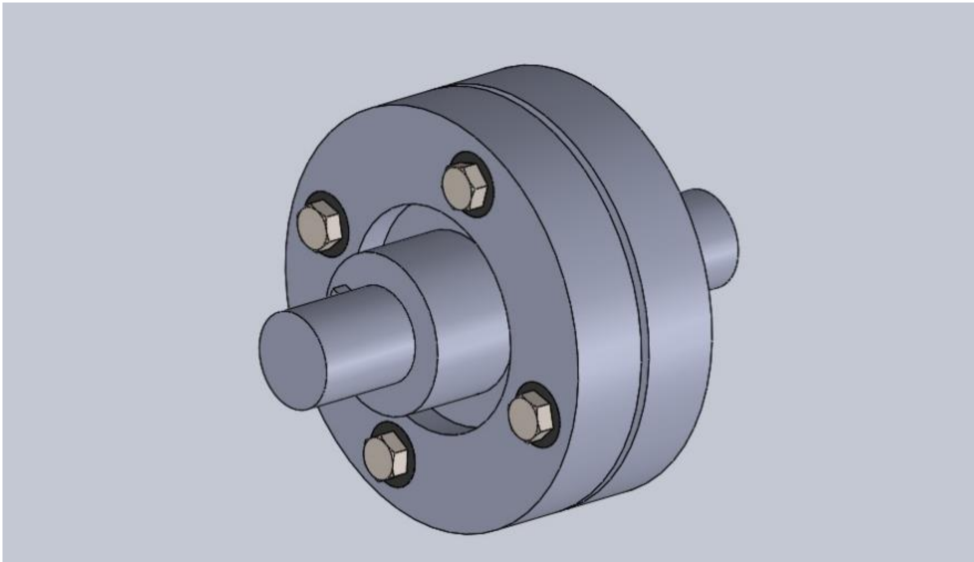
- ***Flange Coupling :-***



- ***Nomenclature for design of flange coupling :-***

Let d = Diameter of shaft or inner diameter of hub,

D = Outer diameter of hub,

d_1 = Nominal or outside diameter of bolt,

D_1 = Diameter of bolt circle,

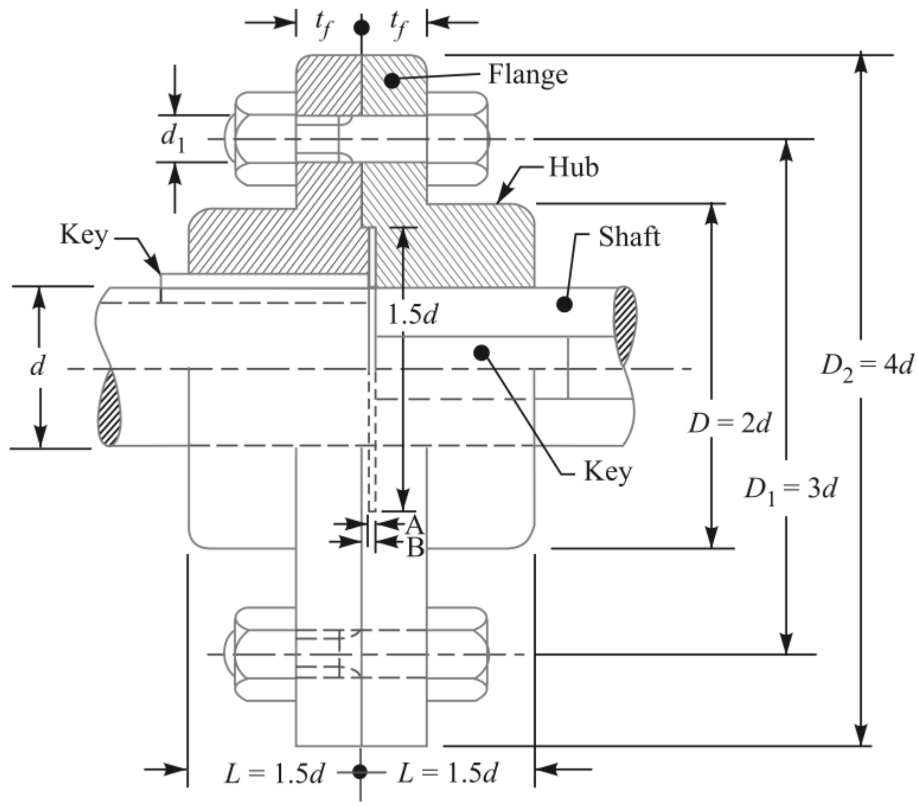
n = Number of bolts,

t_f = Thickness of flange,

τ_s, τ_b & τ_k = Allowable shear stress for shaft, bolt and key material respectively

τ_c = Allowable shear stress for the flange material i.e. cast iron,

σ_{cb}, & σ_{ck} = Allowable crushing stress for bolt and key material respectively.



- ***Design for hub :-***

The hub is designed by considering it as a hollow shaft, transmitting the same torque (T) as that of a solid shaft.

$$\therefore T = \frac{\pi}{16}\tau_c\left(\frac{D^4 - d^4}{D}\right)$$

The outer diameter of hub is usually taken as twice the diameter of shaft. Therefore, from the above relation, the induced shearing stress in the hub may be checked.

The length of hub (L) is taken as 1.5 d.

- ***Design for key :-***

The key is designed with usual proportions and then checked for shearing and crushing stresses. The material of key is usually the same as that of shaft. The length of key is taken equal to the length of hub.

- ***Design for flange :-***

The flange at the junction of the hub is under shear while transmitting the torque.

Therefore, the torque transmitted, T = Circumference of hub × Thickness of flange × Shear stress of flange × Radius of hub

$$= \pi D * t_f * \tau_c * \frac{D}{2}$$

$$= \frac{\pi D^2}{2} * t_f * \tau_c$$

The thickness of flange is usually taken as half the diameter of shaft. Therefore, from the above relation, the induced shearing stress in the flange may be checked.

- ***Design for bolt :-***

The bolts are subjected to shear stress due to the torque transmitted. The number of bolts (n) depends upon the diameter of shaft and the pitch circle diameter of bolts (D_1) is taken as 3 d.

Load on each bolt = $\frac{\pi}{4} d_1^2 * \tau_b$

Total load on all the bolts = $\frac{\pi}{4} d_1^2 * \tau_b * n$

Torque transmitted, T = $\frac{\pi}{4} d_1^2 * \tau_b * n * \frac{D_1}{2}$

From this equation, the diameter of bolt (d_1) will be obtained.

Now the diameter of bolt may be checked in crushing.

We know that area resisting crushing of all the bolts = $n \times d_1 \times t_f$

and crushing strength of all the bolts = $(n \times d_1 \times t_f)\ \sigma_{cb}$

∴ Torque, T = $n * d_1 * t_f * \sigma_{cb} * \frac{D_1}{2}$

- ***Generalised program for Design of Flange Coupling :-***

```
#include<stdio.h>
#include<math.h>
#define pi 3.14
void main()
{

       int i, n, shaft, kandb, shaftyt, kandbyt, flange, flangeut,
dnew;
    int d_h, l_h, D, t, t_1, d_r, D_o, c, r, f, N, d_1, b, h, l;
    int
k[32]={5,6,8,10,12,14,16,18,20,22,25,28,30,32,35,40,45,50,55,60,65,70
,75,80,90,100,110,120,140,160,180,200};    //shaft diameter array
       float Power, shaftf, kandbf, flangef, shaftsy, shearshaft,
kandbsy, shearkandb, crushingkandb;
       float crushingstresskandb, flangesu, shearflange,
servicefactor, designtorque, dshaft, dnewshaft;
       float a, J, hubshear, shear_stress_flange, depth, shear_key,
comp_key, d_b, comp_stress;
```

```
    system("color 70");
       printf("\nEnter the value of Power (KW) : ");
       scanf("%f",&Power);

       printf("\nEnter the rpm (n) : ");
       scanf("%d",&n);

       printf("\nMaterial of shaft that are available is: 
\n\t\t\t\t\t1) 40C8 (Carbon Steel (0.40%% carbon)) \n\t\t\t\t\t2) 
30C8 (Carbon Steel (0.30%% carbon)) \n\t\t\t\t\t3) 35C8 (Carbon Steel 
(0.35%% carbon))\n");      //shaft material selection
       printf("\nEnter the serial no for shaft material : ");
       scanf("%d",&shaft);

       switch(shaft)
       {
              case 1:
                     printf("\nYield Tensile strength of 40C8 shaft 
is 380 M-pa");
            shaftyt=380;
                     break;
              case 2:
                     printf("\nYield Tensile strength of 30C8 shaft 
is 400 M-pa");
                     shaftyt=400;
                     break;
              case 3:
                     printf("\nYield Tensile strength of 35C8 shaft 
is 390 M-pa");
                     shaftyt=390;
                     break;
              default:
                     printf("Default yield tensile strength is of 
40C8 is 380 M-pa");
                     break;
       }

        printf("\n\nEnter the safety factor for the shafts : ");
        scanf("%f",&shaftf);

        printf("\nMaterial for bolts and keys that are available is: 
\n\t\t\t\t\t1) 40C8 (Carbon Steel (0.40%% carbon)) \n\t\t\t\t\t2) 
30C8 (Carbon Steel (0.30%% carbon)) \n\t\t\t\t\t3) 35C8 (Carbon Steel 
(0.35%% carbon))\n");
        //MATERIAL OF BOLTS AND KEY
        printf("\nEnter the serial no for bolt and keys material : 
");
        scanf("%d",&kandb);

      switch(kandb)
      {
              case 1:
                     printf("\nYield Tensile strength of40C8 key and 
```

```
bolts is 380 M-pa");
                        kandbyt=380;
                        break;
                case 2:
                        printf("\nYield Tensile strength of 30C8 keys 
and bolts is 400 M-pa");
                        kandbyt=400;
                        break;
                case 3:
                        printf("\nYield Tensile strength of 35C8 keys 
and bolts is 390 M-pa");
                        kandbyt=390;
                        break;
                default:
                        printf("Default yield tensile strength is of 
30C8 is 400 M-pa");
                        break;
        }

         printf("\n\nEnter the safety factor for the key and bolts : 
");
         scanf("%f",&kandbf);

         printf("\nMaterial for flange that are available is: 
\n\t\t\t\t\t1) FG200 (Grey Cast Iron) \n\t\t\t\t\t2) FG250 (Grey Cast 
Iron) \n\t\t\t\t\t3) FG300 (Grey Cast Iron)\n");    //material of 
flange
         printf("\nEnter the serial no for flange material : ");
         scanf("%d", &flange);

        switch(flange)
        {
                case 1:
                        printf("\nUtimate Tensile strength of FG200 
flange is 200 M-pa");
                        flangeut=200;
                        break;
                case 2:
                        printf("\nUltimate Tensile strength of FG250 
flange is 250 M-pa");
                        flangeut=250;
                        break;
                case 3:
                        printf("\nUltimate Tensile strength of FG300 
shaft is 300 M-pa");
                        flangeut=300;
                        break;
                default:
                        printf("Default Ultimate tensile strength is of 
FG200 is 200 M-pa");
                        break;
        }
```

```
      printf("\n\nEnter the safety factor for the flange : ");
      scanf("%f",&flangef);

      shaftsy = 0.5 * shaftyt;
      shearshaft = shaftsy / shaftf;
      printf("\nshear in shaft = %0.3f M-pa\n",shearshaft);

      kandbsy = 0.5 * kandbyt;
      shearkandb = kandbsy / kandbf;
      printf("\nshear in key and bolt = %0.3f M-pa\n",shearkandb);

      crushingkandb = 1.5 * kandbyt;
      crushingstresskandb = crushingkandb / kandbf;
      printf("\nCompressive stress in key and bolt = %0.3f M-
pa\n",crushingstresskandb);

      flangesu = 0.5 * flangeut;
      shearflange = flangesu / flangef;
      printf("\nFlange shear = %0.3f M-pa\n",shearflange);

      printf("\n\n\t**Diameter of shafts**\n");
      printf("\n\t  --------------------  ");
      printf("\n\nEnter value of servicefactor : ");
      scanf("%f",&servicefactor);

      designtorque=((60 * 1000000 * servicefactor * Power) / (2 * pi
* n));
      printf("\n\nDesign torque = %0.3f N-mm\n",designtorque);
      a=((16 * designtorque) / (3.14 * shearshaft));

        dshaft=pow(a,0.3333);
        for(i=0;i<32;i++)
        {
            if(k[i]>dshaft)
                {
                    dnew=k[i];
                    printf("\nDiameter of shaft = %d mm\n",dnew);
                    break;
                }
        }

    printf("\n\n*********** Dimension of Flange Coupling are as
follows **************\n");

    d_h = (2 * dnew);
    l_h = (1.5 * dnew);
    D = (3 * dnew);
    t = (0.5 * dnew);
    t_1 = (0.25 * dnew);
    d_r = (1.5 * dnew);
    D_o = ((4 * dnew) + (2 * t_1));

    printf("\n\t\tOutside Diameter of hub (D) = %d mm\n",d_h);
```

```
    printf("\n\t\tLength of hub (L) = %d mm\n",l_h);
    printf("\n\t\tPitch Circle diameter of bolts (D1) = %d mm\n",D);
    printf("\n\t\tThickness of flange (tf) = %d mm\n",t);
    printf("\n\t\tThickness of Protecting Rim (t) = %d mm\n",t_1);
    printf("\n\t\tDiameter of Spigot and recess = %d mm\n",d_r);
    printf("\n\t\tOutside Diameter of flange (D2) = %d mm\n",D_o);

//Thickness of Recess is assumed to be 5mm.
//The Hub is treated as hollow shaft subjected to Torsional Moment.

    c = pow(d_h,4);
    b = pow(dnew,4);

    J = ((3.14 * (c-b)) / 32);
    r = d_h / 2;
    f = pow(d_h,2);

//Torsional Shear Stress is hub.
    hubshear = ((designtorque * r) / J);

    if(hubshear<shearflange)
    {
        printf("\nDesign of Hub Diameter is safe...\n");
    }
    else
    {
        printf("\n try again!!\n");
    }

//shear stress in the flange at the junction of hub.
    shear_stress_flange = ((2 * designtorque) / (3.14 * f*t));

    if(shear_stress_flange < shearflange)
    {
        printf("\nStresses in the flange are within permissible
limits...\n");
    }
    else
    {
        printf("\n try again!!\n");
    }

    if(dnew<=40)
    {
        N=3;
        printf("\n\t\tNo of Bolts (N) = 3,  (as shaft diameter <= 40
mm)\n");
    }
    else if(40<dnew<=100)
    {
        N=4;
        printf("\n\t\tNo of Bolts (N) = 4,    (as shaft diameter 40
mm < d <= 100 mm)\n");
```

```
    }
    else if(100<dnew<180)
    {
        N=6;
        printf("\n\t\tNo of Bolts (N) = 6,    (as shaft diameter 100
mm < d <= 180 mm)\n");
    }

//Diameter of bolt
    d_b = ((8 * designtorque) / (3.14 * D * N * shearkandb));
    d_b = sqrt(d_b);
    d_1 = ceil(d_b);
    printf("\n\t\tDiameter of Bolts (d1) = %d mm\n",d_1);

//compressive stress in bolt is determined.
    comp_stress=((2 * designtorque) / (3.14 * d_1 * t * D * N));

    if(comp_stress<crushingstresskandb)
    {
        printf("\nIt is safe as it is within permissible limit of
compressive stress...\n");
    }
    else
    {
        printf("\n try again!!\n");
    }

    if(6<dnew && dnew<=8)
    {
        b=2;
        h=2;
        depth=1.2;
    }
    else if(8<dnew && dnew<=10)
    {
        b=3;
        h=3;
        depth=1.8;
    }
    else if(10<dnew && dnew<=12)
    {
        b=4;
        h=4;
        depth=2.5;
    }
    else if(12<dnew && dnew<=17)
    {
        b=5;
        h=5;
        depth=3;
    }
    else if(17<dnew && dnew<=22)
    {
```

```
        b=6;
        h=6;
        depth=3.5;
    }
    else if(22<dnew && dnew<=30)
    {
        b=8;
        h=7;
        depth=4;
    }
    else if(30<dnew && dnew<=38)
    {
        b=10;
        h=8;
        depth=5;
    }
    else if(38<dnew && dnew<=44)
    {
        b=12;
        h=8;
        depth=5;
    }
    else if(44<dnew && dnew<=50)
    {
        b=14;
        h=9;
        depth=5.5;
    }
    else if(50<dnew && dnew<=58)
    {
        b=16;
        h=10;
        depth=6;
    }
    else if(58<dnew && dnew<=65)
    {
        b=18;
        h=11;
        depth=7;
    }
    else if(65<dnew && dnew<=75)
    {
        b=20;
        h=12;
        depth=7.5;
    }
    else if(75<dnew && dnew<=85)
    {
        b=22;
        h=14;
        depth=9;
    }
    else if(85<dnew && dnew<=95)
```

```
    {
        b=25;
        h=14;
        depth=9;
    }
    else if(95<dnew && dnew<=110)
    {
        b=28;
        h=16;
        depth=10;
    }
    else if(110<dnew && dnew<=130)
    {
        b=32;
        h=18;
        depth=11;
    }
    else if(130<dnew && dnew<=150)
    {
        b=36;
        h=20;
        depth=12;
    }
    else if(150<dnew && dnew<=170)
    {
        b=40;
        h=22;
        depth=13;
    }
    else if(170<dnew && dnew<=200)
    {
        b=45;
        h=25;
        depth=15;
    }
    //The length of the key is equal to hub diameter.
    l=l_h;

    printf("\n\t\tLength of Key (L) = %d mm",l);
    printf("\n\n\t\tBreadth of Key (b) = %d mm",b);
    printf("\n\n\t\tHeight of Key (h) = %d mm",h);

    shear_key=((2* designtorque)/(dnew * b * l));

    if (shear_key < shearkandb)
    {
        printf("\n\nShear stress induced in key is within Permissible
limit...");
    }

    comp_key=((4 * designtorque) / (dnew * h * l));

    if(comp_key < crushingstresskandb)
```

```
    {
        printf("\n\nCompressive stress induced in key is within
Permissible limit...");
    }
    printf("\n\n\n\n");

}
```

- ***Output :-***

C:\Users\rspat\Desktop\chande.exe

```
Enter the value of Power (KW) : 37.5

Enter the rpm (n) : 180

Material of shaft that are available is:
                                        1) 40C8 (Carbon Steel (0.40% carbon))
                                        2) 30C8 (Carbon Steel (0.30% carbon))
                                        3) 35C8 (Carbon Steel (0.35% carbon))

Enter the serial no for shaft material : 1

Yield Tensile strength of 40C8 shaft is 380 M-pa

Enter the safety factor for the shafts : 2.5

Material for bolts and keys that are available is:
                                        1) 40C8 (Carbon Steel (0.40% carbon))
                                        2) 30C8 (Carbon Steel (0.30% carbon))
                                        3) 35C8 (Carbon Steel (0.35% carbon))

Enter the serial no for bolt and keys material : 2

Yield Tensile strength of 30C8 keys and bolts is 400 M-pa

Enter the safety factor for the key and bolts : 2.5

Material for flange that are available is:
                                        1) FG200 (Grey Cast Iron)
                                        2) FG250 (Grey Cast Iron)
                                        3) FG300 (Grey Cast Iron)

Enter the serial no for flange material : 1

Utimate Tensile strength of FG200 flange is 200 M-pa

Enter the safety factor for the flange : 6

shear in shaft = 76.000 M-pa

shear in key and bolt = 80.000 M-pa

Compressive stress in key and bolt = 240.000 M-pa

Flange shear = 16.667 M-pa
```

C:\Users\rspat\Desktop\chande.exe

```
        **Diameter of shafts**

          --------------------

Enter value of servicefactor : 1.5


Design torque = 2985668.750 N-mm

Diameter of shaft = 60 mm


************ Dimension of Flange Coupling are as follows ***************

                Outside Diameter of hub (D) = 120 mm

                Length of hub (L) = 90 mm

                Pitch Circle diameter of bolts (D1) = 180 mm

                Thickness of flange (tf) = 30 mm

                Thickness of Protecting Rim (t) = 15 mm

                Diameter of Spigot and recess = 90 mm

                Outside Diameter of flange (D2) = 270 mm

Design of Hub Diameter is safe...

Stresses in the flange are within permissible limits...

                No of Bolts (N) = 4,    (as shaft diameter 40 mm < d <= 100 mm)

                Diameter of Bolts (d1) = 12 mm

It is safe as it is within permissible limit of compressive stress...

                Length of Key (L) = 90 mm

                Breadth of Key (b) = 18 mm

                Height of Key (h) = 11 mm
```

- **References:-**

-PSG Design Data book

- Mechanical design book by shigley-10th_edition

- (Mechanical) Bhandari, V.B. - Design of Machine Elements-Tata McGraw-Hill (2010)