## KEY CALCULATIONS :-

FOR SHAFT 1 :-

$d = 6mm$

$n = 13320$ rpm

$p = 1180$ W

$S_{yt} = 800$ MPa $= 800$ N/mm$^2$

FOS $= 5$

As our application is in aerospace domain a higher factor of safety is required. Thus we have considered the factor of safety as 5

STEP 1 :

Calculation of Permissible compressive and shear stress :

$$S_{yt} = S_{yc} = 800 \text{ MPa} = 800 \text{ N/mm}^2$$

$$\therefore \sigma_c = \frac{S_{yc}}{FOS} = \frac{800}{5} = 160 \text{ N/mm}^2$$

According to maximum shear stress theory of failure,

$$\therefore S_{sy} = 0.5\, S_{yt}$$
$$= 0.5 \times 800$$
$$= 400 \text{ N/mm}^2$$

$$\therefore \tau = \frac{S_{sy}}{FOS} = \frac{400}{5} = 80 \quad N/mm^2$$

STEP 2 :-

(TORQUE TRANSMITTED BY THE SHAFT)

$$M_t = \frac{60 \times 10^6 \times kW}{2\pi n}$$

$$= \frac{60 \times 10^6 \times 1.180}{2 \times \pi \times 13320}$$

$$M_t = 845.95 \quad N\text{-}MM$$

STEP 3 :-

(KEY DIMENSIONS)

The industrial practice is to use a square key with sides equal to one quarter of the shaft diameter

THUS,

$$b = h = \frac{d}{4} = \frac{b}{4} = 1.5\ mm$$

$$\therefore l = \frac{2M_t}{\tau d b} = \frac{2 \times 845.95}{80 \times 6 \times 1.5} = 2.35\ mm \quad \text{—①}$$

Also,

$$l = \frac{4 \times M_t}{\sigma_c \times d \times h} = \frac{4 \times 845.45}{160 \times 6 \times 1.5} = 2.349 \text{ mm} - (2)$$

∵ From (1) & (2)

∴ length of key should be a minimum of $1.5 \times 1.5 \times 2.35$ mm

THUS, considering the gear dimensions and standard key table from Design of Machine elements by V.B. Bhandari, we chose the key of following dimensions.

square and rectangular sunk key of $2 \times 2 \times 19$ mm.

FOR SHAFT 2 :-

$d = 8\ mm$

$n = 4440\ rpm$

$P = 1180\ kW$

$S_{yt} = 800\ MPa = 800\ N/mm^2$

$FOS = 5$

STEP 1 :-

$S_{yt} = S_{yc} = 800\ N/mm^2$

$$\sigma_c = \frac{S_{yc}}{FOS} = \frac{800}{5} = 160\ N/mm^2$$

and, $S_{sy} = 0.5\, S_{yt} = 0.5 \times 800 = 400\ N/mm^2$

$$\therefore \tau = \frac{S_{sy}}{FOS} = \frac{400}{5} = 80\ N/mm^2$$

STEP 2 :-

$$M_t = \frac{60 \times 10^6 \times kW}{2\pi n}$$

$$= \frac{60 \times 10^6 \times 1180}{2 \times \pi \times 4440}$$

$$M_t = 2537.87\ N\text{-}mm$$

STEP 3:-

$$b = h = \frac{d}{4} = \frac{8}{4} = 2 \text{ mm}$$

$$\therefore l = \frac{2Mt}{\tau bd} = \frac{2 \times 2537.87}{80 \times 8 \times 2} = 3.965 \text{ mm}$$

$$\therefore l = 3.965 \text{ mm} \quad \text{—①}$$

$$\therefore l = \frac{4Mt}{\sigma_c dh} = \frac{4 \times 2537.87}{160 \times 8 \times 2} = 3.965$$

$$\therefore l = 3.965 \text{ mm} \quad \text{—②}$$

∴ Thus from ① & ②, length of the key should be minimum of $2 \times 2 \times 3.96$ mm

∴ Thus considering the gear dimensions and standard key dimensions from Design of Machine elements by VB Bhandari.

We chose, the following key for intermediate shaft, $2 \times 2 \times 19$ mm (square and rectangular sunk key)

Dimensions = $2 \times 2 \times 19$ MM

FOR SHAFT 3:-

$d = 10$ mm
$n = 2220$ rpm
$P = 1180$ W
$S_{yt} = 800$ MPa $= 800$ N/mm²
FOS $= 5$

STEP 1:-

$S_{yc} = S_{yt} = 800$ N/mm²

and $S_{sy} = 0.5\, S_{yt} = 0.5\,(800) = 400$ N/mm²

$$\tau = \frac{S_{sy}}{FOS} = \frac{400}{5} = 80 \text{ N/mm}^2 \quad \& \quad \sigma_c = \frac{S_{yc}}{FOS} = \frac{800}{5}$$

$\sigma_c = 160$ N/mm²

Step 2:-

$$M_t = \frac{60 \times 10^6 \times (kW)}{2\pi n}$$

$$= \frac{60 \times 10^6 \times 1.180}{2 \times \pi \times 2220}$$

$$= 5075.75 \text{ N-mm}$$

STEP 3:- KEY DIMENSIONS:

$$b = h = d/4 = \frac{10}{4} = 2.5 \text{ mm}$$

$$\therefore l = \frac{2Mt}{\tau d b} = \frac{2 \times 5075.75}{80 \times 10 \times 2.5} = 5.075 \text{ mm} \quad -①$$

and,

$$l = \frac{4Mt}{\sigma_c \times d h} = \frac{4 \times 5075.75}{160 \times 10 \times 2.5} = 5.07 \text{ mm} \quad -②$$

∴ THUS, from ① & ②, the length of the key dimensi-ons should be minimum $2.5 \times 2.5 \times 5.1$ mm

THUS, considering the gear dimensions and standard key table from V.B Bhandari's machine elements book, we chose the following key for intermediate shaft.

∴ Dimensions are $3 \times 3 \times 22$ mm (square and rectangular sunk key)