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* Design of Machine elements Lab-4:

Parts:

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Flanges → Grey-Cast-Iron → sustain compression
Key → Plain Carbon-Steel → sustain shear
Bolt → Plain -11- → -11-
Hub → Grey Cast Iron → Centrifugal-Compression
Shaft → Plain Carbon-Steel 30C8 → Shear stress.

* Now taking factor of safety.

FOS: → Flange, Hub → 5 — it sustains highest stress
Key-shaft-bolt → 2.5

$$\boxed{\sigma_c = 2\sigma_{yt}} \quad \text{and} \quad \boxed{\tau = \frac{1}{2}\sigma_{yt}}$$

σ_{ut} (Flange, Hub) = 200 MPa
σ_{yt} (Key, shaft bolt) = 400 MPa } from Chart.

$$(\sigma_{ut})_{allow} = \frac{200}{5} = 40 \text{ MPa}$$

$$(\sigma_{yt})_{allow} = \frac{400}{2.5} = 160 \text{ MPa.}$$

$\therefore (\sigma_c)_{Flange/Hub} = 2 \times 40 = 80$ MPa $(\sigma_c)(\tau_c)$ -11- $= \frac{1}{2} \times 40 = 20$ MPa

$(\sigma_c)_{allow}$ (key, shaft, Bolt) $= 160 \times 2 = 320\,MPa$.

$(\tau)_{allow}$ (key, shaft, bolt) $= \frac{1}{2} \times 160 = 80\,MPa$

Given: $P = 5\,kW$; $\omega = 1000\,r.p.m$; Service factor $= 2.0$

$$P = T \cdot \omega \Rightarrow 5 \times 10^3 = T \times \frac{1000 \times 2\pi}{360}$$

$$\Rightarrow \boxed{T = 47746.82}$$

$$\therefore T_{effective} = 2 \times T = \boxed{954922\,Nmm}$$

① Design of Hub: $\frac{T}{J} = \frac{\tau}{r}$

$$\frac{954.92 \times 10^3}{\frac{\pi}{32}(D^4 - d^4)} = \frac{20}{D/2} \Rightarrow \boxed{D = 2d}$$

Empirical relation

$$\therefore d = \sqrt[3]{\frac{32 \times 954.92 \times 10^3}{\pi \times 20 \times 15}}$$

$$\therefore d = \sqrt[3]{\frac{3055744}{\cancel{\pi \times 20 \times 15}\ 942.477}} \times 10$$

$\sqrt[3]{32.422 \times 10} \Rightarrow d = 31.85mm$

$\boxed{d \simeq 32mm}$

$\therefore \boxed{D \simeq 64mm}$ 63.5

$\boxed{L = 1.5 \times d}$
$47.7 \simeq 48mm$

$\boxed{t_f = \frac{d}{3} \simeq \cancel{10mm}\ 11mm.}$ 10.67

Design of - Flange:

T = circumference of hub × Thickness × Shear stress $\times \frac{D}{2}$

$\therefore = 954.92 \times 10^3$

$= (\pi \times D) \times t_f \times \tau_c \times \frac{D}{2}$

$\Rightarrow \tau_c = \frac{954.92 \times 2 \times 10^3}{\pi \times (63.5)^2 \times t_f} = \frac{175.46}{10.67}$

$= 16.44$

$< (\tau_1) = (20)$ allow

$\therefore \boxed{t_f = d/3 \text{ is safe}}$

* **Design of - Bolt:**

$T = P \times \frac{D}{2} \times N$

$\Rightarrow P = \frac{2T}{DN} = \frac{\pi}{4} d_1^2 \times \tau$

$\Rightarrow \tau = \frac{8T}{DN\pi d_1^2} \Rightarrow \cancel{d<40}$

From empirical relation $d < 40mm$

$\therefore N = 3$

$$\therefore d_1 = \sqrt{\frac{8 \times 954929.64}{\cancel{532} 63.5 \times 3 \times 3.14 \times 80}}$$

$$\Rightarrow d_1 = \sqrt{\frac{7639437.12}{478536.}}$$

$$\Rightarrow d_1 = \sqrt{159.64} = 12.63\,mm$$

$$\simeq \boxed{13\,mm}$$

* **Design of Key:**

$$P = T/d/2 \Rightarrow P = \frac{2T}{d}$$

$$\tau = P/bL = \frac{2T}{bd}$$

$L = 1.5 \times d$

$L = 47.7$

$\simeq 48\,mm$

$\therefore$

$$b = \frac{2 \times 954929.64}{100 \times \cancel{2} \times \cancel{4} \; 31.85 \times 47.7} = \frac{1909859.28}{151924.5}$$

$$b = 12.57\,mm \simeq \boxed{13mm}$$

$$\therefore h = \frac{4T}{d\,L\,\sigma_{c\,allow}} = \frac{4 \times 954929.64}{47.7 \times 31.85 \times 32}$$

$$\Rightarrow h = \frac{3819718.56}{}$$

$h \simeq 7.85 mm$ $\Rightarrow$ $\boxed{h \approx 8 mm}$

So $\rightarrow$ final dimensions.

$t_f = 11 mm$ $d_1 = 13 mm$ $d = 32 mm$

$D = 64 mm$ $N = 3$ $D_1 = 96 mm$

$D_2 = 128 mm$. $L = 48 mm$ $b = 15 mm$

$h = 8 mm$.