,  16,  21,  28 }
Part[  87] = {   3,  14,  17,  20,  21 }
Part[  88] = {  14,  15,  17,  19,  20,  21 }
Part[  89] = {   3,  14,  16,  19,  21,  24 }
Part[  90] = {   2,  14,  17,  19,  20,  21,  24,  26 }
```

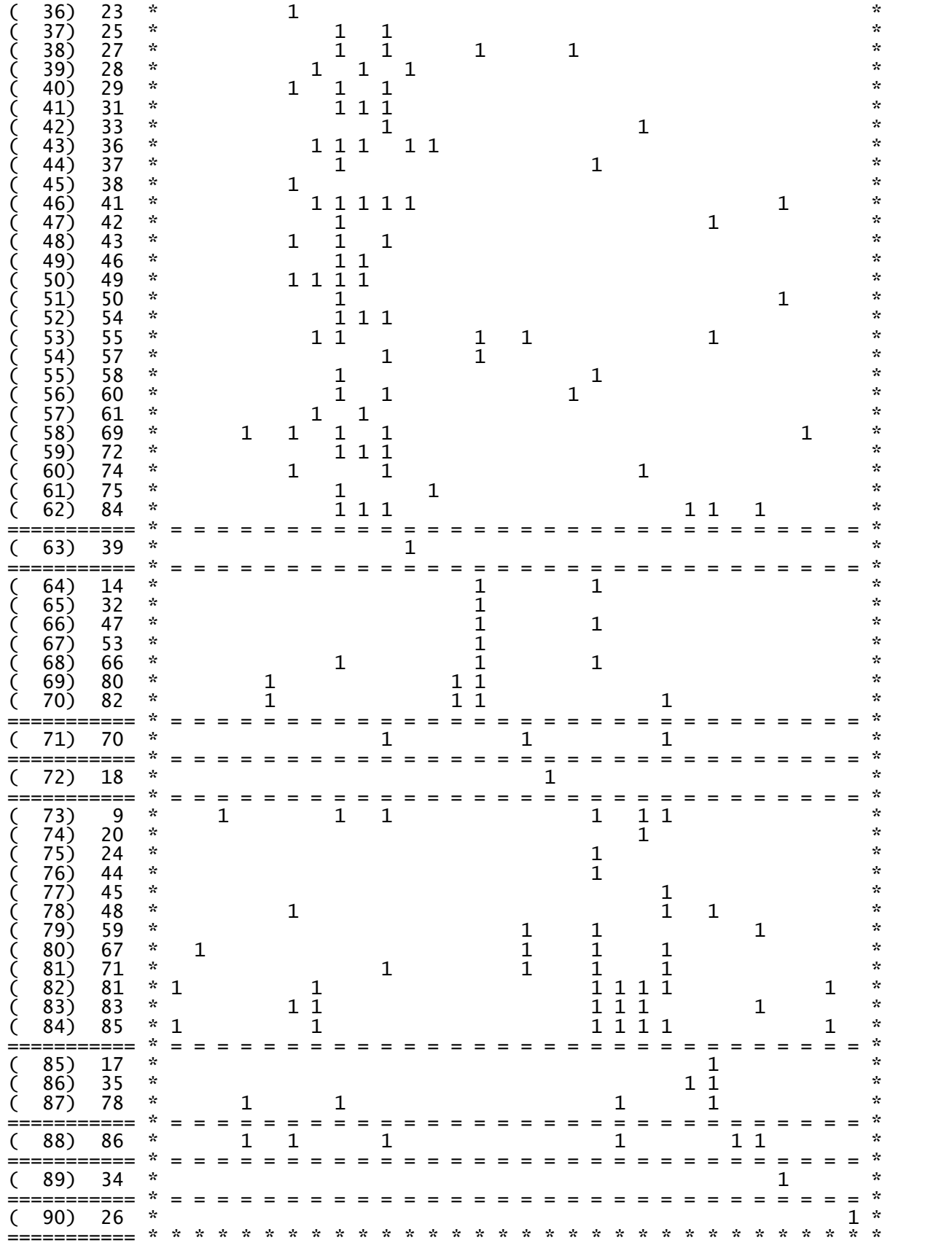
< Block Diagonal Solution Matrix >

< Locations >

	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	3
	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0

< Machines >

	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1	1	1	2	2	0	2	2	2	2	0	0	1	2	0	1	1	2	0	1	2	3	0	2	1	1	0	0	0	1
< Parts >	1	7	9	1	4	4	5	6	7	8	7	8	3	9	2	4	0	3	3	5	2	0	6	0	2	6	1	9	5	8
==========	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
(1) 8	*	1		1	1	1															1	1										*
(2) 15	*	1	1	1		1															1											*
(3) 21	*	1	1	1	1	1															1	1										*
(4) 22	*	1	1	1	1	1															1	1										*
(5) 30	*	1																			1											*
(6) 40	*	1	1	1	1	1													1										1			*
(7) 51	*	1	1	1																												*
(8) 52	*			1		1																1										*
(9) 56	*	1	1		1														1										1			*
(10) 62	*	1		1																						1						*
(11) 63	*	1	1					1																1								*
(12) 64	*	1	1		1														1										1			*
(13) 65	*			1		1				1						1			1							1						*
(14) 68	*	1	1	1																												*
(15) 73	*	1	1	1	1												1															*
(16) 76	*	1	1	1	1	1																							1			*
(17) 77	*		1	1		1										1								1			1	1				*
(18) 79	*		1		1	1		1		1													1		1	1						*
(19) 87	*		1		1											1			1						1							*
(20) 88	*		1	1	1											1				1					1							*
(21) 89	*			1	1	1										1			1							1						*
(22) 90	*		1	1	1	1			1						1	1								1								*
==========	*	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	*
(23) 1	*									1																							*
(24) 2	*							1																1								*
(25) 3	*							1																								*
(26) 4	*					1		1																								*
(27) 5	*							1	1																							*
(28) 6	*							1																								*
(29) 7	*							1																								*
(30) 10	*						1																									*
(31) 11	*						1	1	1	1	1																					*
(32) 12	*								1																							*
(33) 13	*							1	1	1																						*
(34) 16	*									1																			1			*
(35) 19	*						1	1																								*



```
< Machine cells and Part families  >
============================================================
Machine Cell[ 1] = { 11, 17, 19, 21, 24 }
Machine Cell[ 2] = { 4, 25, 26, 27, 28 }
Machine Cell[ 3] = { 7, 8 }
```

```
Machine Cell[ 4] = { 13, 29 }
Machine Cell[ 5] = { 2, 14 }
Machine Cell[ 6] = { 10, 23 }
Machine Cell[ 7] = { 3, 15, 22, 30 }
Machine Cell[ 8] = { 6, 20 }
Machine Cell[ 9] = { 12, 16 }
Machine Cell[10] = { 1, 9 }
Machine Cell[11] = { 5, 18 }
============================================================
Part  Family[ 1] = { 8, 15, 21, 22, 30, 40, 51, 52, 56, 62, 63, 64, 65, 68, 73,
76, 77, 79, 87, 88, 89, 90 }
Part  Family[ 2] = { 1, 2, 3, 4, 5, 6, 7, 10, 11, 12, 13, 16, 19, 23, 25, 27,
28, 29, 31, 33, 36, 37, 38, 41, 42, 43, 46, 49, 50, 54, 55, 57, 58, 60, 61, 69,
72, 74, 75, 84 }
Part  Family[ 3] = { 39 }
Part  Family[ 4] = { 14, 32, 47, 53, 66, 80, 82 }
Part  Family[ 5] = { 70 }
Part  Family[ 6] = { 18 }
Part  Family[ 7] = { 9, 20, 24, 44, 45, 48, 59, 67, 71, 81, 83, 85 }
Part  Family[ 8] = { 17, 35, 78 }
Part  Family[ 9] = { 86 }
Part  Family[10] = { 34 }
Part  Family[11] = { 26 }
============================================================

< Summary of the performance measures >
============================================================
No. of machines                          = 30
No. of part types                        = 90
No. of cells                             = 11
Machine cell size                        = 6
Total no. of 1's in the original MPIM : |A| = 302
Matrix density                           = 0.112
Total no. of within-block 1's            = 192
No. of exceptional elements (EEs)        = 110
No. of voids                             = 198
Sum of EEs and voids                     = 308
Group Cability Index (GCI)               = 63.58 %
grouping efficiency (GE)                 = 72.23 %
Grouping efficacy (GF)                   = 38.40 %
Machine utilization (MU)                 = 49.23 %
No. of redundant machines (RMs)          = 5
============================================================
```

Problem(92) --> Data file name : DC_23_DeWitte(1980)_12x19.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   1,   4,   8,   9 }
Part[   2] = {   1,   2,   6,   4,   8,   7 }
Part[   3] = {   1,   2,   4,   7,   8,   9 }
Part[   4] = {   1,   4,   7,   9 }
Part[   5] = {   1,   6,  10,   7,   9 }
Part[   6] = {   6,  10,   7,   8,   9 }
Part[   7] = {   6,   4,   8,   9 }
Part[   8] = {   3,   5,   2,   6,   4,   8,   9 }
Part[   9] = {   3,   5,   6,   4,   8,   9 }
Part[  10] = {   3,   6,   4,   8 }
Part[  11] = {   6,  12 }
Part[  12] = {  11,   7,  12 }
Part[  13] = {  11,  10,   7,  12 }
Part[  14] = {  11,   7,  10 }
Part[  15] = {  11,  10 }
Part[  16] = {  11,  12 }
Part[  17] = {  11,   7,  12 }
Part[  18] = {   6,   7,  10 }
Part[  19] = {  10,   7 }
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 1 1 1
              1 2 3 4 5 6 7 8 9 0 1 2
            < Machines >
              0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 1 1 1 0 0
< Parts >     1 4 6 8 9 3 7 0 1 2 2 5
=========== * * * * * * * * * * * * * *
(   1)   1  * 1 1   1 1                 *
(   2)   2  * 1 1 1 1     1       1     *
(   3)   3  * 1 1   1 1   1       1     *
(   4)   4  * 1 1     1   1             *
(   5)   5  * 1   1   1   1 1           *
(   6)   6  *     1 1 1   1 1           *
(   7)   7  *   1 1 1 1                 *
(   8)   8  *   1 1 1 1 1           1 1 *
(   9)   9  *   1 1 1 1 1             1 *
(  10)  10  *   1 1 1   1               *
=========== * = = = = = = = = = = = = = *
(  11)  11  *     1               1     *
(  12)  12  *               1   1 1     *
(  13)  13  *               1 1 1 1     *
(  14)  14  *               1 1 1       *
(  15)  15  *                 1 1       *
(  16)  16  *                   1 1     *
(  17)  17  *               1   1 1     *
(  18)  18  *     1         1 1         *
(  19)  19  *               1 1         *
=========== * = = = = = = = = = = = = = *
=========== * * * * * * * * * * * * * *
```

< Machine cells and Part families >

```
Machine Cell[ 1] = { 1, 4, 6, 8, 9 }
Machine Cell[ 2] = { 3, 7, 10, 11, 12 }
Machine Cell[ 3] = { 2, 5 }  --> Residual cell
```

```
Part  Family[ 1] = { 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 }
Part  Family[ 2] = { 11, 12, 13, 14, 15, 16, 17, 18, 19 }
Part  Family[ 3] --> Empty Part family
```

< Summary of the performance measures >

```
No. of machines                                  = 12
No. of part types                                = 19
No. of cells                                     = 3
Machine cell size                                = 5
Total no. of 1's in the original MPIM : |A|      = 75
Matrix density                                   = 0.329
Total no. of within-block 1's                    = 58
No. of exceptional elements (EEs)                = 17
No. of voids                                     = 37
Sum of EEs and voids                             = 54
Group Cability Index (GCI)                       = 77.33 %
grouping efficiency (GE)                         = 74.14 %
Grouping efficacy (GF)                           = 51.79 %
Machine utilization (MU)                         = 61.05 %
No. of redundant machines (RMs)                  = 3
============================================================
```

Problem(93) --> Data file name : DC_24_ChanMilner(1982)_Figure_3a_15x10.cfp

< Machines visited by parts: Process route numbers(PRN) >
```
Part[   1] = {   2,   6,   7,  11,  12 }
Part[   2] = {   5,   9,  10,  13,  15 }
Part[   3] = {   1,   3,   6,  14 }
Part[   4] = {   1,   4,   6,  13,  14 }
Part[   5] = {   8,   9,  10,  13,  15 }
Part[   6] = {   2,   6,   7,  11,  12 }
Part[   7] = {   2,   6,  11,  12 }
Part[   8] = {   1,   3,   4,   6,  11,  14 }
Part[   9] = {   3,   4,   6,  14 }
Part[  10] = {   8,   9,  10,  13,  15 }
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 1 1 1 1 1 1
              1 2 3 4 5 6 7 8 9 0 1 2 3 4 5
            < Machines >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 1 0 0 0 1 1 1 0 0 1 1
< Parts >     1 3 4 6 4 5 8 9 0 3 5 2 7 1 2
========== * * * * * * * * * * * * * * * *
(   1)   3  * 1 1   1 1                     *
(   2)   4  * 1   1 1 1         1           *
(   3)   8  * 1 1 1 1 1                 1   *
(   4)   9  *   1 1 1 1                     *
========== * = = = = = = = = = = = = = = = *
(   5)   2  *           1   1 1 1 1         *
(   6)   5  *             1 1 1 1 1         *
(   7)  10  *             1 1 1 1 1         *
========== * = = = = = = = = = = = = = = = *
(   8)   1  *       1               1 1 1 1 *
(   9)   6  *       1               1 1 1 1 *
(  10)   7  *       1                 1   1 *
========== * * * * * * * * * * * * * * * * *
```

< Machine cells and Part families >
```
Machine Cell[ 1] = { 1, 3, 4, 6, 14 }
Machine Cell[ 2] = { 5, 8, 9, 10, 13, 15 }
Machine Cell[ 3] = { 2, 7, 11, 12 }
```
```
Part  Family[ 1] = { 3, 4, 8, 9 }
Part  Family[ 2] = { 2, 5, 10 }
Part  Family[ 3] = { 1, 6, 7 }
```

< Summary of the performance measures >
```
No. of machines                          = 15
No. of part types                        = 10
No. of cells                             = 3
Machine cell size                        = 6
Total no. of 1's in the original MPIM : |A| = 48
Matrix density                           = 0.32
Total no. of within-block 1's            = 43
No. of exceptional elements (EEs)        = 5
No. of voids                             = 7
Sum of EEs and voids                     = 12
Group Cability Index (GCI)               = 89.58 %
grouping efficiency (GE)                 = 90.50 %
Grouping efficacy (GF)                   = 78.18 %
Machine utilization (MU)                 = 86.00 %
No. of redundant machines (RMs)          = 0
```

Problem(94) --> Data file name : DC_25_Seifoddini(1989)_11x22.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
============================================================
Part[   1] = {   1,   4,   5,  10 }
Part[   2] = {   1,   4,   5,  10 }
Part[   3] = {   1,   4,   5,  10 }
Part[   4] = {   7,   9,  11 }
Part[   5] = {   2,   3,   6,   8,  10 }
Part[   6] = {   3,   7,   8 }
Part[   7] = {   5,  10 }
Part[   8] = {   2,   6,  10 }
Part[   9] = {   7,   8,   9,  11 }
Part[  10] = {   8,  11 }
Part[  11] = {   1,   2,   4,  10 }
Part[  12] = {   2,   3,   6,   8,  10 }
Part[  13] = {   3,   8 }
Part[  14] = {   7,   8,   9 }
Part[  15] = {   1,   4,   5,  10 }
Part[  16] = {   1,   4,   5,  10 }
Part[  17] = {   7,   8,   9,  11 }
Part[  18] = {   7,   8,   9,  10,  11 }
Part[  19] = {   2,   3,   6,   8 }
Part[  20] = {   1,   4,   5 }
Part[  21] = {   1,   4,   5 }
Part[  22] = {   1,   4,   5 }
============================================================
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 1 1
              1 2 3 4 5 6 7 8 9 0 1
            < Machines >
              0 0 0 0 0 0 0 0 0 0 0
              0 0 0 1 0 0 0 1 0 0 0
< Parts >     1 4 5 0 7 8 9 1 2 3 6
=========== * * * * * * * * * * * * *
(   1)   1  * 1 1 1 1                 *
(   2)   2  * 1 1 1 1                 *
(   3)   3  * 1 1 1 1                 *
(   4)   7  *     1 1                 *
(   5)  11  * 1 1   1         1       *
(   6)  15  * 1 1 1 1                 *
(   7)  16  * 1 1 1 1                 *
(   8)  20  * 1 1 1                   *
(   9)  21  * 1 1 1                   *
(  10)  22  * 1 1 1                   *
=========== * = = = = = = = = = = = *
(  11)   4  *         1   1 1         *
(  12)   6  *         1 1         1   *
(  13)   9  *         1 1 1 1         *
(  14)  10  *           1   1         *
(  15)  13  *           1         1   *
(  16)  14  *         1 1 1           *
(  17)  17  *         1 1 1 1         *
(  18)  18  *       1 1 1 1 1         *
=========== * = = = = = = = = = = = *
(  19)   5  *       1   1     1 1 1 *
(  20)   8  *       1         1   1 *
(  21)  12  *       1   1     1 1 1 *
(  22)  19  *           1     1 1 1 *
=========== * * * * * * * * * * * * *
```

< Machine cells and Part families >

```
============================================================
Machine Cell[ 1] = { 1, 4, 5, 10 }
Machine Cell[ 2] = { 7, 8, 9, 11 }
Machine Cell[ 3] = { 2, 3, 6 }
============================================================
Part  Family[ 1] = { 1, 2, 3, 7, 11, 15, 16, 20, 21, 22 }
```

```
Part  Family[ 2] = { 4, 6, 9, 10, 13, 14, 17, 18 }
Part  Family[ 3] = { 5, 8, 12, 19 }
============================================================

< Summary of the performance measures >
============================================================
No. of machines                              = 11
No. of part types                            = 22
No. of cells                                 = 3
Machine cell size                            = 4
Total no. of 1's in the original MPIM : |A|  = 78
Matrix density                               = 0.322
Total no. of within-block 1's                = 68
No. of exceptional elements (EEs)            = 10
No. of voids                                 = 16
Sum of EEs and voids                         = 26
Group Cability Index (GCI)                   = 87.18 %
grouping efficiency (GE)                     = 87.31 %
Grouping efficacy (GF)                       = 72.34 %
Machine utilization (MU)                     = 80.95 %
No. of redundant machines (RMs)              = 0
============================================================
```

Problem(95) --> Data file name : DC_26_Harhalakis(1990)_20x20.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   1,   9,  12,  18,  20 }
Part[   2] = {   2,   3,  11 }
Part[   3] = {   8,  19,  20 }
Part[   4] = {   2,   3,  10,  11 }
Part[   5] = {   4,   6,   7,  15 }
Part[   6] = {   5,  11,  14,  16,  17 }
Part[   7] = {   5,  16,  17 }
Part[   8] = {   4,   7,   9,  13,  15 }
Part[   9] = {   1,   9,  11,  12,  18 }
Part[  10] = {   8,  19,  20 }
Part[  11] = {   3,  11,  14 }
Part[  12] = {   1,   5,   9,  12,  18 }
Part[  13] = {   6,   7,  15,  17 }
Part[  14] = {   1,   2,   8,  10 }
Part[  15] = {  13,  14,  16,  17 }
Part[  16] = {   6,   7,  15,  19 }
Part[  17] = {   1,   9,  12 }
Part[  18] = {   8,  10,  19,  20 }
Part[  19] = {   2,   3,   5,  11 }
Part[  20] = {   1,  10,  12,  18 }
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 2
              1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
            < Machines >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 1 1 1 0 0 0 1 1 1 1 0 1 2 0 0 0 1 1
< Parts >     1 9 0 2 8 2 3 5 1 4 6 7 8 9 0 4 6 7 3 5
=========== * * * * * * * * * * * * * * * * * * * * *
(   1)   1  * 1 1   1 1                   1           *
(   2)   9  * 1 1   1 1       1                       *
(   3)  12  * 1 1   1 1     1                         *
(   4)  14  * 1   1     1             1               *
(   5)  17  * 1 1   1                                 *
(   6)  20  * 1   1 1 1                               *
=========== * = = = = = = = = = = = = = = = = = = = = *
(   7)   2  *           1 1   1                       *
(   8)   4  *     1     1 1   1                       *
(   9)   6  *               1 1 1 1 1                 *
(  10)   7  *               1     1 1                 *
(  11)  11  *             1   1 1                     *
(  12)  15  *                 1 1 1             1     *
(  13)  19  *           1 1 1 1                       *
=========== * = = = = = = = = = = = = = = = = = = = = *
(  14)   3  *                         1 1 1           *
(  15)  10  *                         1 1 1           *
(  16)  18  *     1                   1 1 1           *
=========== * = = = = = = = = = = = = = = = = = = = = *
(  17)   5  *                               1 1 1   1 *
(  18)   8  *   1                           1   1 1 1 *
(  19)  13  *                       1         1 1   1 *
(  20)  16  *                         1       1 1   1 *
=========== * * * * * * * * * * * * * * * * * * * * *
```

< Machine cells and Part families >

```
============================================================
Machine Cell[ 1] = { 1, 9, 10, 12, 18 }
Machine Cell[ 2] = { 2, 3, 5, 11, 14, 16, 17 }
Machine Cell[ 3] = { 8, 19, 20 }
Machine Cell[ 4] = { 4, 6, 7, 13, 15 }
============================================================
Part  Family[ 1] = { 1, 9, 12, 14, 17, 20 }
Part  Family[ 2] = { 2, 4, 6, 7, 11, 15, 19 }
Part  Family[ 3] = { 3, 10, 18 }
```

Part Family[4] = { 5, 8, 13, 16 }
==========

< Summary of the performance measures >
==========
No. of machines = 20
No. of part types = 20
No. of cells = 4
Machine cell size = 7
Total no. of 1's in the original MPIM : |A| = 79
Matrix density = 0.198
Total no. of within-block 1's = 68
No. of exceptional elements (EEs) = 11
No. of voids = 40
Sum of EEs and voids = 51
Group Cability Index (GCI) = 86.08 %
grouping efficiency (GE) = 79.60 %
Grouping efficacy (GF) = 57.14 %
Machine utilization (MU) = 62.96 %
No. of redundant machines (RMs) = 0
==========

Problem(96) --> Data file name : DC_27_SeifoddiniDjassemi(1991)_18x24.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {  10,  14 }
Part[   2] = {   1,   4,  15,  16,  17 }
Part[   3] = {   3,  10,  13,  14 }
Part[   4] = {   5,   6,  14,  15 }
Part[   5] = {   1,   3,   4,  15,  17 }
Part[   6] = {   1,   3,   4,   9 }
Part[   7] = {   9,  10,  11 }
Part[   8] = {   3,   4,   7,  15,  17 }
Part[   9] = {   3,   4,   7,  15,  17 }
Part[  10] = {   3,   8,   9,  10,  11,  12,  14,  15 }
Part[  11] = {   2,  15 }
Part[  12] = {   1,   4,  15,  16,  17 }
Part[  13] = {   4,   9,  10,  11 }
Part[  14] = {   7,   9 }
Part[  15] = {   3,   4,  10,  15,  17 }
Part[  16] = {   2,  15 }
Part[  17] = {   3,   4,  10,  15,  17 }
Part[  18] = {   9,  10,  11,  18 }
Part[  19] = {   7,   9,  16 }
Part[  20] = {   2,  14,  18 }
Part[  21] = {   9,  11,  18 }
Part[  22] = {   4,   7,   9,  11 }
Part[  23] = {   3,   8,   9,  15 }
Part[  24] = {   3,  13,  14,  15 }
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1
              1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
            < Machines >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 1 1 0 0 0 0 0 1 1 1 1 0 1 0 1 0 1 0
< Parts >     7 9 1 8 1 2 3 4 0 4 5 7 6 2 8 6 5 3 1 2
=========== * * * * * * * * * * * * * * * * * * * * *
(   1)   7  *   1 1           1                       *
(   2)  13  *   1 1         1 1                       *
(   3)  14  * 1 1                                     *
(   4)  18  *   1 1 1         1                       *
(   5)  19  * 1 1                               1     *
(   6)  21  *   1 1 1                                 *
(   7)  22  * 1 1 1         1                         *
=========== * = = = = = = = = = = = = = = = = = = = = *
(   8)   1  *                 1 1                     *
(   9)   2  *         1     1     1 1       1         *
(  10)   3  *             1   1 1                 1   *
(  11)   4  *                 1 1   1       1       *
(  12)   5  *         1   1 1     1 1                 *
(  13)   6  *   1     1   1 1                         *
(  14)   8  * 1           1 1     1 1                 *
(  15)   9  * 1           1 1     1 1                 *
(  16)  10  *   1 1       1   1 1 1     1 1           *
(  17)  11  *           1         1                   *
(  18)  12  *         1     1     1 1       1         *
(  19)  15  *             1 1 1   1 1                 *
(  20)  16  *           1         1                   *
(  21)  17  *             1 1 1   1 1                 *
(  22)  20  *       1   1       1                     *
(  23)  23  *   1         1       1       1           *
(  24)  24  *             1     1 1               1   *
=========== * = = = = = = = = = = = = = = = = = = = = *
=========== * = = = = = = = = = = = = = = = = = = = = *
=========== * = = = = = = = = = = = = = = = = = = = = *
=========== * * * * * * * * * * * * * * * * * * * * *
```

< Machine cells and Part families >

```
============================================================
Machine Cell[ 1] = { 7, 9, 11, 18 }
Machine Cell[ 2] = { 1, 2, 3, 4, 10, 14, 15, 17 }
Machine Cell[ 3] = { 6, 12 }  --> Residual cell
Machine Cell[ 4] = { 8, 16 }  --> Residual cell
Machine Cell[ 5] = { 5, 13 }  --> Residual cell
============================================================
Part  Family[ 1] = { 7, 13, 14, 18, 19, 21, 22 }
Part  Family[ 2] = { 1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 15, 16, 17, 20, 23, 24
}
Part  Family[ 3] --> Empty Part family
Part  Family[ 4] --> Empty Part family
Part  Family[ 5] --> Empty Part family
============================================================

< Summary of the performance measures >
============================================================
No. of machines                              = 18
No. of part types                            = 24
No. of cells                                 = 5
Machine cell size                            = 8
Total no. of 1's in the original MPIM : |A| = 95
Matrix density                               = 0.22
Total no. of within-block 1's                = 73
No. of exceptional elements (EEs)            = 22
No. of voids                                 = 91
Sum of EEs and voids                         = 113
Group Cability Index (GCI)                   = 76.84 %
grouping efficiency (GE)                     = 68.15 %
Grouping efficacy (GF)                       = 39.25 %
Machine utilization (MU)                     = 44.51 %
No. of redundant machines (RMs)              = 6
============================================================
```

Problem(97) --> Data file name : DC_28_MoonChi(1992)_12x19.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   4,   8 }
Part[   2] = {   9,  10,  11 }
Part[   3] = {   9,  11,  12 }
Part[   4] = {   4,   8 }
Part[   5] = {  11 }
Part[   6] = {   1,   6 }
Part[   7] = {   2,   9,  12 }
Part[   8] = {   1,   2,   5,   6 }
Part[   9] = {  10,  11,  12 }
Part[  10] = {  10,  11 }
Part[  11] = {   7,   9,  12 }
Part[  12] = {   1,   3,   5 }
Part[  13] = {   3,   4,   6,   8 }
Part[  14] = {   4,   8,  10 }
Part[  15] = {   5,   6,  10 }
Part[  16] = {   4,   5,   8 }
Part[  17] = {   1,  10,  11 }
Part[  18] = {   1,   5,   6,   7 }
Part[  19] = {   9,  12 }
```

< Block Diagonal Solution Matrix >

```
             < Locations >
               0 0 0 0 0 0 0 0 0 0 0 0
               0 0 0 0 0 0 0 0 0 1 1 1
               1 2 3 4 5 6 7 8 9 0 1 2
             < Machines >
               0 0 0 0 0 0 0 0 0 0 0 0
               0 0 0 1 1 1 0 0 0 0 0 0
< Parts >      4 8 9 0 1 2 1 5 6 7 2 3
============ * * * * * * * * * * * * * *
(   1)   1   * 1 1                     *
(   2)   4   * 1 1                     *
(   3)  13   * 1 1               1     1 *
(   4)  14   * 1 1   1                 *
(   5)  16   * 1 1             1       *
============ * = = = = = = = = = = = = *
(   6)   2   *     1 1 1               *
(   7)   3   *     1   1 1             *
(   8)   5   *         1               *
(   9)   7   *     1     1         1   *
(  10)   9   *       1 1 1             *
(  11)  10   *       1 1               *
(  12)  11   *     1     1       1     *
(  13)  17   *       1 1   1           *
(  14)  19   *     1     1             *
============ * = = = = = = = = = = = = *
(  15)   6   *             1   1       *
(  16)   8   *             1 1 1   1   *
(  17)  12   *             1 1       1 *
(  18)  15   *       1       1 1       *
(  19)  18   *             1 1 1 1     *
============ * = = = = = = = = = = = = *
============ * * * * * * * * * * * * * *
```

< Machine cells and Part families >

```
Machine Cell[ 1] = { 4, 8 }
Machine Cell[ 2] = { 9, 10, 11, 12 }
Machine Cell[ 3] = { 1, 5, 6, 7 }
Machine Cell[ 4] = { 2, 3 }  --> Residual cell
```

```
Part  Family[ 1] = { 1, 4, 13, 14, 16 }
Part  Family[ 2] = { 2, 3, 5, 7, 9, 10, 11, 17, 19 }
Part  Family[ 3] = { 6, 8, 12, 15, 18 }
Part  Family[ 4] --> Empty Part family
```

< Summary of the performance measures >

No. of machines	= 12
No. of part types	= 19
No. of cells	= 4
Machine cell size	= 4
Total no. of 1's in the original MPIM : |A|	= 53
Matrix density	= 0.232
Total no. of within-block 1's	= 43
No. of exceptional elements (EEs)	= 10
No. of voids	= 23
Sum of EEs and voids	= 33
Group Cability Index (GCI)	= 81.13 %
grouping efficiency (GE)	= 79.49 %
Grouping efficacy (GF)	= 56.58 %
Machine utilization (MU)	= 65.15 %
No. of redundant machines (RMs)	= 2

Problem(98) --> Data file name : DC_29_Sule(1994)_11x20.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   3,   4,   9,  10 }
Part[   2] = {   3,   4,   9,  10 }
Part[   3] = {   3,   4,   9,  10 }
Part[   4] = {   6,   8,  11 }
Part[   5] = {   1,   2,   5,   7,  10 }
Part[   6] = {   2,   6,   7 }
Part[   7] = {   4,   9,  10 }
Part[   8] = {   1,   5,  10 }
Part[   9] = {   6,   7,   8,  11 }
Part[  10] = {   7,  11 }
Part[  11] = {   1,   3,  10 }
Part[  12] = {   1,   2,   5,   7,   9,  10 }
Part[  13] = {   2,   7 }
Part[  14] = {   6,   7,   8 }
Part[  15] = {   3,   4,  10 }
Part[  16] = {   3,   4,  10 }
Part[  17] = {   6,   7,   8,  11 }
Part[  18] = {   6,   7,   8,  11 }
Part[  19] = {   1,   2,   5,   7 }
Part[  20] = {   1,   3,   4,   9 }
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 1 1
              1 2 3 4 5 6 7 8 9 0 1
            < Machines >
              0 0 0 0 0 0 0 0 0 0 0
              0 0 0 1 0 0 0 1 0 0 0
< Parts >     3 4 9 0 6 7 8 1 1 2 5
=========== * * * * * * * * * * * * *
(   1)   1  * 1 1 1 1                 *
(   2)   2  * 1 1 1 1                 *
(   3)   3  * 1 1 1 1                 *
(   4)   7  *   1 1 1                 *
(   5)  11  * 1     1         1       *
(   6)  15  * 1 1   1                 *
(   7)  16  * 1 1   1                 *
(   8)  20  * 1 1 1           1       *
=========== * = = = = = = = = = = = = *
(   9)   4  *         1   1 1         *
(  10)   6  *         1 1       1     *
(  11)   9  *         1 1 1 1         *
(  12)  10  *           1   1         *
(  13)  13  *           1       1     *
(  14)  14  *         1 1 1           *
(  15)  17  *         1 1 1 1         *
(  16)  18  *         1 1 1 1         *
=========== * = = = = = = = = = = = = *
(  17)   5  *       1   1     1 1 1   *
(  18)   8  *       1         1   1   *
(  19)  12  *     1 1   1     1 1 1   *
(  20)  19  *         1       1 1 1   *
=========== * * * * * * * * * * * * *
```

< Machine cells and Part families >

```
Machine Cell[ 1] = { 3, 4, 9, 10 }
Machine Cell[ 2] = { 6, 7, 8, 11 }
Machine Cell[ 3] = { 1, 2, 5 }
```

```
Part  Family[ 1] = { 1, 2, 3, 7, 11, 15, 16, 20 }
Part  Family[ 2] = { 4, 6, 9, 10, 13, 14, 17, 18 }
Part  Family[ 3] = { 5, 8, 12, 19 }
```

< Summary of the performance measures >

No. of machines	= 11
No. of part types	= 20
No. of cells	= 3
Machine cell size	= 5
Total no. of 1's in the original MPIM : |A|	= 71
Matrix density	= 0.323
Total no. of within-block 1's	= 60
No. of exceptional elements (EEs)	= 11
No. of voids	= 16
Sum of EEs and voids	= 27
Group Cability Index (GCI)	= 84.51 %
grouping efficiency (GE)	= 85.65 %
Grouping efficacy (GF)	= 68.97 %
Machine utilization (MU)	= 78.95 %
No. of redundant machines (RMs)	= 0

Problem(99) --> Data file name : DC_30_Chen(1995)_20x60.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   2,   3,  12 }
Part[   2] = {   2,   3,   4 }
Part[   3] = {   1,   3 }
Part[   4] = {   1,   3,   4 }
Part[   5] = {   1,   2,   4 }
Part[   6] = {   1,   3,  14 }
Part[   7] = {   1,   3 }
Part[   8] = {   3,   4 }
Part[   9] = {   3,   4,  15 }
Part[  10] = {   1,   4 }
Part[  11] = {   1 }
Part[  12] = {   2,   3,   4,  20 }
Part[  13] = {   5,   8 }
Part[  14] = {   5,   6 }
Part[  15] = {   7 }
Part[  16] = {   7 }
Part[  17] = {   7,   8 }
Part[  18] = {   6,   7,  14 }
Part[  19] = {   7 }
Part[  20] = {   5,  20 }
Part[  21] = {   5,   6,   8 }
Part[  22] = {   5 }
Part[  23] = {   7,  10 }
Part[  24] = {  11 }
Part[  25] = {   9,  10 }
Part[  26] = {   9,  10,  12 }
Part[  27] = {  10,  11,  12,  13 }
Part[  28] = {   9,  10 }
Part[  29] = {  10,  11 }
Part[  30] = {   9,  10,  12 }
Part[  31] = {   3,  15 }
Part[  32] = {  12 }
Part[  33] = {   9,  10,  11 }
Part[  34] = {   8,  10,  12 }
Part[  35] = {   9,  10,  11,  12 }
Part[  36] = {   2,   4,  11,  12 }
Part[  37] = {  14,  15 }
Part[  38] = {   5,  13,  14,  16 }
Part[  39] = {  10,  14,  15,  16 }
Part[  40] = {   8,  14,  15 }
Part[  41] = {  16 }
Part[  42] = {  12,  15 }
Part[  43] = {  14,  15,  16 }
Part[  44] = {  15 }
Part[  45] = {  13,  16 }
Part[  46] = {  13,  14,  16 }
Part[  47] = {   9,  14,  15 }
Part[  48] = {  13,  14,  15 }
Part[  49] = {  18,  19 }
Part[  50] = {  19,  20 }
Part[  51] = {  18,  20 }
Part[  52] = {   3,  11,  17,  18,  19,  20 }
Part[  53] = {   5,   6,  13,  19,  20 }
Part[  54] = {   6,   9,  13,  18,  19,  20 }
Part[  55] = {   2,  16,  17,  18,  19 }
Part[  56] = {  17,  18,  19,  20 }
Part[  57] = {  17 }
Part[  58] = {  20 }
Part[  59] = {  18,  19 }
Part[  60] = {  17,  18,  20 }
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 2
              1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
```

		< Machines >																				
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		0	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	2	
< Parts >		9	0	1	2	1	2	3	4	5	6	7	8	3	4	5	6	7	8	9	0	
==========	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
(1)	23	*	1									1										*
(2)	24	*		1																		*
(3)	25	*	1	1																		*
(4)	26	*	1	1		1																*
(5)	27	*		1	1	1								1								*
(6)	28	*	1	1																		*
(7)	29	*		1	1																	*
(8)	30	*	1	1		1																*
(9)	32	*				1																*
(10)	33	*	1	1	1																	*
(11)	34	*		1		1							1									*
(12)	35	*	1	1	1	1																*
(13)	42	*				1										1						*
==========	*	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	*
(14)	1	*			1		1	1														*
(15)	2	*					1	1	1													*
(16)	3	*				1		1														*
(17)	4	*				1		1	1													*
(18)	5	*				1	1		1													*
(19)	6	*				1		1							1							*
(20)	7	*				1		1														*
(21)	8	*						1	1													*
(22)	9	*						1	1							1						*
(23)	10	*				1			1													*
(24)	11	*				1																*
(25)	12	*					1	1	1												1	*
(26)	31	*						1								1						*
(27)	36	*		1	1		1		1													*
==========	*	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	*
(28)	13	*								1			1									*
(29)	14	*								1	1											*
(30)	15	*										1										*
(31)	16	*										1										*
(32)	17	*										1	1									*
(33)	18	*									1	1			1							*
(34)	19	*										1										*
(35)	21	*								1	1		1									*
(36)	22	*								1												*
==========	*	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	*
(37)	37	*													1	1						*
(38)	38	*								1				1	1		1					*
(39)	39	*		1											1	1	1					*
(40)	40	*											1		1	1						*
(41)	41	*															1					*
(42)	43	*													1	1	1					*
(43)	44	*														1						*
(44)	45	*												1			1					*
(45)	46	*												1	1		1					*
(46)	47	*	1												1	1						*
(47)	48	*												1	1	1						*
==========	*	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	*
(48)	20	*								1											1	*
(49)	49	*																1	1			*
(50)	50	*																	1	1		*
(51)	51	*																1		1		*
(52)	52	*		1			1										1	1	1	1		*
(53)	53	*								1	1			1					1	1		*
(54)	54	*	1								1			1				1	1	1		*
(55)	55	*					1										1	1	1			*
(56)	56	*																1	1	1	1	*
(57)	57	*																1				*
(58)	58	*																			1	*
(59)	59	*																	1	1		*
(60)	60	*																1	1		1	*
==========	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

```
< Machine cells and Part families  >
============================================================
Machine Cell[ 1] = { 9, 10, 11, 12 }
Machine Cell[ 2] = { 1, 2, 3, 4 }
Machine Cell[ 3] = { 5, 6, 7, 8 }
Machine Cell[ 4] = { 13, 14, 15, 16 }
Machine Cell[ 5] = { 17, 18, 19, 20 }
============================================================
Part  Family[ 1] = { 23, 24, 25, 26, 27, 28, 29, 30, 32, 33, 34, 35, 42 }
Part  Family[ 2] = { 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 31, 36 }
Part  Family[ 3] = { 13, 14, 15, 16, 17, 18, 19, 21, 22 }
Part  Family[ 4] = { 37, 38, 39, 40, 41, 43, 44, 45, 46, 47, 48 }
Part  Family[ 5] = { 20, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60 }
============================================================

< Summary of the performance measures >
============================================================
No. of machines                              = 20
No. of part types                            = 60
No. of cells                                 = 5
Machine cell size                            = 4
Total no. of 1's in the original MPIM : |A|  = 155
Matrix density                               = 0.129
Total no. of within-block 1's                = 128
No. of exceptional elements (EEs)            = 27
No. of voids                                 = 112
Sum of EEs and voids                         = 139
Group Cability Index (GCI)                   = 82.58 %
grouping efficiency (GE)                     = 75.26 %
Grouping efficacy (GF)                       = 47.94 %
Machine utilization (MU)                     = 53.33 %
No. of redundant machines (RMs)              = 0
============================================================
```

Problem(100) --> Data file name : DC_31_BhaskarNarendran(1996)_9x30.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   4 }
Part[   2] = {   3,   4 }
Part[   3] = {   1,   3,   4,   8,   9 }
Part[   4] = {   2,   3,   4,   8 }
Part[   5] = {   1,   3,   9 }
Part[   6] = {   9 }
Part[   7] = {   2,   6,   7 }
Part[   8] = {   1 }
Part[   9] = {   4,   9 }
Part[  10] = {   1,   2,   7 }
Part[  11] = {   2,   6,   9 }
Part[  12] = {   1,   3,   7,   8 }
Part[  13] = {   1,   3,   4 }
Part[  14] = {   9 }
Part[  15] = {   5,   6 }
Part[  16] = {   1,   7,   9 }
Part[  17] = {   2,   6 }
Part[  18] = {   1,   8 }
Part[  19] = {   1,   2 }
Part[  20] = {   1,   9 }
Part[  21] = {   6 }
Part[  22] = {   2,   3,   8 }
Part[  23] = {   1,   8 }
Part[  24] = {   1,   3,   7 }
Part[  25] = {   4,   7,   8 }
Part[  26] = {   2,   7,   8 }
Part[  27] = {   1,   3,   6,   7,   8 }
Part[  28] = {   1,   5,   6,   7 }
Part[  29] = {   3,   5,   7 }
Part[  30] = {   5,   6,   8 }
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0
              1 2 3 4 5 6 7 8 9
            < Machines >
              0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0
< Parts >     4 9 2 5 6 1 3 7 8
=========== * * * * * * * * * *
(   1)   1  * 1                 *
(   2)   2  * 1           1     *
(   3)   6  *   1               *
(   4)   9  * 1 1               *
(   5)  14  *   1               *
=========== * = = = = = = = = = *
(   6)   7  *     1   1     1   *
(   7)  11  *   1 1   1         *
(   8)  15  *       1 1         *
(   9)  17  *     1   1         *
(  10)  19  *     1     1       *
(  11)  21  *         1         *
(  12)  30  *       1 1       1 *
=========== * = = = = = = = = = *
(  13)   3  * 1 1       1 1   1 *
(  14)   4  * 1   1       1   1 *
(  15)   5  *   1       1 1     *
(  16)   8  *           1       *
(  17)  10  *     1     1   1   *
(  18)  12  *           1 1 1 1 *
(  19)  13  * 1         1 1     *
(  20)  16  *   1       1   1   *
(  21)  18  *           1     1 *
(  22)  20  *   1       1       *
(  23)  22  *     1       1   1 *
```

```
(  24)  23  *           1     1 *
(  25)  24  *           1 1 1   *
(  26)  25  * 1             1 1 *
(  27)  26  *     1           1 1 *
(  28)  27  *         1 1 1 1 1 *
(  29)  28  *       1 1 1   1   *
(  30)  29  *       1     1 1   *
=========== * * * * * * * * * * *

< Machine cells and Part families  >
============================================================
Machine Cell[ 1] = { 4, 9 }
Machine Cell[ 2] = { 2, 5, 6 }
Machine Cell[ 3] = { 1, 3, 7, 8 }
============================================================
Part  Family[ 1] = { 1, 2, 6, 9, 14 }
Part  Family[ 2] = { 7, 11, 15, 17, 19, 21, 30 }
Part  Family[ 3] = { 3, 4, 5, 8, 10, 12, 13, 16, 18, 20, 22, 23, 24, 25, 26, 27,
28, 29 }
============================================================

< Summary of the performance measures >
============================================================
No. of machines                              = 9
No. of part types                            = 30
No. of cells                                 = 3
Machine cell size                            = 4
Total no. of 1's in the original MPIM : |A| = 79
Matrix density                               = 0.293
Total no. of within-block 1's                = 58
No. of exceptional elements (EEs)            = 21
No. of voids                                 = 45
Sum of EEs and voids                         = 66
Group Cability Index (GCI)                   = 73.42 %
grouping efficiency (GE)                     = 71.87 %
Grouping efficacy (GF)                       = 46.77 %
Machine utilization (MU)                     = 56.31 %
No. of redundant machines (RMs)              = 0
============================================================
```

Problem(101) --> Data file name : DC_32_LeeGarcia(1996)_12x16.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   1,   4,   8,   9 }
Part[   2] = {   1,   2,   4,   6,   7,   8 }
Part[   3] = {   1,   2,   3,   4,   7,   8,   9 }
Part[   4] = {   1,   4,   7,   9 }
Part[   5] = {   1,   6,   7,   9,  10 }
Part[   6] = {   6,   7,   8,  10 }
Part[   7] = {   4,   6,   7,   8 }
Part[   8] = {   2,   3,   4,   5,   6 }
Part[   9] = {   2,   3,   4,   5,   6,   8 }
Part[  10] = {   3,   4,   8,  12 }
Part[  11] = {   7,  11,  12 }
Part[  12] = {   7,  10,  11,  12 }
Part[  13] = {   7,  10,  11 }
Part[  14] = {   9,  10,  11 }
Part[  15] = {   7,  10,  11,  12 }
Part[  16] = {   6,   7,  10 }
```

< Block Diagonal Solution Matrix >

```
             < Locations >
               0 0 0 0 0 0 0 0 0 0 0 0
               0 0 0 0 0 0 0 0 0 1 1 1
               1 2 3 4 5 6 7 8 9 0 1 2
             < Machines >
               0 0 0 0 0 0 0 0 0 0 0 0
               0 0 0 0 0 1 1 1 0 0 0 0
< Parts >      1 4 8 9 7 0 1 2 2 3 5 6
=========== * * * * * * * * * * * * *
(   1)   1  * 1 1 1 1                   *
(   2)   2  * 1 1 1   1       1     1 *
(   3)   3  * 1 1 1 1 1       1 1     *
(   4)   4  * 1 1   1 1                 *
(   5)   5  * 1     1 1 1           1 *
(   6)   7  *   1 1   1             1 *
(   7)  10  *   1 1         1   1     *
=========== * = = = = = = = = = = = = *
(   8)   6  *     1   1 1           1 *
(   9)  11  *         1   1 1         *
(  10)  12  *         1 1 1 1         *
(  11)  13  *         1 1 1           *
(  12)  14  *       1   1 1           *
(  13)  15  *         1 1 1 1         *
(  14)  16  *         1 1           1 *
=========== * = = = = = = = = = = = = *
(  15)   8  *   1             1 1 1 1 *
(  16)   9  *   1 1           1 1 1 1 *
=========== * * * * * * * * * * * * *
```

< Machine cells and Part families >

```
Machine Cell[ 1] = { 1, 4, 8, 9 }
Machine Cell[ 2] = { 7, 10, 11, 12 }
Machine Cell[ 3] = { 2, 3, 5, 6 }
```

```
Part  Family[ 1] = { 1, 2, 3, 4, 5, 7, 10 }
Part  Family[ 2] = { 6, 11, 12, 13, 14, 15, 16 }
Part  Family[ 3] = { 8, 9 }
```

< Summary of the performance measures >

```
No. of machines                                 = 12
No. of part types                               = 16
No. of cells                                    = 3
Machine cell size                               = 4
Total no. of 1's in the original MPIM : |A| = 69
Matrix density                                  = 0.359
```

```
Total no. of within-block 1's               = 48
No. of exceptional elements (EEs)           = 21
No. of voids                                = 16
Sum of EEs and voids                        = 37
Group Cability Index (GCI)                  = 69.57 %
grouping efficiency (GE)                    = 79.30 %
Grouping efficacy (GF)                      = 56.47 %
Machine utilization (MU)                    = 75.00 %
No. of redundant machines (RMs)             = 0
============================================================
```

Problem(102) --> Data file name :
DC_33_NairNarendran(1996)_Figure_1_24x40.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   1,  13,  21,  22 }
Part[   2] = {   3,  20 }
Part[   3] = {   7,  14,  23,  24 }
Part[   4] = {   6,   8,  12,  15,  18 }
Part[   5] = {   6,   8,  15,  18 }
Part[   6] = {   9,  10,  17 }
Part[   7] = {  10,  12,  17,  22 }
Part[   8] = {   4,  16,  19 }
Part[   9] = {   1,   5,  13,  21,  22,  24 }
Part[  10] = {   2,   5,   9,  11,  19 }
Part[  11] = {   3,   8,  20 }
Part[  12] = {   3,  20 }
Part[  13] = {   2,   5,  11,  17,  19 }
Part[  14] = {   2,   5,  11,  12,  19 }
Part[  15] = {   3,  20 }
Part[  16] = {   1,  21,  22 }
Part[  17] = {   1,  13,  22 }
Part[  18] = {   6,   8,  11,  12,  15,  18 }
Part[  19] = {   4,   7,  16 }
Part[  20] = {   9,  10,  17,  22 }
Part[  21] = {   4,  16 }
Part[  22] = {   2,   5,  11,  19,  20 }
Part[  23] = {   3,   7,  20 }
Part[  24] = {   3,  20 }
Part[  25] = {   7,   8,  14,  23,  24 }
Part[  26] = {   6,   8,  12,  15,  18 }
Part[  27] = {   6,   8,  11,  12,  15,  18 }
Part[  28] = {   1,   4,  16 }
Part[  29] = {   9,  10,  17 }
Part[  30] = {   8,  12,  18 }
Part[  31] = {   3,  20 }
Part[  32] = {   7,  14,  23,  24 }
Part[  33] = {   1,  13,  21,  22 }
Part[  34] = {   3,  10,  20 }
Part[  35] = {   2,   5,  19 }
Part[  36] = {   2,   5,  11,  13,  19 }
Part[  37] = {   4,  16 }
Part[  38] = {   4,  16 }
Part[  39] = {   4,  16 }
Part[  40] = {   9,  10,  17 }
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 2 2 2 2 2
              1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
            < Machines >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 1 0 2 0 0 1 1 1 0 1 2 2 0 0 1 1 0 1 1 0 1 2 2
< Parts >     4 6 3 0 6 8 2 5 8 7 4 3 4 2 5 1 9 9 0 7 1 3 1 2
========== * * * * * * * * * * * * * * * * * * * * * * * * * * *
(   1)   8  * 1 1                                 1               *
(   2)  19  * 1 1                 1                               *
(   3)  21  * 1 1                                                 *
(   4)  28  * 1 1                                         1       *
(   5)  37  * 1 1                                                 *
(   6)  38  * 1 1                                                 *
(   7)  39  * 1 1                                                 *
========== * = = = = = = = = = = = = = = = = = = = = = = = = = = *
(   8)   2  *     1 1                                             *
(   9)  11  *     1 1   1                                         *
(  10)  12  *     1 1                                             *
(  11)  15  *     1 1                                             *
(  12)  23  *     1 1           1                                 *
(  13)  24  *     1 1                                             *
```

```
(  14)  31  *     1 1                                                  *
(  15)  34  *     1 1                                 1                *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  16)   4  *         1 1 1 1 1                                        *
(  17)   5  *         1 1   1 1                                        *
(  18)  18  *         1 1 1 1 1                 1                      *
(  19)  26  *         1 1 1 1 1                                        *
(  20)  27  *         1 1 1 1 1                 1                      *
(  21)  30  *           1 1   1                                        *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  22)   3  *                   1 1 1 1                                *
(  23)  25  *           1       1 1 1 1                                *
(  24)  32  *                   1 1 1 1                                *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  25)  10  *                           1 1 1 1 1                      *
(  26)  13  *                           1 1 1 1     1                  *
(  27)  14  *             1             1 1 1 1                        *
(  28)  22  *       1                   1 1 1 1                        *
(  29)  35  *                           1 1   1                        *
(  30)  36  *                           1 1 1 1           1            *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  31)   6  *                                   1 1 1                  *
(  32)   7  *             1                       1 1             1    *
(  33)  20  *                                   1 1 1             1    *
(  34)  29  *                                   1 1 1                  *
(  35)  40  *                                   1 1 1                  *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  36)   1  *                                             1 1 1 1      *
(  37)   9  *                         1   1               1 1 1 1      *
(  38)  16  *                                             1   1 1      *
(  39)  17  *                                             1 1   1      *
(  40)  33  *                                             1 1 1 1      *
=========== * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

< Machine cells and Part families  >
============================================================
Machine Cell[ 1] = { 4, 16 }
Machine Cell[ 2] = { 3, 20 }
Machine Cell[ 3] = { 6, 8, 12, 15, 18 }
Machine Cell[ 4] = { 7, 14, 23, 24 }
Machine Cell[ 5] = { 2, 5, 11, 19 }
Machine Cell[ 6] = { 9, 10, 17 }
Machine Cell[ 7] = { 1, 13, 21, 22 }
============================================================
Part  Family[ 1] = { 8, 19, 21, 28, 37, 38, 39 }
Part  Family[ 2] = { 2, 11, 12, 15, 23, 24, 31, 34 }
Part  Family[ 3] = { 4, 5, 18, 26, 27, 30 }
Part  Family[ 4] = { 3, 25, 32 }
Part  Family[ 5] = { 10, 13, 14, 22, 35, 36 }
Part  Family[ 6] = { 6, 7, 20, 29, 40 }
Part  Family[ 7] = { 1, 9, 16, 17, 33 }
============================================================

< Summary of the performance measures >
============================================================
No. of machines                              = 24
No. of part types                            = 40
No. of cells                                 = 7
Machine cell size                            = 5
Total no. of 1's in the original MPIM : |A|  = 143
Matrix density                               = 0.149
Total no. of within-block 1's                = 124
No. of exceptional elements (EEs)            = 19
No. of voids                                 = 7
Sum of EEs and voids                         = 26
Group Cability Index (GCI)                   = 86.71 %
grouping efficiency (GE)                     = 96.18 %
Grouping efficacy (GF)                       = 82.67 %
Machine utilization (MU)                     = 94.66 %
No. of redundant machines (RMs)              = 0
============================================================
```

Problem(103) --> Data file name :
DC_34_NairNarendran(1996)_Figure_3_24x40.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   1,   4,  13,  22 }
Part[   2] = {   1,   3,  11,  20 }
Part[   3] = {   7,   8,  14,  23,  24 }
Part[   4] = {   5,   6,  12,  15 }
Part[   5] = {   8,  12,  15,  18 }
Part[   6] = {   9,  10,  17 }
Part[   7] = {   9,  14,  17 }
Part[   8] = {   4,  16,  17 }
Part[   9] = {  13,  21,  22 }
Part[  10] = {   2,   5,  11,  17,  19 }
Part[  11] = {   3,  20 }
Part[  12] = {  20 }
Part[  13] = {   2,   5,  19 }
Part[  14] = {   2,  11,  14,  19 }
Part[  15] = {   3,  12,  18,  20 }
Part[  16] = {   2,  13,  21,  22 }
Part[  17] = {   1,  12,  13,  19,  21,  22 }
Part[  18] = {   8,   9,  12,  15,  18 }
Part[  19] = {   4,  16 }
Part[  20] = {   9,  10 }
Part[  21] = {   1,   4 }
Part[  22] = {   2,  11,  19,  20 }
Part[  23] = {   3,  20,  22 }
Part[  24] = {   3,  20 }
Part[  25] = {  11,  14,  23,  24 }
Part[  26] = {   6,   8,  12,  18 }
Part[  27] = {   6,   8,  12,  15,  18 }
Part[  28] = {   3,   4,  16 }
Part[  29] = {   9,  10,  17,  24 }
Part[  30] = {   6,  11,  12,  13,  15,  18 }
Part[  31] = {   3,  20 }
Part[  32] = {   6,   7,  14,  23,  24 }
Part[  33] = {   1,  13,  22 }
Part[  34] = {   1,   3,  20 }
Part[  35] = {   2,   5,  11,  12 }
Part[  36] = {   2,   5,  11,  12,  19 }
Part[  37] = {  16 }
Part[  38] = {   4,  16,  22,  24 }
Part[  39] = {   4,  16 }
Part[  40] = {   9,  10,  17,  20 }
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 3 4
              1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 1 2 1 4
            < Machines >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 1 0 0 1 1 1 0 1 2 2 0 2 0 1 2 2 0 1 1 0 0 1 1 1 1 2 2
< Parts >     4 6 6 8 2 5 8 7 4 3 4 3 0 1 3 1 2 9 0 7 2 5 1 9 3 4 3 4
=========== * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
(   1)   8  * 1 1                                       1             *
(   2)  19  * 1 1                                                     *
(   3)  21  * 1                           1                           *
(   4)  28  * 1 1                       1                             *
(   5)  37  *   1                                                     *
(   6)  38  * 1 1                     1           1                   *
(   7)  39  * 1 1                                                    *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(   8)   4  *     1   1 1                                   1         *
(   9)   5  *       1 1 1 1                                         *
(  10)  18  *       1 1 1 1                       1                 *
(  11)  26  *     1 1 1   1                                         *
(  12)  27  *     1 1 1 1 1                                         *
(  13)  30  *     1   1 1 1               1                   1     *
```

```
========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  14)   3  *       1       1 1 1 1                                 *
(  15)  25  *                 1 1 1                             1   *
(  16)  32  *     1           1 1 1 1                               *
========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  17)   2  *                         1 1 1                     1   *
(  18)  11  *                         1 1                           *
(  19)  12  *                           1                           *
(  20)  15  *         1   1           1 1                           *
(  21)  23  *                         1 1         1                 *
(  22)  24  *                         1 1                           *
(  23)  31  *                         1 1                           *
(  24)  34  *                         1 1 1                         *
========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  25)   1  * 1                           1 1   1                   *
(  26)   9  *                               1 1 1                   *
(  27)  16  *                               1 1 1       1           *
(  28)  17  *         1                   1 1 1 1             1     *
(  29)  33  *                             1 1   1                   *
========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  30)   6  *                                       1 1 1           *
(  31)   7  *                   1                   1   1           *
(  32)  20  *                                       1 1             *
(  33)  29  *                       1               1 1 1           *
(  34)  40  *                           1           1 1 1           *
========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  35)  10  *                                         1 1 1 1 1     *
(  36)  13  *                                           1 1   1     *
(  37)  14  *                   1                       1   1 1     *
(  38)  22  *                           1               1   1 1     *
(  39)  35  *         1                                 1 1 1       *
(  40)  36  *         1                                 1 1 1 1     *
========== * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

< Machine cells and Part families  >
============================================================
Machine Cell[ 1] = { 4, 16 }
Machine Cell[ 2] = { 6, 8, 12, 15, 18 }
Machine Cell[ 3] = { 7, 14, 23, 24 }
Machine Cell[ 4] = { 3, 20 }
Machine Cell[ 5] = { 1, 13, 21, 22 }
Machine Cell[ 6] = { 9, 10, 17 }
Machine Cell[ 7] = { 2, 5, 11, 19 }
============================================================
Part  Family[ 1] = { 8, 19, 21, 28, 37, 38, 39 }
Part  Family[ 2] = { 4, 5, 18, 26, 27, 30 }
Part  Family[ 3] = { 3, 25, 32 }
Part  Family[ 4] = { 2, 11, 12, 15, 23, 24, 31, 34 }
Part  Family[ 5] = { 1, 9, 16, 17, 33 }
Part  Family[ 6] = { 6, 7, 20, 29, 40 }
Part  Family[ 7] = { 10, 13, 14, 22, 35, 36 }
============================================================

< Summary of the performance measures >
============================================================
No. of machines                          = 24
No. of part types                        = 40
No. of cells                             = 7
Machine cell size                        = 5
Total no. of 1's in the original MPIM : |A| = 141
Matrix density                           = 0.147
Total no. of within-block 1's            = 111
No. of exceptional elements (EEs)        = 30
No. of voids                             = 20
Sum of EEs and voids                     = 50
Group Cability Index (GCI)               = 78.72 %
grouping efficiency (GE)                 = 90.56 %
Grouping efficacy (GF)                   = 68.94 %
Machine utilization (MU)                 = 84.73 %
No. of redundant machines (RMs)          = 0
============================================================
```

Problem(104) --> Data file name : DC_35_SeifoddiniDjassemi(1996)_35x15.cfp

< Machines visited by parts: Process route numbers(PRN) >
```
Part[   1] = {   2,   8,  11,  20,  24,  31 }
Part[   2] = {   9,  13,  18,  25,  30 }
Part[   3] = {   5,  10,  14,  27,  35 }
Part[   4] = {   2,   3,   9,  20,  24,  31 }
Part[   5] = {  12,  15,  16,  22,  26,  28 }
Part[   6] = {   1,   5,  10,  15,  17,  19 }
Part[   7] = {  11,  13,  18,  21,  30,  32 }
Part[   8] = {   7,  16,  26 }
Part[   9] = {   5,   7,  12,  15,  29,  34 }
Part[  10] = {   4,  11,  18,  23,  33 }
Part[  11] = {   1,  14,  19,  27 }
Part[  12] = {   1,   5,   9,  21,  24,  30,  32 }
Part[  13] = {   3,   8,  12,  16,  23,  33 }
Part[  14] = {   2,   6,  10,  14,  17,  24 }
Part[  15] = {   5,   7,  12,  13,  15,  16,  26,  28,  34 }
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 3 3 3 3 3 3
              1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5
            < Machines >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 1 1 1 2 2 2 3 3 3 0 0 0 0 1 1 1 2 2 2 3 0 0 1 1 1 1 2 3 2 2 0 2 3
< Parts >     2 9 1 3 8 0 1 4 0 1 2 3 5 7 8 2 5 6 2 6 8 4 1 6 0 4 7 9 7 5 5 9 4 3 3
=========== * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
(   1)   1  * 1   1     1   1   1         1                                             *
(   2)   2  *   1   1 1       1                                                 1       *
(   3)   4  * 1 1         1   1   1   1                                               *
(   4)   7  *     1 1 1   1   1   1                                                   *
(   5)  12  *   1         1 1 1   1   1                       1                       *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(   6)   5  *                               1 1 1 1 1 1                             *
(   7)   8  *                                   1       1   1                       *
(   8)   9  *                             1 1   1 1         1                 1     *
(   9)  13  *                         1     1 1   1                             1 1 *
(  10)  15  *       1                   1 1   1 1 1   1 1 1                         *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  11)   3  *                           1                       1 1     1 1         *
(  12)   6  *                           1       1           1   1   1 1             *
(  13)  11  *                                               1     1   1 1           *
(  14)  14  * 1             1                                   1 1 1 1             *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  15)  10  *     1   1                                                       1 1 1 *
=========== * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
```

< Machine cells and Part families >
```
Machine Cell[ 1] = { 2, 9, 11, 13, 18, 20, 21, 24, 30, 31, 32 }
Machine Cell[ 2] = { 3, 5, 7, 8, 12, 15, 16, 22, 26, 28, 34 }
Machine Cell[ 3] = { 1, 6, 10, 14, 17, 19, 27, 35 }
Machine Cell[ 4] = { 25, 29 }  --> Residual cell
Machine Cell[ 5] = { 4, 23, 33 }
```
```
Part  Family[ 1] = { 1, 2, 4, 7, 12 }
Part  Family[ 2] = { 5, 8, 9, 13, 15 }
Part  Family[ 3] = { 3, 6, 11, 14 }
Part  Family[ 4] --> Empty Part family
Part  Family[ 5] = { 10 }
```

< Summary of the performance measures >
```
No. of machines                          = 35
No. of part types                        = 15
No. of cells                             = 5
Machine cell size                        = 11
Total no. of 1's in the original MPIM : |A| = 86
Matrix density                           = 0.164
Total no. of within-block 1's            = 70
No. of exceptional elements (EEs)        = 16
No. of voids                             = 75
```

```
Sum of EEs and voids                          = 91
Group Cability Index (GCI)                    = 81.40 %
grouping efficiency (GE)                      = 72.03 %
Grouping efficacy (GF)                        = 43.48 %
Machine utilization (MU)                      = 48.28 %
No. of redundant machines (RMs)               = 2
============================================================
```

Problem(105) --> Data file name : DC_36_Viswanathan(1996)_10x12.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   4,   5 }
Part[   2] = {   4,   5,   9,  10 }
Part[   3] = {   4 }
Part[   4] = {   1,   3,   4,   6,   8,  10 }
Part[   5] = {   1,   7,  10 }
Part[   6] = {   1,   2,   3,   6,   7 }
Part[   7] = {   1,   2,   7,   8 }
Part[   8] = {   1,   6,   7,   8,  10 }
Part[   9] = {   2,   8 }
Part[  10] = {   6,   8,  10 }
Part[  11] = {   1,   6,   8 }
Part[  12] = {   1,   8,  10 }
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 1
              1 2 3 4 5 6 7 8 9 0
            < Machines >
              0 0 0 0 0 0 0 0 0 0
              0 0 0 0 1 0 0 0 0 0
< Parts >     1 6 7 8 0 4 5 9 2 3
=========== * * * * * * * * * * * *
(   1)   4  * 1 1   1 1 1       1 *
(   2)   5  * 1   1   1           *
(   3)   6  * 1 1 1           1 1 *
(   4)   7  * 1   1 1         1   *
(   5)   8  * 1 1 1 1 1           *
(   6)  10  *   1   1 1           *
(   7)  11  * 1 1   1             *
(   8)  12  * 1     1 1           *
=========== * = = = = = = = = = = *
(   9)   1  *           1 1       *
(  10)   2  *         1 1 1 1     *
(  11)   3  *           1         *
=========== * = = = = = = = = = = *
(  12)   9  *       1         1   *
=========== * * * * * * * * * * * *
```

< Machine cells and Part families >

```
Machine Cell[ 1] = { 1, 6, 7, 8, 10 }
Machine Cell[ 2] = { 4, 5, 9 }
Machine Cell[ 3] = { 2, 3 }
```

```
Part  Family[ 1] = { 4, 5, 6, 7, 8, 10, 11, 12 }
Part  Family[ 2] = { 1, 2, 3 }
Part  Family[ 3] = { 9 }
```

< Summary of the performance measures >

```
No. of machines                              = 10
No. of part types                            = 12
No. of cells                                 = 3
Machine cell size                            = 5
Total no. of 1's in the original MPIM : |A|  = 41
Matrix density                               = 0.342
Total no. of within-block 1's                = 34
No. of exceptional elements (EEs)            = 7
No. of voids                                 = 17
Sum of EEs and voids                         = 24
Group Cability Index (GCI)                   = 82.93 %
grouping efficiency (GE)                     = 78.26 %
Grouping efficacy (GF)                       = 58.62 %
Machine utilization (MU)                     = 66.67 %
No. of redundant machines (RMs)              = 1
```

Problem(106) --> Data file name : DC_37_NairNarendran(1998)_Example_5_20x20.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   1,   9,  12,  18,  20 }
Part[   2] = {   2,   3,  11 }
Part[   3] = {   8,  19,  20 }
Part[   4] = {   2,   3,  10,  11 }
Part[   5] = {   4,   6,   7,  15 }
Part[   6] = {   5,  11,  14,  16,  17 }
Part[   7] = {   6,  16,  17 }
Part[   8] = {   4,   7,   9,  13,  15 }
Part[   9] = {   1,   9,  11,  12,  18 }
Part[  10] = {   8,  19,  20 }
Part[  11] = {   3,   8,  14 }
Part[  12] = {   1,   5,   9,  12,  18 }
Part[  13] = {   6,   7,  15,  17 }
Part[  14] = {   1,   2,   8,  10 }
Part[  15] = {  13,  14,  16,  17 }
Part[  16] = {   6,   7,  15,  19 }
Part[  17] = {   1,   9,  12 }
Part[  18] = {   8,  10,  19,  20 }
Part[  19] = {   2,   3,   5,  11 }
Part[  20] = {   1,  10,  12,  18 }
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 2
              1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
            < Machines >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 1 1 0 0 0 1 1 0 0 0 1 1 0 1 1 2 1 1
< Parts >     1 9 2 8 2 3 5 1 4 4 6 7 3 5 8 0 9 0 6 7
=========== * * * * * * * * * * * * * * * * * * * * *
(   1)   1  * 1 1 1 1                           1     *
(   2)   9  * 1 1 1 1       1                         *
(   3)  12  * 1 1 1 1     1                           *
(   4)  17  * 1 1 1                                   *
(   5)  20  * 1   1 1                         1       *
=========== * = = = = = = = = = = = = = = = = = = = = *
(   6)   2  *         1 1   1                         *
(   7)   4  *         1 1   1               1         *
(   8)   6  *             1 1 1                   1 1 *
(   9)  11  *           1     1           1           *
(  10)  19  *         1 1 1 1                         *
=========== * = = = = = = = = = = = = = = = = = = = = *
(  11)   5  *                   1 1 1   1             *
(  12)   8  *   1               1   1 1 1             *
(  13)  13  *                     1 1   1           1 *
(  14)  16  *                     1 1   1     1       *
=========== * = = = = = = = = = = = = = = = = = = = = *
(  15)   3  *                             1   1 1     *
(  16)  10  *                             1   1 1     *
(  17)  14  * 1       1                   1 1         *
(  18)  18  *                             1 1 1 1     *
=========== * = = = = = = = = = = = = = = = = = = = = *
(  19)   7  *                     1               1 1 *
(  20)  15  *                 1       1           1 1 *
=========== * * * * * * * * * * * * * * * * * * * * *
```

< Machine cells and Part families >

```
Machine Cell[ 1] = { 1, 9, 12, 18 }
Machine Cell[ 2] = { 2, 3, 5, 11, 14 }
Machine Cell[ 3] = { 4, 6, 7, 13, 15 }
Machine Cell[ 4] = { 8, 10, 19, 20 }
Machine Cell[ 5] = { 16, 17 }
```

```
Part  Family[ 1] = { 1, 9, 12, 17, 20 }
Part  Family[ 2] = { 2, 4, 6, 11, 19 }
Part  Family[ 3] = { 5, 8, 13, 16 }
Part  Family[ 4] = { 3, 10, 14, 18 }
Part  Family[ 5] = { 7, 15 }
```

< Summary of the performance measures >

```
============================================================
No. of machines                                 = 20
No. of part types                               = 20
No. of cells                                    = 5
Machine cell size                               = 5
Total no. of 1's in the original MPIM : |A|     = 79
Matrix density                                  = 0.198
Total no. of within-block 1's                   = 63
No. of exceptional elements (EEs)               = 16
No. of voids                                    = 22
Sum of EEs and voids                            = 38
Group Cability Index (GCI)                      = 79.75 %
grouping efficiency (GE)                        = 84.52 %
Grouping efficacy (GF)                          = 62.38 %
Machine utilization (MU)                        = 74.12 %
No. of redundant machines (RMs)                 = 0
============================================================
```

Problem(107) --> Data file name : DC_38_NairNarendran(1998)_Example_6_25x40.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   4,   7,  10,  16,  18,  22 }
Part[   2] = {   1,   2,  17,  25 }
Part[   3] = {   3,  11,  20 }
Part[   4] = {  12,  23 }
Part[   5] = {   4,  12,  18 }
Part[   6] = {  12,  16,  23 }
Part[   7] = {   4,   7,  10,  16,  18 }
Part[   8] = {   5,  16,  19 }
Part[   9] = {   3,  11,  20,  25 }
Part[  10] = {   8,   9,  25 }
Part[  11] = {   8,  21 }
Part[  12] = {   1,   3,  17,  24,  25 }
Part[  13] = {   3,  11,  20 }
Part[  14] = {   3,   5,  11,  20 }
Part[  15] = {   2,   5,  10,  16,  19 }
Part[  16] = {   4,   7,  16,  18 }
Part[  17] = {   7,  10,  18 }
Part[  18] = {  14,  15,  22 }
Part[  19] = {   8,   9,  10 }
Part[  20] = {  23 }
Part[  21] = {   8,   9,  10 }
Part[  22] = {   3,   8,   9,  17 }
Part[  23] = {   5,  16,  19 }
Part[  24] = {   5,  16 }
Part[  25] = {   6,  15,  21 }
Part[  26] = {   4,  12,  15,  23 }
Part[  27] = {  12,  21,  22 }
Part[  28] = {   8,   9,  10 }
Part[  29] = {   5,   6,  21 }
Part[  30] = {   4,   7,  16,  18 }
Part[  31] = {   5,  17,  19 }
Part[  32] = {  13,  14,  15,  22 }
Part[  33] = {  11,  20,  25 }
Part[  34] = {  12,  23,  24 }
Part[  35] = {   6,  15,  21,  22 }
Part[  36] = {   1,   2,  11,  17 }
Part[  37] = {   7,  12,  23 }
Part[  38] = {   8,   9,  22 }
Part[  39] = {  12 }
Part[  40] = {   6,  15,  21 }
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2
              1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7
            < Machines >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 1 0 0 1 1 0 1 2 0 1 2 2 0 0 1 2 1 1 1 2 2 0 1 2 3
< Parts >     8 9 0 4 7 6 8 3 1 0 6 5 1 2 1 2 7 5 3 4 2 3 4 5 9 0 1
============ * * * * * * * * * * * * * * * * * * * * * * * * * * * *
(   1)  10   * 1 1                                 1                 *
(   2)  11   * 1                             1                       *
(   3)  19   * 1 1 1                                                 *
(   4)  21   * 1 1 1                                                 *
(   5)  22   * 1 1           1                     1                 *
(   6)  28   * 1 1 1                                                 *
(   7)  38   * 1 1                             1                     *
============ * = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(   8)   1   *     1 1 1 1 1                   1                     *
(   9)   5   *       1     1                               1         *
(  10)   7   *     1 1 1 1 1                                         *
(  11)  16   *       1 1 1 1                                         *
(  12)  17   *     1   1   1                                         *
(  13)  24   *           1                                       1   *
(  14)  30   *       1 1 1 1                                         *
============ * = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  15)   3   *               1 1 1                                   *
(  16)   9   *               1 1 1                 1                 *
(  17)  13   *               1 1 1                                   *
(  18)  14   *               1 1 1                               1   *
(  19)  33   *                 1 1                 1                 *
============ * = = = = = = = = = = = = = = = = = = = = = = = = = = = *
```

```
(  20)  18  *                       1   1           1           *
(  21)  25  *                   1 1 1                           *
(  22)  27  *                       1 1               1         *
(  23)  29  *                   1   1                       1   *
(  24)  35  *                   1 1 1 1                         *
(  25)  40  *                   1 1 1                           *
========== * = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  26)   2  *                           1 1 1 1                 *
(  27)  12  *               1           1   1 1         1       *
(  28)  36  *                 1         1 1 1                   *
========== * = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  29)  32  *                       1   1         1 1           *
========== * = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  30)   4  *                                       1 1         *
(  31)   6  *           1                           1 1         *
(  32)  20  *                                         1         *
(  33)  26  *       1               1                 1 1         *
(  34)  34  *                                       1 1 1       *
(  35)  37  *         1                             1 1         *
(  36)  39  *                                       1           *
========== * = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  37)   8  *           1                                   1 1 *
(  38)  15  *     1     1                   1               1 1 *
(  39)  23  *           1                                   1 1 *
(  40)  31  *                             1                 1 1 *
========== * * * * * * * * * * * * * * * * * * * * * * * * * * *

< Machine cells and Part families  >
============================================================
Machine Cell[ 1] = { 8, 9, 10 }
Machine Cell[ 2] = { 4, 7, 16, 18 }
Machine Cell[ 3] = { 3, 11, 20 }
Machine Cell[ 4] = { 6, 15, 21, 22 }
Machine Cell[ 5] = { 1, 2, 17, 25 }
Machine Cell[ 6] = { 13, 14 }
Machine Cell[ 7] = { 12, 23, 24 }
Machine Cell[ 8] = { 5, 19 }
============================================================
Part  Family[ 1] = { 10, 11, 19, 21, 22, 28, 38 }
Part  Family[ 2] = { 1, 5, 7, 16, 17, 24, 30 }
Part  Family[ 3] = { 3, 9, 13, 14, 33 }
Part  Family[ 4] = { 18, 25, 27, 29, 35, 40 }
Part  Family[ 5] = { 2, 12, 36 }
Part  Family[ 6] = { 32 }
Part  Family[ 7] = { 4, 6, 20, 26, 34, 37, 39 }
Part  Family[ 8] = { 8, 15, 23, 31 }
============================================================

< Summary of the performance measures >
============================================================
No. of machines                              = 25
No. of part types                            = 40
No. of cells                                 = 8
Machine cell size                            = 4
Total no. of 1's in the original MPIM : |A|  = 132
Matrix density                               = 0.132
Total no. of within-block 1's                = 100
No. of exceptional elements (EEs)            = 32
No. of voids                                 = 31
Sum of EEs and voids                         = 63
Group Cability Index (GCI)                   = 75.76 %
grouping efficiency (GE)                     = 86.33 %
Grouping efficacy (GF)                       = 61.35 %
Machine utilization (MU)                     = 76.34 %
No. of redundant machines (RMs)              = 0
============================================================
```

Problem(108) --> Data file name : DC_39_SuHsu(1998)_18x35.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   2,   4,  10,  12,  13 }
Part[   2] = {   7,  13,  14,  15,  17 }
Part[   3] = {   3,   8,  10,  16,  18 }
Part[   4] = {   1,   5,  11,  15 }
Part[   5] = {   6,   9,  15 }
Part[   6] = {   9,  10,  15 }
Part[   7] = {   3,  10,  16 }
Part[   8] = {   3,  10,  16,  18 }
Part[   9] = {   4,   6,  10,  12,  15 }
Part[  10] = {   2,   6,  12,  13 }
Part[  11] = {   2,   4,   6,  13 }
Part[  12] = {   2,   4,   6,   7,  12,  13 }
Part[  13] = {   7,  14,  15,  17 }
Part[  14] = {   3,   8,  10,  16,  18 }
Part[  15] = {   8,  10,  16,  18 }
Part[  16] = {   1,   5,  11,  15 }
Part[  17] = {   1,   5,  11,  15 }
Part[  18] = {   6,   9,  15 }
Part[  19] = {   1,   5,  11,  15 }
Part[  20] = {   8,  16,  18 }
Part[  21] = {   6,   9,  10,  15 }
Part[  22] = {   3,   7,  13,  14,  15 }
Part[  23] = {   2,   4,   6,  12,  13 }
Part[  24] = {   4,   6,  10,  12,  13 }
Part[  25] = {   3,   7,  13,  17 }
Part[  26] = {   3,   7,  13,  14,  17 }
Part[  27] = {   3,   8,  15,  16,  18 }
Part[  28] = {   1,  11,  15 }
Part[  29] = {   1,  11,  15 }
Part[  30] = {   6,   9,  10,  15,  17 }
Part[  31] = {   6,   9,  10,  15,  18 }
Part[  32] = {   3,   8,  10,  16,  18 }
Part[  33] = {   7,  13,  14,  15,  17 }
Part[  34] = {   2,   4,  10,  12,  13 }
Part[  35] = {   3,   7,  14,  15,  17 }
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1
              1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8
            < Machines >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 1 1 0 0 0 0 1 1 1 1 0 0 1 0 1 1
< Parts >     3 8 6 8 2 4 6 9 0 2 3 5 1 5 1 7 4 7
=========== * * * * * * * * * * * * * * * * * * * *
(   1)   3  * 1 1 1 1         1                     *
(   2)   7  * 1   1           1                     *
(   3)   8  * 1   1 1         1                     *
(   4)  14  * 1 1 1 1         1                     *
(   5)  15  *   1 1 1         1                     *
(   6)  20  *   1 1 1                               *
(   7)  27  * 1 1 1 1                 1             *
(   8)  32  * 1 1 1 1           1                   *
=========== * = = = = = = = = = = = = = = = = = = = *
(   9)   1  *         1 1     1 1 1                 *
(  10)   5  *             1 1       1               *
(  11)   6  *               1 1     1               *
(  12)   9  *           1 1   1 1   1               *
(  13)  10  *         1   1     1 1                 *
(  14)  11  *         1 1 1       1                 *
(  15)  12  *         1 1 1     1 1         1       *
(  16)  18  *             1 1       1               *
(  17)  21  *             1 1 1     1               *
(  18)  23  *         1 1 1     1 1                 *
(  19)  24  *           1 1   1 1 1                 *
(  20)  30  *             1 1 1     1           1 * *
(  21)  31  *       1     1 1 1     1               *
(  22)  34  *         1 1     1 1 1                 *
=========== * = = = = = = = = = = = = = = = = = = = *
(  23)   4  *                       1 1 1 1         *
(  24)  16  *                       1 1 1 1         *
(  25)  17  *                       1 1 1 1         *
```

```
(  26)  19  *                       1 1 1 1       *
(  27)  28  *                       1 1   1       *
(  28)  29  *                       1 1   1       *
=========== * = = = = = = = = = = = = = = = = = = *
(  29)   2  *                     1 1       1 1 1 *
(  30)  13  *                       1       1 1 1 *
(  31)  22  * 1                   1 1       1 1   *
(  32)  25  * 1                   1         1   1 *
(  33)  26  * 1                   1         1 1 1 *
(  34)  33  *                     1 1       1 1 1 *
(  35)  35  * 1                     1       1 1 1 *
=========== * * * * * * * * * * * * * * * * * * * *

< Machine cells and Part families  >
============================================================
Machine Cell[ 1] = { 3, 8, 16, 18 }
Machine Cell[ 2] = { 2, 4, 6, 9, 10, 12, 13, 15 }
Machine Cell[ 3] = { 1, 5, 11 }
Machine Cell[ 4] = { 7, 14, 17 }
============================================================
Part  Family[ 1] = { 3, 7, 8, 14, 15, 20, 27, 32 }
Part  Family[ 2] = { 1, 5, 6, 9, 10, 11, 12, 18, 21, 23, 24, 30, 31, 34 }
Part  Family[ 3] = { 4, 16, 17, 19, 28, 29 }
Part  Family[ 4] = { 2, 13, 22, 25, 26, 33, 35 }
============================================================

< Summary of the performance measures >
============================================================
No. of machines                              = 18
No. of part types                            = 35
No. of cells                                 = 4
Machine cell size                            = 8
Total no. of 1's in the original MPIM : |A| = 151
Matrix density                               = 0.24
Total no. of within-block 1's                = 121
No. of exceptional elements (EEs)            = 30
No. of voids                                 = 62
Sum of EEs and voids                         = 92
Group Cability Index (GCI)                   = 80.13 %
grouping efficiency (GE)                     = 79.70 %
Grouping efficacy (GF)                       = 56.81 %
Machine utilization (MU)                     = 66.12 %
No. of redundant machines (RMs)              = 0
============================================================
```

```
Problem(109) --> Data file name :    DC_40_SeifoddiniDjassemi(2001)_Figure_6_36x15.cfp

< Machines visited by parts: Process route numbers(PRN) >
==============================================================
Part[   1] = {   3,  21,  32,   9,  25,  12 }
Part[   2] = {  19,  10,  14,  31,  26 }
Part[   3] = {  16,   8,  15,  11,  28,  36 }
Part[   4] = {   3,  21,  32,   4,  25,  10 }
Part[   5] = {   1,  16,  17,  27,  13,  23,  29 }
Part[   6] = {   1,  16,   2,  20,  11,  18 }
Part[   7] = {  19,  25,  22,  12,  14,  33,  31 }
Part[   8] = {   1,  17,  27,   8,  35,  14 }
Part[   9] = {   1,  16,   6,   8,  13,  35,  30 }
Part[  10] = {  34,  24,   5,  19,  12 }
Part[  11] = {   8,   2,  20,  15,  28 }
Part[  12] = {  16,  20,  25,  10,  22,  33,  31 }
Part[  13] = {   6,  13,   9,  34,   4,  24 }
Part[  14] = {   7,  15,  11,  18,   3 }
Part[  15] = {   1,  16,   6,  17,  27,   8,  13,  23,  35,  29 }
==============================================================

< Block Diagonal Solution Matrix >
            < Locations >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 3 3 3 3 3 3 3
              1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6
            < Machines >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 1 1 1 2 2 2 3 3 0 1 1 1 1 2 2 2 3 3 3 0 0 1 1 1 2 2 3 0 0 2 3 0 2
< Parts >     1 6 8 3 6 7 3 7 9 0 5 3 0 2 4 9 1 2 5 1 2 3 2 7 1 5 8 0 8 6 5 9 4 4 4 6
=========== * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
(   1)   5  * 1     1 1 1 1 1 1                                                       *
(   2)   8  * 1   1     1   1     1       1                                           *
(   3)   9  * 1 1 1 1 1         1 1                                                   *
(   4)  15  * 1 1 1 1 1 1 1 1 1   1                                                   *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(   5)   1  *                       1   1     1   1   1                     1         *
(   6)   2  *                         1   1 1       1                               1 *
(   7)   4  *                       1 1       1   1   1                           1   *
(   8)   7  *                           1 1 1   1 1 1   1                             *
(   9)  12  *         1               1         1 1 1   1           1                 *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  10)   3  *     1   1                                         1 1     1 1           *
(  11)   6  * 1       1                                   1   1   1 1                 *
(  12)  11  *     1                                       1     1   1 1               *
(  13)  14  *                       1                       1 1 1 1                   *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  14)  10  *                           1   1                             1   1 1     *
(  15)  13  *   1   1                                                       1 1 1 1   *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
=========== * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

< Machine cells and Part families  >
============================================================
Machine Cell[ 1] = { 1, 6, 8, 13, 16, 17, 23, 27, 29, 30, 35 }
Machine Cell[ 2] = { 3, 10, 12, 14, 19, 21, 22, 25, 31, 32, 33 }
Machine Cell[ 3] = { 2, 7, 11, 15, 18, 20, 28, 36 }
Machine Cell[ 4] = { 5, 9, 24, 34 }
Machine Cell[ 5] = { 4, 26 }  --> Residual cell
============================================================
Part  Family[ 1] = { 5, 8, 9, 15 }
Part  Family[ 2] = { 1, 2, 4, 7, 12 }
Part  Family[ 3] = { 3, 6, 11, 14 }
Part  Family[ 4] = { 10, 13 }
Part  Family[ 5] --> Empty Part family
============================================================

< Summary of the performance measures >
============================================================
No. of machines                            = 36
No. of part types                          = 15
No. of cells                               = 5
Machine cell size                          = 11
Total no. of 1's in the original MPIM : |A| = 94
Matrix density                             = 0.174
Total no. of within-block 1's              = 77
No. of exceptional elements (EEs)          = 17
No. of voids                               = 62
```

Sum of EEs and voids = 79
Group Cability Index (GCI) = 81.91 %
grouping efficiency (GE) = 75.58 %
Grouping efficacy (GF) = 49.36 %
Machine utilization (MU) = 55.40 %
No. of redundant machines (RMs) = 2
==========

Problem(110) --> Data file name : DC_41_Li(2003)_14x14.cfp

< Machines visited by parts: Process route numbers(PRN) >
```
Part[   1] = {   5,   7,  11,  13 }
Part[   2] = {   6,   8,   9,  10,  12,  14 }
Part[   3] = {   5,   7,  11,  13 }
Part[   4] = {   6,   9,  10,  14 }
Part[   5] = {   1,   3,  11,  13 }
Part[   6] = {   2,   4,  12,  14 }
Part[   7] = {   1,   3,  10,  11,  13 }
Part[   8] = {   2,  13 }
Part[   9] = {   2,   4,  12,  14 }
Part[  10] = {   2,   4,   7 }
Part[  11] = {   1,   3,   5,   7 }
Part[  12] = {   2,   6,   9 }
Part[  13] = {   1,   3,   5,   7,   8 }
Part[  14] = {   2,   4,   6,   9 }
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 0 1 1 1 1
              1 2 3 4 5 6 7 8 9 0 1 2 3 4
            < Machines >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 1 1 0 0 0 0 1 1 0 1
< Parts >     1 3 5 7 1 3 2 4 6 9 0 4 8 2
=========== * * * * * * * * * * * * * * *
(   1)   1  *     1 1 1 1                 *
(   2)   3  *     1 1 1 1                 *
(   3)   5  * 1 1     1 1                 *
(   4)   7  * 1 1     1 1         1       *
(   5)  11  * 1 1 1 1                     *
(   6)  13  * 1 1 1 1                   1 *
=========== * = = = = = = = = = = = = = = *
(   7)   6  *             1 1       1   1 *
(   8)   8  *           1 1               *
(   9)   9  *             1 1       1   1 *
(  10)  10  *       1     1 1             *
(  11)  14  *             1 1 1 1         *
=========== * = = = = = = = = = = = = = = *
(  12)   2  *                 1 1 1 1 1 1 *
(  13)   4  *                 1 1 1 1     *
(  14)  12  *               1   1 1       *
=========== * = = = = = = = = = = = = = = *
=========== * * * * * * * * * * * * * * *
```

< Machine cells and Part families >
```
Machine Cell[ 1] = { 1, 3, 5, 7, 11, 13 }
Machine Cell[ 2] = { 2, 4 }
Machine Cell[ 3] = { 6, 9, 10, 14 }
Machine Cell[ 4] = { 8, 12 }  --> Residual cell
```
```
Part  Family[ 1] = { 1, 3, 5, 7, 11, 13 }
Part  Family[ 2] = { 6, 8, 9, 10, 14 }
Part  Family[ 3] = { 2, 4, 12 }
Part  Family[ 4] --> Empty Part family
```

< Summary of the performance measures >
```
No. of machines                              = 14
No. of part types                            = 14
No. of cells                                 = 4
Machine cell size                            = 5
Total no. of 1's in the original MPIM : |A| = 56
Matrix density                               = 0.286
Total no. of within-block 1's                = 43
```

No. of exceptional elements (EEs) = 13
No. of voids = 15
Sum of EEs and voids = 28
Group Cability Index (GCI) = 76.79 %
grouping efficiency (GE) = 82.36 %
Grouping efficacy (GF) = 60.56 %
Machine utilization (MU) = 74.14 %
No. of redundant machines (RMs) = 2
==========

Problem(111) --> Data file name : DC_42_Chan(2006)_37x30.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   7,   8,  16,  18,  21 }
Part[   2] = {   4,  16,  22 }
Part[   3] = {  23,  25 }
Part[   4] = {  15,  24 }
Part[   5] = {  15,  24 }
Part[   6] = {  24,  32,  33 }
Part[   7] = {   7,   9,  11,  17,  18,  21 }
Part[   8] = {   7,   8,  16,  18,  21,  22,  26 }
Part[   9] = {  15,  24 }
Part[  10] = {  17,  22 }
Part[  11] = {  34,  35 }
Part[  12] = {  27,  28 }
Part[  13] = {   7,   9,  16,  19,  21 }
Part[  14] = {  10,  11,  12,  16,  20,  21 }
Part[  15] = {   8,  11,  12,  13,  16,  18 }
Part[  16] = {   3,   4,  24,  34 }
Part[  17] = {   3,  24,  34,  37 }
Part[  18] = {   1,   5,   7 }
Part[  19] = {   2,   6,   7 }
Part[  20] = {  14,  17,  22,  29 }
Part[  21] = {  14,  17,  30 }
Part[  22] = {   4,  21 }
Part[  23] = {  21,  31 }
Part[  24] = {   9,  15,  18 }
Part[  25] = {   7,  17,  24 }
Part[  26] = {  35,  36 }
Part[  27] = {  24,  35 }
Part[  28] = {   3,   4,   9,  19,  24,  34 }
Part[  29] = {   3,   9,  19,  24,  34,  37 }
Part[  30] = {   3,   4,   5,  24,  34 }
```

< Block Diagonal Solution Matrix >

< Locations >

	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3		
	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7

< Machines >

< Parts >	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	1	1	1	1	1	1	2	2	2	3	0	0	0	0	1	1	2	3	3	3	3	3	1	1	2	2	3	0	0	2	2	2	2	
	7	8	9	0	1	2	3	6	8	0	1	6	1	1	3	4	5	5	9	4	2	3	4	5	6	7	4	7	2	9	0	2	6	3	5	7	8
==========	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
(1) 1	*	1	1					1	1		1																												*
(2) 2	*							1							1														1										*
(3) 7	*	1		1		1			1		1																	1											*
(4) 8	*	1	1					1	1		1	1																	1										*
(5) 13	*	1		1				1			1								1																				*
(6) 14	*				1	1	1	1		1	1																												*
(7) 15	*		1			1	1	1	1	1																													*
(8) 22	*								1						1																							*
(9) 23	*								1		1																											*
(10) 24	*			1				1										1																				*
==========	*	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	*
(11) 4	*																	1		1																		*
(12) 5	*																	1		1																		*
(13) 6	*																			1	1	1																*
(14) 9	*																	1		1																		*
(15) 11	*																						1	1														*
(16) 16	*													1	1					1			1																*
(17) 17	*													1						1			1		1													*
(18) 18	*	1											1			1																							*
(19) 25	*	1																		1						1												*
(20) 26	*																							1	1													*
(21) 27	*																			1				1														*
(22) 28	*			1										1	1				1	1			1															*
(23) 29	*			1										1					1	1			1		1													*
(24) 30	*													1	1	1				1			1															*
==========	*	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	*
(25) 10	*																										1	1										*
(26) 20	*																									1	1	1	1									*
(27) 21	*																									1	1			1								*
==========	*	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	*
(28) 3	*																																1	1				*
(29) 12	*																																			1	1	*

```
(  30)  19  * 1                                                                1 1         *
=========== * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

< Machine cells and Part families  >
============================================================
Machine Cell[ 1] = { 7, 8, 9, 10, 11, 12, 13, 16, 18, 20, 21, 26, 31 }
Machine Cell[ 2] = { 1, 3, 4, 5, 15, 19, 24, 32, 33, 34, 35, 36, 37 }
Machine Cell[ 3] = { 14, 17, 22, 29, 30 }
Machine Cell[ 4] = { 2, 6, 23, 25, 27, 28 }
============================================================
Part  Family[ 1] = { 1, 2, 7, 8, 13, 14, 15, 22, 23, 24 }
Part  Family[ 2] = { 4, 5, 6, 9, 11, 16, 17, 18, 25, 26, 27, 28, 29, 30 }
Part  Family[ 3] = { 10, 20, 21 }
Part  Family[ 4] = { 3, 12, 19 }
============================================================

< Summary of the performance measures >
============================================================
No. of machines                          = 37
No. of part types                        = 30
No. of cells                             = 4
Machine cell size                        = 13
Total no. of 1's in the original MPIM : |A| = 107
Matrix density                           = 0.0964
Total no. of within-block 1's            = 94
No. of exceptional elements (EEs)        = 13
No. of voids                             = 251
Sum of EEs and voids                     = 264
Group Cability Index (GCI)               = 87.85 %
grouping efficiency (GE)                 = 62.77 %
Grouping efficacy (GF)                   = 26.26 %
Machine utilization (MU)                 = 27.25 %
No. of redundant machines (RMs)          = 0
============================================================
```

Problem(112) --> Data file name : DC_43_YangYang(2008)_Figure_7_28x35.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {  24,  26,   3 }
Part[   2] = {  24,  26,  16 }
Part[   3] = {  26,  25,   5,  12,  10 }
Part[   4] = {  20,  26,  19,  27,  11,   4 }
Part[   5] = {  22,  10,   4,  17,  28 }
Part[   6] = {   1,   7,  14,  21,  15 }
Part[   7] = {  24,  26,   3,  16 }
Part[   8] = {   1,   7,  14,  21,  15,   9,  27 }
Part[   9] = {  25,   9,  12,  23,  11 }
Part[  10] = {  21,  25,   9,   5,  12 }
Part[  11] = {  19,  23,  27,  11 }
Part[  12] = {  26,  16,  18,  22,  10,   4,  17 }
Part[  13] = {   6,  26,   3,  16,  18,  22 }
Part[  14] = {   1,  14,  21,  15,   3,   5 }
Part[  15] = {   1,   7,  14,  15,  20,  16 }
Part[  16] = {   8,   2,   6,  13,  20 }
Part[  17] = {  21,   2,  16,  25,   9,   5,  12,  10 }
Part[  18] = {  21,  13,   9,   5,  17 }
Part[  19] = {  15,  19,  23,  27,  11 }
Part[  20] = {  25,  12,  23,  18,  22,  10,   4,  28 }
Part[  21] = {  21,  24,  26,   3,  16 }
Part[  22] = {  24,  26,   3,  16 }
Part[  23] = {   2,  24,  25,  22,  10,   4,  17,  28 }
Part[  24] = {   2,  25,   9,   5,  12,  19,  22 }
Part[  25] = {  24,  26,   3,  16 }
Part[  26] = {   8,   2,   6,  13,  20,   5,  27,   4 }
Part[  27] = {   6,   5,  19,  23,  27 }
Part[  28] = {   8,   2,   6,  20 }
Part[  29] = {  14,  24,  12,  18,  22,   4,  17,  28 }
Part[  30] = {   1,   7,  14,  21,  15,   6 }
Part[  31] = {   2,  24,  26,   3,  16,  23,  27 }
Part[  32] = {   5,  18,  22,  10,   4,  17,  28 }
Part[  33] = {  19,  23,  27,  11 }
Part[  34] = {   1,   7,  14,  21,  15 }
Part[  35] = {  15,  18,   4,  17,  28 }
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2
              1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
            < Machines >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 1 1 2 0 1 2 2 0 0 0 1 2 0 0 1 2 1 1 2 2 0 1 1 1 2 2 3 3 4
< Parts >     1 7 4 5 1 3 6 4 6 2 6 8 3 0 5 9 2 5 1 9 3 7 4 0 7 8 2 8 4 5 6
=========== * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
(   1)   6  * 1 1 1 1 1                                                   *
(   2)   8  * 1 1 1 1 1                       1           1               *
(   3)  14  * 1   1 1 1 1                   1                             *
(   4)  15  * 1 1 1 1     1             1                                 *
(   5)  30  * 1 1 1 1 1           1                                       *
(   6)  34  * 1 1 1 1 1                                                   *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(   7)   1  *           1   1 1                                         *
(   8)   2  *             1 1 1                                         *
(   9)   7  *           1 1 1 1                                         *
(  10)  13  *           1 1   1   1                           1 1       *
(  11)  21  *         1 1 1 1 1                                         *
(  12)  22  *           1 1 1 1                                         *
(  13)  25  *           1 1 1 1                                         *
(  14)  31  *           1 1 1 1 1                     1 1               *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  15)  16  *                   1 1 1 1 1                               *
(  16)  26  *                   1 1 1 1 1 1             1 1             *
(  17)  28  *                   1 1 1   1                               *
=========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
```

```
(  18)   3  *                  1           1   1 1           1         *
(  19)   9  *                                1 1 1 1   1                 *
(  20)  10  *         1                    1 1 1 1                       *
(  21)  17  *         1   1     1          1 1 1 1           1           *
(  22)  18  *         1               1    1 1                 1         *
(  23)  24  *                       1      1 1 1 1   1             1   *
========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  24)   4  *                  1         1         1 1   1 1             *
(  25)  11  *                                      1 1 1 1               *
(  26)  19  *       1                              1 1 1 1               *
(  27)  27  *                      1       1         1 1 1               *
(  28)  33  *                                      1 1 1 1               *
========== * = = = = = = = = = = = = = = = = = = = = = = = = = = = = = *
(  29)   5  *                                                1 1 1   1 1 *
(  30)  12  *             1   1                              1 1 1 1 1   *
(  31)  20  *                                    1 1     1   1 1   1 1 1 *
(  32)  23  *               1   1                  1         1 1 1   1 1 *
(  33)  29  *     1         1                    1           1   1 1 1 1 *
(  34)  32  *                              1                 1 1 1 1 1 1 *
(  35)  35  *       1                                        1   1 1   1 *
========== * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
```

```
< Machine cells and Part families  >
============================================================
Machine Cell[ 1] = { 1, 7, 14, 15, 21 }
Machine Cell[ 2] = { 3, 16, 24, 26 }
Machine Cell[ 3] = { 2, 6, 8, 13, 20 }
Machine Cell[ 4] = { 5, 9, 12, 25 }
Machine Cell[ 5] = { 11, 19, 23, 27 }
Machine Cell[ 6] = { 4, 10, 17, 18, 22, 28 }
============================================================
Part  Family[ 1] = { 6, 8, 14, 15, 30, 34 }
Part  Family[ 2] = { 1, 2, 7, 13, 21, 22, 25, 31 }
Part  Family[ 3] = { 16, 26, 28 }
Part  Family[ 4] = { 3, 9, 10, 17, 18, 24 }
Part  Family[ 5] = { 4, 11, 19, 27, 33 }
Part  Family[ 6] = { 5, 12, 20, 23, 29, 32, 35 }
============================================================

< Summary of the performance measures >
============================================================
No. of machines                          = 28
No. of part types                        = 35
No. of cells                             = 6
Machine cell size                        = 6
Total no. of 1's in the original MPIM : |A| = 195
Matrix density                           = 0.199
Total no. of within-block 1's            = 144
No. of exceptional elements (EEs)        = 51
No. of voids                             = 19
Sum of EEs and voids                     = 70
Group Cability Index (GCI)               = 73.85 %
grouping efficiency (GE)                 = 91.05 %
Grouping efficacy (GF)                   = 67.29 %
Machine utilization (MU)                 = 88.34 %
No. of redundant machines (RMs)          = 0
============================================================
```

Problem(113) --> Data file name : DC_44_Arkat(2011)_10x17.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   1,   4,   5,   7 }
Part[   2] = {   1,   2,   6,   7,  10 }
Part[   3] = {   2,   5,   6 }
Part[   4] = {   1,   2,   3,   4,   6,   8,   9 }
Part[   5] = {  12,   3,   4,   6,   8 }
Part[   6] = {   7,   8 }
Part[   7] = {   2,   3,   5,   6 }
Part[   8] = {   1,   2,   6,   7 }
Part[   9] = {   1,   2,   4,   5,   9,  10 }
Part[  10] = {   1,   2,   6,   7,   8,   9,  10 }
Part[  11] = {   2,   3,   4,   5,   9 }
Part[  12] = {   1,   3,   7,   8 }
Part[  13] = {   1,   2,   4,   6,   7,   8,   9 }
Part[  14] = {   6,   7,   8,   9,  10 }
Part[  15] = {   1,   2,   4,   5,   6 }
Part[  16] = {   3,   4,   9 }
Part[  17] = {   1,   2,   3,   6,   8 }
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 1
              1 2 3 4 5 6 7 8 9 0
            < Machines >
              0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 1
< Parts >     4 5 9 1 2 6 7 8 3 0
=========== * * * * * * * * * * *
(   1)   1  * 1 1   1     1       *
(   2)   9  * 1 1 1 1 1         1 *
(   3)  11  * 1 1 1   1       1   *
(   4)  16  * 1   1             1   *
=========== * = = = = = = = = = = *
(   5)   2  *       1 1 1 1     1 *
(   6)   3  *   1     1 1         *
(   7)   4  * 1   1 1 1 1   1 1   *
(   8)   5  * 1         1   1 1   *
(   9)   6  *             1 1     *
(  10)   7  *   1     1 1     1   *
(  11)   8  *       1 1 1 1       *
(  12)  10  *     1 1 1 1 1 1   1 *
(  13)  12  *       1     1 1 1   *
(  14)  13  * 1   1 1 1 1 1 1     *
(  15)  14  *     1     1 1 1   1 *
(  16)  15  * 1 1   1 1 1         *
(  17)  17  *       1 1 1   1 1   *
=========== * = = = = = = = = = = *
=========== * * * * * * * * * * *
```

< Machine cells and Part families >

```
Machine Cell[ 1] = { 4, 5, 9 }
Machine Cell[ 2] = { 1, 2, 6, 7, 8 }
Machine Cell[ 3] = { 3, 10 }  --> Residual cell
```

```
Part  Family[ 1] = { 1, 9, 11, 16 }
Part  Family[ 2] = { 2, 3, 4, 5, 6, 7, 8, 10, 12, 13, 14, 15, 17 }
Part  Family[ 3] --> Empty Part family
```

< Summary of the performance measures >

```
No. of machines                                = 10
No. of part types                              = 17
No. of cells                                   = 3
Machine cell size                              = 5
```

```
Total no. of 1's in the original MPIM : |A| = 80
Matrix density                              = 0.471
Total no. of within-block 1's               = 53
No. of exceptional elements (EEs)           = 27
No. of voids                                = 24
Sum of EEs and voids                        = 51
Group Cability Index (GCI)                  = 66.25 %
grouping efficiency (GE)                    = 69.90 %
Grouping efficacy (GF)                      = 50.96 %
Machine utilization (MU)                    = 68.83 %
No. of redundant machines (RMs)             = 2
============================================================
```

Problem(114) --> Data file name : DC_45_ShaferRogers(1993)_Figure_3_20x20.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   1,   4,   5,   7,  15 }
Part[   2] = {   2,   3,   4,   5,   8,  16,  20 }
Part[   3] = {   4,   5,  11 }
Part[   4] = {   2,   5,   8,  14 }
Part[   5] = {   3,   5,  11,  19 }
Part[   6] = {   2,   3,   8,  10 }
Part[   7] = {   4,   7,   9,  19 }
Part[   8] = {   6,   8,   9,  14 }
Part[   9] = {   8,   9 }
Part[  10] = {   3,   6,   7,   8,   9,  10,  17 }
Part[  11] = {   7,  11,  12,  14 }
Part[  12] = {   1,   4,  12,  14,  15 }
Part[  13] = {  11,  13,  15 }
Part[  14] = {   2,   7,   8,  14,  15 }
Part[  15] = {   2,  12,  15 }
Part[  16] = {  17,  18,  20 }
Part[  17] = {   6,   7,   9,  16,  18,  19 }
Part[  18] = {  16,  17,  18,  19,  20 }
Part[  19] = {   3,  16,  17,  18,  19 }
Part[  20] = {   2,  13,  17,  18 }
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 2
              1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
            < Machines >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 1 1 1 1 1 2 0 0 0 1 1 0 0 1 1 1
< Parts >     6 7 8 9 4 6 7 8 9 0 2 3 5 0 1 1 4 2 3 5
=========== * * * * * * * * * * * * * * * * * * * * *
(   1)   7  *   1   1         1                1       *
(   2)   8  * 1   1 1 1                              *
(   3)   9  *     1 1                                *
(   4)  10  * 1 1 1 1     1         1   1            *
(   5)  11  *   1     1                    1     1    *
(   6)  14  *   1 1   1           1                 1 *
(   7)  17  * 1 1   1   1   1 1                       *
=========== * = = = = = = = = = = = = = = = = = = = *
(   8)  16  *             1 1   1                   *
(   9)  18  *           1 1 1 1 1                   *
(  10)  19  *           1 1 1 1     1               *
(  11)  20  *             1 1     1             1   *
=========== * = = = = = = = = = = = = = = = = = = = *
(  12)   2  *     1     1       1 1 1 1       1      *
(  13)   3  *                         1   1   1      *
(  14)   4  *     1   1           1   1              *
(  15)   5  *                 1     1 1   1          *
(  16)   6  *     1               1 1   1            *
=========== * = = = = = = = = = = = = = = = = = = = *
(  17)   1  *   1                     1     1 1    1 *
(  18)  12  *         1                     1 1 1  1 *
(  19)  13  *                           1      1 1 *
(  20)  15  *                   1             1  1 *
=========== * * * * * * * * * * * * * * * * * * * * *
```

< Machine cells and Part families >

```
Machine Cell[ 1] = { 6, 7, 8, 9, 14 }
Machine Cell[ 2] = { 16, 17, 18, 19, 20 }
Machine Cell[ 3] = { 2, 3, 5, 10, 11 }
Machine Cell[ 4] = { 1, 4, 12, 13, 15 }
```

```
Part  Family[ 1] = { 7, 8, 9, 10, 11, 14, 17 }
Part  Family[ 2] = { 16, 18, 19, 20 }
Part  Family[ 3] = { 2, 3, 4, 5, 6 }
```

Part Family[4] = { 1, 12, 13, 15 }
==========

< Summary of the performance measures >
==========
No. of machines = 20
No. of part types = 20
No. of cells = 4
Machine cell size = 5
Total no. of 1's in the original MPIM : |A| = 87
Matrix density = 0.217
Total no. of within-block 1's = 58
No. of exceptional elements (EEs) = 29
No. of voids = 42
Sum of EEs and voids = 71
Group Cability Index (GCI) = 66.67 %
grouping efficiency (GE) = 74.17 %
Grouping efficacy (GF) = 44.96 %
Machine utilization (MU) = 58.00 %
No. of redundant machines (RMs) = 0
==========

Problem(115) --> Data file name : DC_46_ShaferRogers(1993)_Figure_4_20x20.cfp

< Machines visited by parts: Process route numbers(PRN) >

```
Part[   1] = {   1,   2,   3,   5,   6,   8,   9,  10,  17,  19 }
Part[   2] = {   1,   4,   5,  12,  15,  17,  20 }
Part[   3] = {   1,   2,   3,   4,   5,   7,   8,  10,  12,  13,  16,  17 }
Part[   4] = {   1,   2,   3,   4,   7,   8,   9,  13,  15,  18 }
Part[   5] = {   3,   4,   5,   8,   9,  12,  16,  19,  20 }
Part[   6] = {   6,   7,   8,  14,  20 }
Part[   7] = {   2,   7,   8,   9,  11,  12,  13,  17,  19 }
Part[   8] = {   1,   6,   7,   8,   9,  12,  14,  16,  17 }
Part[   9] = {   1,   6,   7,   8,   9,  10,  11,  13,  14,  18 }
Part[  10] = {   2,   4,   7,   8,   9,  10,  12,  13,  19 }
Part[  11] = {   4,   5,   6,   7,   8,   9,  11,  12,  14,  15,  17,  18,  19 }
Part[  12] = {   5,   7,   9,  10,  11,  12,  13,  14,  17,  19 }
Part[  13] = {   6,  10,  11,  13 }
Part[  14] = {   5,   7,  10,  11,  12,  14,  15 }
Part[  15] = {   1,   7,   8,   9,  11,  12,  13,  14,  18,  19 }
Part[  16] = {   1,   7,  12,  15,  16,  17,  18 }
Part[  17] = {   2,   8,   9,  10,  12,  14,  15,  16,  17,  18 }
Part[  18] = {   2,   5,   6,   8,  12,  13,  16,  17,  19 }
Part[  19] = {   6,  10,  16,  17,  18,  20 }
Part[  20] = {   2,   4,   6,   7,  11,  13,  16,  17,  18,  20 }
```

< Block Diagonal Solution Matrix >

```
            < Locations >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 2
              1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
            < Machines >
              0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
              0 0 0 0 0 0 1 1 1 1 0 0 0 1 1 1 1 1 1 2
< Parts >     1 2 3 4 5 6 0 1 3 4 7 8 9 2 9 5 6 7 8 0
=========== * * * * * * * * * * * * * * * * * * * * * *
(   1)   1  * 1 1 1   1 1 1         1 1   1     1     *
(   2)   3  * 1 1 1 1 1   1   1   1 1   1     1 1     *
(   3)   4  * 1 1 1 1         1   1 1 1     1     1   *
=========== * = = = = = = = = = = = = = = = = = = = = *
(   4)   6  *           1       1 1 1                 1 *
(   5)   9  * 1         1 1 1 1 1 1 1 1           1   *
(   6)  13  *           1 1 1 1                       *
(   7)  14  *         1   1 1   1 1     1   1         *
=========== * = = = = = = = = = = = = = = = = = = = = *
(   8)   5  *     1 1 1             1 1 1 1   1     1 *
(   9)   7  *   1           1 1   1 1 1 1 1     1     *
(  10)   8  * 1         1       1 1 1 1 1     1 1     *
(  11)  10  *   1   1     1   1   1 1 1 1 1             *
(  12)  11  *       1 1 1   1   1 1 1 1 1 1 1   1 1   *
(  13)  12  *         1   1 1 1 1 1   1 1 1     1     *
(  14)  15  * 1             1 1 1 1 1 1 1 1       1   *
(  15)  18  *   1     1 1     1     1   1 1   1 1     *
=========== * = = = = = = = = = = = = = = = = = = = = *
(  16)   2  * 1     1 1                   1   1   1   1 *
(  17)  16  * 1                     1     1   1 1 1 1   *
(  18)  17  *   1         1     1   1 1 1   1 1 1 1   *
(  19)  19  *           1 1                   1 1 1 1 *
(  20)  20  *   1   1   1   1 1   1           1 1 1 1 *
=========== * * * * * * * * * * * * * * * * * * * * * *
```

< Machine cells and Part families >

```
============================================================
Machine Cell[ 1] = { 1, 2, 3, 4, 5 }
Machine Cell[ 2] = { 6, 10, 11, 13, 14 }
Machine Cell[ 3] = { 7, 8, 9, 12, 19 }
Machine Cell[ 4] = { 15, 16, 17, 18, 20 }
============================================================
Part  Family[ 1] = { 1, 3, 4 }
Part  Family[ 2] = { 6, 9, 13, 14 }
Part  Family[ 3] = { 5, 7, 8, 10, 11, 12, 15, 18 }
```

Part Family[4] = { 2, 16, 17, 19, 20 }
==========

< Summary of the performance measures >
==========
No. of machines = 20
No. of part types = 20
No. of cells = 4
Machine cell size = 5
Total no. of 1's in the original MPIM : |A| = 176
Matrix density = 0.44
Total no. of within-block 1's = 81
No. of exceptional elements (EEs) = 95
No. of voids = 19
Sum of EEs and voids = 114
Group Cability Index (GCI) = 46.02 %
grouping efficiency (GE) = 74.67 %
Grouping efficacy (GF) = 41.54 %
Machine utilization (MU) = 81.00 %
No. of redundant machines (RMs) = 0
==========