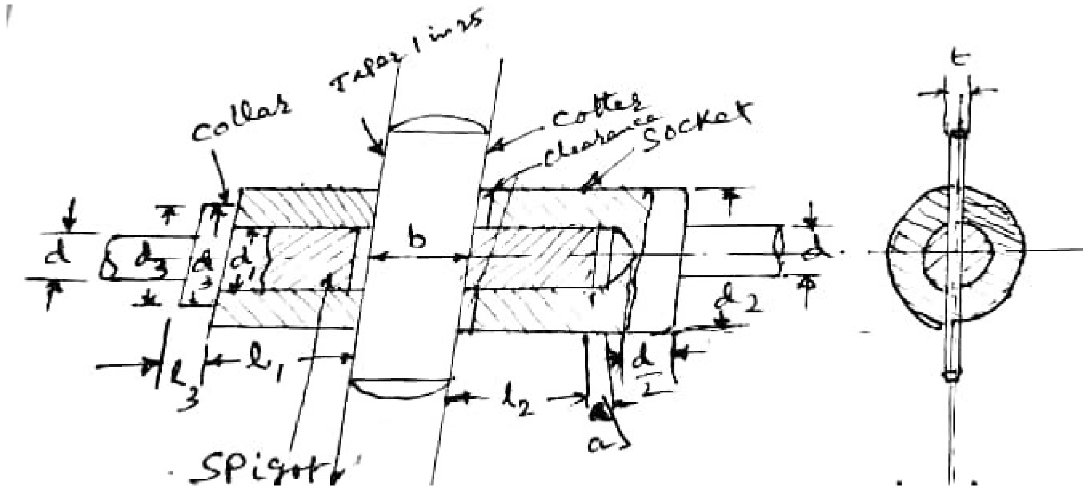
MACHINE DESIGN

DESIGN OF COTTER JOINT

PROBLEM: Design a cotter joint to with stand a load varying from 30KN in tension to 30KN in compression. The material for all components of the joint is steel with their allowable stresses in tension, compression & shears as $60 N/mm^2$,$80 N/mm^2$ and $45 N/mm^2$ respectively.



SOLVE:-

$$F=\pm 30\,KN,\ a_t=60\,N/mm^2,\ a_c=80\,N/mm^2,\ T_s=45\,N/mm^2$$

$$Dia\ of\ \ rod=d,\quad F=\frac{\pi}{4}d^2 a_t,\quad d=\sqrt{\frac{4F}{\pi\times a_t}}=\sqrt{\frac{4\times 30\times 10^3}{\pi\times 60}}=25.24\,mm \simeq 26\,mm$$

Using empirical relation

$$d_1=1.21d=1.21\times 26=31.46\simeq 32\,mm$$

$$d_2=1.75d=1.75\times 26=45.5\simeq 46\,mm$$

$$d_3=1.5d=1.5\times 26=39\,mm$$

$$t=0.4d=0.4\times 26=10.4\simeq 11\,mm$$

$$b=1.6\times d=1.6\times 26=41.6\simeq 42\,mm$$

$$l_1=l_2=0.75d=0.75\times 26=19.5\simeq 20\,mm$$

$$l_3=0.45d=0.45\times 26=11.7\simeq 12\,mm$$

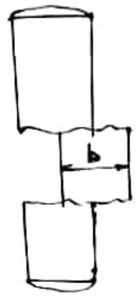
$$clearance=3\,mm,Tapper\ of\ \ cotter\ 1:25$$

$$a=2\times clearance=2\times 3=6\,mm$$

$$l=lenght\ of\ \ cotter=4d=4\times 26=104\simeq 105\,mm.$$

Design of cotter

i) Clee kif of cotter under shear stress cotter are in double shear.



$F = 2bt \times T_s$

$30 \times 10^3 = 2 \times 42 \times 11 \times T_s$

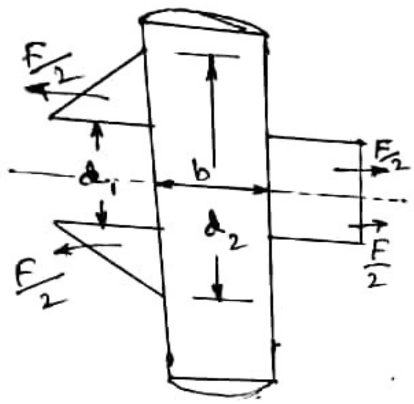
$T_s = 32.46\ N/mm^2$

Which is below the allowable shear stress. Hence safe .

ii) Failure of cotter under bending.

$M_b = [(\frac{d_2 - d_1}{2} \times \frac{1}{3} + \frac{d_1}{2}) - \frac{d_1}{4}] \times \frac{F}{2}$

$\rightarrow \frac{F}{12}(d_2 + \frac{d_1}{2})$



Hence $M_b = F_b \times Z$.

where F_b *is the bending stress at the centre*.

$\frac{F}{12}(d_2 + \frac{d_1}{2}) = f_b \times \frac{tb^2}{6}$

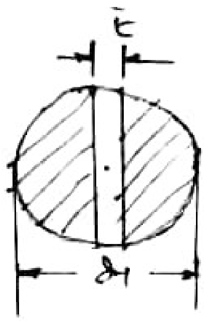
$\frac{30 \times 10^3}{12}(46 + \frac{32}{2}) = f_b \times \frac{(11) \times (42)^2}{6}$

$f_b = 47.92\ N/mm^2$, *which is below the allowable stress, Hence Safe*.

Design of Spigot

i) Tension failure of the Spigot at the location of the centre.

$F = (\frac{\pi}{4} d_1^2 - d_1 \times t) a_t$



$30 \times 10^3 = [\frac{\pi}{4}(32)^2 - 32 \times 11] a_t$

$a_t = 66.39\ N/mm^2$

Which is more then the allowable tensile stress i.e. 60N/mm^2.To make the safe under tensile stress, increase the dia of Spigot is 35mm, Hence the stress is

$30 \times 10^3 = [\frac{\pi}{4}(35)^2 - 35 \times 11] \times a_t$

$a_t = 52.02\ N/mm^2$, *Which is below allowable stress i.e.* $60\ N/mm^2$, *Hence Safe*.

ii) Crushing failure of spigot or cotter.

$F = d_1 \times t \times a_c$

$a_c = \frac{F}{(d_1 \times t)} = \frac{30 \times 10^3}{(35 \times 11)} = 77.92\, N/mm^2$

which is below the allowable stress. Hence safe.

iii) Shear failure of the Spigot End.

$F = 2 l_2 d_1 T_2$

$30 \times 10^3 = 2 \times 20 \times 35 \times T_s$

$T_s = 21.43\, N/mm^2$

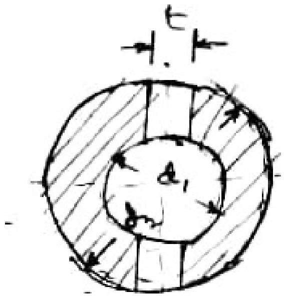
Which is below the allowable shear stress i.e. $45\, N/mm^2$. *Hence Safe.*

Design of Socket

i) Tension failure of the socket at the location of centre.

$F = [\frac{\pi}{4}(d_2^2 - d_1^2) - (d_2 - d_1) \times t] a_t$

$30 \times 10^3 = [\frac{\pi}{4}\{(46^2) - (35^2)\} - (46 - 35) \times 11] \times a_t$



$a_t = 51.86\, N/mm^2$. *Which is below the allowable stress i.e.* $60\, N/mm^2$.

Hence safe.

ii) Crushing failure of socket &cotter.

$F = (d_2 - d_1) \times t \times a_c$

$30 \times 10^3 = (46 - 35) \times 11 \times a_c$

$a_c = 247.93\, N/mm^2$

Which is more then the allowable crushing stress is 80N/mm^2. So, increase the outer dia of socket is 70mm. So, d_2 =70mm.

Hence, $30 \times 10^3 = (70 - 35) \times 11 \times a_c$

$a_c = 77.92\, N/mm^2$.

Which is below the safe crushing stress i.e. $80\, N/mm^2$. *Hence Safe.*

iii) Shear failure of the Socket End.

$F = 2 l_1 (d_2 - d_1) \times T_s$

$30\times10^3=2\times20\times(70-35)\times T_s$

$T_s=21.42\ N/mm^2$

Which is below the allowable shear stress i.e. $45\ N/mm^2$. *Hence Safe.*

Design of Collar

i) Shear failure of the Collar.

$F=\pi\, d_1 l_3\times T_s$

$30\times10^3=\pi\times35\times12\times T_s$

Which is below the allowable shear stress i.e. $45\ N/mm^2$.

ii) Crushing failure of the Collar.

$F=\frac{\pi}{4}(d_3^2-d_1^2)\,a_c$

$30\times10^3=\pi\{(39)^2-(32)^2\}\times a_c$

$a_c=129.11\ N/mm^2$

Which is more than allowable crushing stress i.e. 80N/mm^2.So, we increase the dia of collar from 39mm to 42 mm.

Hence, $30\times10^3=\frac{\pi}{4}\{(42)^2-(35)^2\}\times a_c$

$a_c=70.90\ N/mm^2$

Which is below the allowable crushing stress i.e. 80N/mm^2.Hence Safe.

Final Dimensions are

d_1=35mm.	b=42mm.
d_2=70mm.	l_1=l_2=20mm.
d_3=42mm.	l_3=12mm.
t=11mm.	clearance=3mm.
Taper of cotter=1:25	l=105mm.

$a=2\times clearance=2\times3=6\,mm.$