Production planning and resource scheduling

Planning pallet execution for a set of boxes, we have the input data:

- Storage capacity (number of pallets)
- Storage cost per day for 1 pallet
- Pallet demand for an interval of time (number&type of pallets, client, date/position/interval)
- Pallet creation time
- Resources working costs (normal operation, overtime). 3 shifts types will be defined: the first time in the morning – pallets are loaded into the trucks; 8-17 production and pallet creation in normal regime; evening - overtime
- Decision variables
- How many and what types of pallets are done in each day
- How many pallets and what types are done before time
- Objective function
- Cost minimization (robot assembly, storage and overtime)

We start from the data of the problem:

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1	Date problema(Production planning and resource scheduling)																				
2	Interval (zile)	Post 1			Post 2			...	Post n	Total paleti realizati interval curent			Stoc pentru intervalul urmator			Stoc platibil (in plus fata de intervalul urmator)			Cerere client pe interval		
3		paleti tip 1	paleti tip 2	paleti tip 3	paleti tip 1	paleti tip 2	paleti tip 3			paleti tip 1	paleti tip 2	paleti tip 3	paleti tip 1	paleti tip 2	paleti tip 3	paleti tip 1	paleti tip 2	paleti tip 3	paleti tip 1	paleti tip 2	paleti tip 3
4	0																				
5	1	9	25	10	1	0	0			10	25	10	10	25	10	0	15	0	10	10	10
6	2	21	21	21	9	0	34			30	21	55	30	36	55	0	6	25	30	30	30
7	3	14	33	20	24	14	11			38	47	31	38	53	56	0	15	18	38	38	38
8	4	29	17	16	19	17	14			48	34	30	48	49	48	0	1	0	48	48	48
9	5	20	20	20	6	6	6			26	26	26	26	27	26	6	7	6	20	20	20
10	6	14	14	14	6	6	6			20	20	20	26	27	26	12	13	12	14	14	14
11																					

We need to find out the following characteristics: WORKING TIMES WORKSTATIONS, Total work P1, Total work P2, Difference between Production 1 and Production 2, NORMAL COSTS WORKSTATIONS, NORMAL TIMES WORKSTATIONS, STORAGE COSTS, OVERTIME TIMES WORKSTATIONS, OVERTIME COSTS and their constraints.

We have the following constraints:

cost normal post 1 (um/dt)exemplu	20	um/min	Constrangeri
cost normal post 2 (um/dt)	30	um/min	stoc platibil / interval urmator >0
…			variabile decizionale >0
cost normal post n (um/dt)	100	um/min	timpi de lucru < 8 (+8) ore /zi
cost overtime post 1 (um/dt)	40	um/min	
cost overtime post 2 (um/dt)	60	um/min	
…			
cost overtime post n (um/dt)	200	um/min	
timp realizare palet post 1	8	min	aici ar trebui timpi diferiti pentru paleti diferiti pe fiecare tip de palet
timp realizare palet post 2	10	min	
…			
timp realizare palet post n	20	min	
limita timp (normal) post 1..n	480	min	8ore lucru normal
limita timp (overtime) post 1..n	480	min	8 ore lucru extra/overtime
cost mentinere 1 palet 1 interval de	20	um	

For WORKING TIMES WORKSTATIONS:

Apply the following formulas for each cell: “timp realizare palet post 1”(8 min)*pallet type 1/2/3(from the workstation 1); “timp realizare palet post 2”(10 min)* pallet type 1/2/3(from the workstation 2). Then “$B$17:$G$22 >= 0” as solver constraint because time needs to be greater or equal to 0.

TIMPI DE LUCRU POSTURI								
Interval (zile)	Post 1			Post 2			…	Post n
	paleti tip 1	paleti tip 2	paleti tip 3	paleti tip 1	paleti tip 2	paleti tip 3		
0	0	0	0	0	0	0		
1	72	200	80	10	0	0		
2	168	168	168	90	0	340		
3	112	264	160	240	140	110		
4	232	136	128	190	170	140		
5	160	160	160	60	60	60		
6	112	112	112	60	60	60		

For Total work P1, Total work P2, Difference between Production 1 and Production 2:

Total lucru P1	Total lucru P2	Diff P1	Diff P2

1	352	10	342	342
2	504	430	74	74
3	536	490	46	46
4	496	500	4	4
5	480	180	300	300
6	336	180	156	156

For calculating “Total lucru P1/P2” we applied the previous results: “WORKING TIMES WORKSTATIONS”(Post 1 or 2)*interval from the base table(B5 up to G10).

For Diff P1 and Diff P2: I applied the base math difference formula ABS(“Total lucru P1”-“Total lucru P2”) and vice-versa, I needed an absolute value for always having a positive number.

For: NORMAL TIMES WORKSTATIONS:

For each workstation, we need to calculate Post 1 = (“paleti tip 1”+”paleti tip 2” + “paleti tip 3”) from the WORKING TIMES WORKSTATIONS table for the corresponding workstation.

TIMPI NORMALI POSTURI				
Interval (zile)	Post 1	Post 2	…	Post n
0				
1	352	10		
2	504	430		
3	536	490		
4	496	500		
5	480	180		
6	336	180		

For: NORMAL COSTS WORKSTATIONS:

We calculate in a row of 6 days “Post 1” multiply by “cost normal post 1 (20 um/dt)”, and “Post 2” is multiplied by “cost normal post 2 (30 um/dt)”

COSTURI NORMALE POSTURI				
Interval (zile)	Post 1	Post 2	…	Post n
0				
1	7040	300		
2	10080	12900		
3	10720	14700		
4	9920	15000		

5	9600	5400	
6	6720	5400	

For OVERTIME TIMES WORKSTATIONS:

IF(SUM("paleti tip 1", "paleti tip 2", "paleti tip 3") - "limita timp (overtime) post 1..n(480 minutes)" greater or equal to 0, SUM("paleti tip 1", "paleti tip 2", "paleti tip 3") – "limita timp (normal) post 1..n(480 minutes)"

TIMPI OVERTIME POSTURI				
Interval (zile)	Post 1	Post 2	…	Post n
0				
1	0	0		
2	24	0		
3	56	10		
4	16	20		
5	0	0		
6	0	0		

For OVERTIME COSTS WORKSTATIONS:

Here we calculate from the previous table "Post 1" * "cost overtime post 1 (40 um/dt)",

And same for the second workstation: "Post 2" * "cost overtime post 2 (60 um/dt)".

COSTURI OVERTIME POSTURI				
Interval (zile)	Post 1	Post 2	…	Post n
0				
1	0	0		
2	960	0		
3	2240	600		
4	640	1200		
5	0	0		
6	0	0		

For STORAGE COSTS:

From the main table we calculate for each individual day: sum of "paleti tip 1/2/3" from the both workstations then we subtract with "Cerere client pe interval", then adding "Stoc platibil (in plus fata de intervalul urmator)", and the resulted number is multiplied with "cost mentinere 1 palet 1 interval de timp (20 um)"

COSTURI STOCARE	
Interval (zile)	
0	
1	600
2	940
3	700
4	-620
5	740
6	1100

And for the final COST we make a final sum between the “COSTURI NORMALE POSTURI”, “COSTURI OVERTIME POSTURI”, “COSTURI STOCARE”.

$B$5:$G$10 = integer and >= 0,

$J$5:$R$10 greater or equal to 0, as last three constraints

COST	116880