B.Tech.

Fifth Semester Examination

Mechanical Machine Design-I (ME-303-F)

Note : Short answer type questions.

Q. 1. (a) What do you mean by Brain Storming?

Ans. Brain Storming means to a technique of getting solution of a problem by each and every resource possible. Then each idea is considered as a proper solution and analysis is done. The best solution is then applied for the treatment of problem. Brain storming makes value of idea given by each person involved in study or solution giving process.

Q. 1. (b) What is the significance of factor of safety?

Ans. To avoid failure of a machine part, the design stress is kept well within the yield stress or the ultimate stess.

Factor of safety is the amount by which the design stress is kept below the limit stress and is expressed by their ratio.

For ductile materials,

$$\boxed{\text{FOS} = \frac{\text{Yield stress}}{\text{Design stress}}}$$

For brittle materials,

$$\boxed{\text{FOS} = \frac{\text{Ultimate stress}}{\text{Design stress}}}$$

For materials subjected to varying loading,

$$\boxed{\text{FOS} = \frac{\text{Endurance limit}}{\text{Design stress}}}$$

Q. 1. (c) Compare keys and cotters?

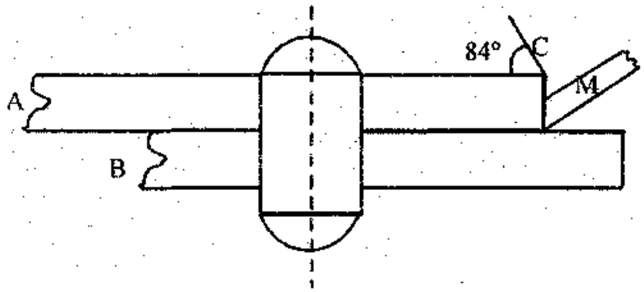
Ans. Keys are usually driven parallel to the axis of the shafts which are subjected to torsional and twisting stress cotters are normally driven at right angles to the axes of the connected parts which are subjected to tensile or compressive stresses along their axes.

A key resists shear over a longitudinal section, whereas a cotter resists shear over two transverse sections.

Q. 1. (d) Why Caulking is done in Riveted joints?

Ans. Joints in pressure vessels (like steam boilers) are made fluid tight by caulking as shown in fig.

A narrow blunt chisel like tool M is used for caulking and is called caulking tool.



Caulking

Q. 1. (e) What is feasibility study?

Ans. Once the problem's need has been established and the specifications have been prepared, accepted and submitted, the feasibility study is done. The purpose of feasibility study is to check the success or failure of a project by economic and technical point of view.

It cuts down fruitters design effort.

Q. 1. (f) Which materials are generally used in making rivets?

Ans. Rivets are made of wrought iron or soft steel for most uses, but where corrosive resistance or light weight is required rivets of copper and alluminium are also used.

Q. 1. (g) Define coefficient of fluctuation of speed?

Ans. Coefficient of fluctuation of speed is defined as ratio of change in speed to mean speed.

i.e., C_s = Coefficient of fluctuation of speed,

$$= \frac{\text{Change in speed}}{\text{Mean speed}} = \frac{V_1 - V_2}{V}$$

Here, $V = \frac{V_1 + V_2}{V}$

V_1 = Maximum velocity

V_2 = Minimum velocity

Q. 1. (h) How many types of keys are commonly used in engineering?

Ans. Following are the types of keys :

1. Light Duty and Medium Duty Keys :

(a)	Square key	(b)	Rectangular key
(c)	Gid-head key	(d)	Wood-ruff key
(e)	Flat key	(f)	Saddle key

2. Heavy Duty Keys :

(a)	Round key	(b)	Barth key

(c) Kennedy key (d) Tangent key

(e) Feather key

Q. 1. (i) What do you mean by clutches?

Ans. The basic function of a clutch is to control the flow of mechanical power within the machine. It must be capable of transmitting specified amount of torsional moment. The device is called as clutch.

Q. 1. (j) What is detailed design?

Ans. Irrespective of the mass manufactured or individual fabricated component a complete set of detail and assembly drawings are needed for successful manufacturing.

On there drawings full dimensions, tolerances, with dimensions of part and components specification of material and conceivable data the production shop may need to know for producing the product are to be determined. This phase of design work consists of :

(i) Detailing the parts components and their assembly.

(ii) Going for sufficient details of manufacture in implementing the design.

Section-A

Q. 2. Explain the importance of tolerances and fits in interchangeability?

What do you understand by preliminary design?

Ans. Interchangeability : Tolerances and Fits : Interchangeability is an important factor in modern mechanical engineering and is indispensable to series and mass production of machine elements and parts and their assemblies. Uniformity is the essence of cheap mass production.

With all the human skill it is never possible to make a part exactly to a given dimension due to inaccuracy of manufacturing methods and other factors. This factor is recognized and certain variations are always allowed in the size of the machine elements or parts.

When an assembly is made of two parts one is known as male surface other as female surface female surface is referred as 'Hole' and male surface as 'shaft.'

As explained certain variations are allowed in dimensions of shafts and holes. This system is called as 'Interchangeable system.

Dimensions obtained by calculation of design based on strength is called 'Basic Dimension' whereas a dimension as measured from manufactured part is 'Actual Size.'

The dimensions within which actual size of part may vary is called maximum size and minimum size.

The difference between maximum size i.e., high limit and minimum size i.e., low limit is called 'tolerance.'

Now when the machine elements are assembled to form a machine, their joints may be either movable or permanent depending on the conditions in which machine elements work in a machine.

The nature of 'fit' is characterized by the presence of size of the 'clearance' (for movable joints) or 'interference' for fixed joints.

Three common types of fits are :

(a) Clearance fit

(b) Interference fit

(c) Transition fit

Preliminary Design : After the process of creativity design is complete, there will be one or more possible design which may satisfy the given set of specifications and requirements. It then becomes necessary to decide which of the solution to choose for preliminary design.

Following are the stages for preliminary design :

(a) Selection of most useful solution from reversal suggested solutions.

(b) Formulation of useful model preferably mathematical for this selected solution.

(c) Analysis of this model.

(d) Forming of criterion in order to determine and measure which values are we attempting to maximise or minimise.

(c) Optimization so as to best meet the objective.

(f) Prediction of performance.

(g) Preparing layout of the selected solution, making a check for its function.

Q. 3. Give classification of engineering materials? How materials are selected in machine design give a systematic approach?

Ans. Classification of engineering materials can be given as follows :

The materials are divided into two groups :

(i) Metallic materials

(ii) Non-metallic materials.

Now metallic materials are divided into :

(a) Ferrous materials – Cast iron, steels etc.

(b) Non-ferrous materials :

   (i) Rubber

   (ii) Leather

   (iii) Composite materials

   (iv) Plastics

   (v) Ceramics etc.

Selection of Materials : Methodology systems design can be well opted for purposes of economical selection of materials. It is expected to be so because of scientific, orderly and systematic nature of methodology.

Following steps are to be followed :

First Step : Define the material requirements.

Second Step : Find possible material.

Third Step : Make a choice.

In first step materials requirement for a specific group of properties is to be found out. Then the materials following or fulfilling criteria are selected these selected materials or possible materials are tested for given qualities preferences and the most efficient, compatible and economic material for the case is selected.

Material selection for the product is shown by algorithm :

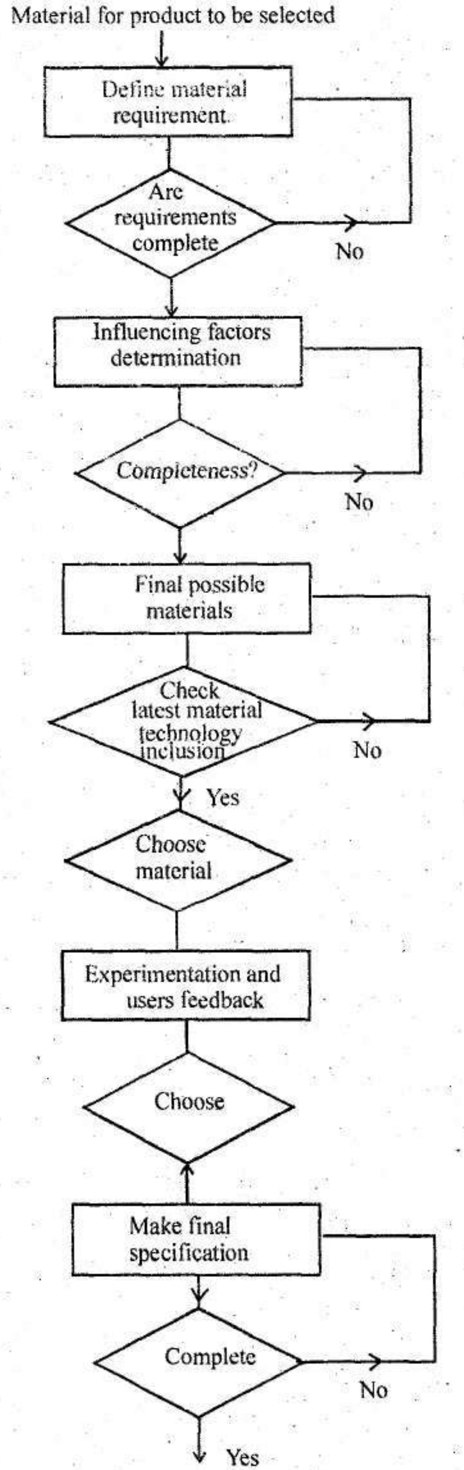


Fig. Material Selected for the Product

Section-B

Q. 4. A screw press is to exert a force of 60 kN with an applied torsional moment of 550 Nm. The unsupported length of the screw is 0.45m and a thrust bearing of hardened steel on CI is provided at the power end. The screw is to be made of steel having an ultimate tensile strength of 530MN/m^2 and a yield stress of 265 MN/m^2. The design stresses are to be 87.5 MN/m^2 in tension and compression 52.5 MN/m^2 in shear and 14 MN/m^2 in thread bending. The nut is of C.I. and the permissible shear is 21 MN/m^2. Determine dimension of screw and nut.

Ans. Axial load f $= 60\,\text{kN}$

Design load βF $= 12.5 \times 60 = 75\,\text{kN}$

$$\therefore \quad d_c = \sqrt{\frac{4\beta F}{\pi F_C}} = \sqrt{\frac{4 \times 75 \times 1000}{\pi \times 87.5}}$$

$$= 33\,\text{mm}$$

Using normal series of square threads and selecting a thread with outside dia., $d_o = 46\,\text{mm}$, $P = 8\,\text{mm}$

$$\therefore \quad d_c = 38\,\text{mm}$$

$$d_m = 32\,\text{mm}$$

Now,
$$\tan\alpha = \frac{P}{\pi d_m} = \frac{8}{\pi \times 42} = 0.666$$

$$\therefore \quad \alpha = 3^\circ - 33'$$

Assuming
$$\mu = 0.15$$

$$\therefore \quad \tan\phi = 0.15 \quad \therefore \quad \phi = 8^\circ - 33'$$

Now,
$$M_t = F\frac{d_m}{2} \times \tan(\alpha + \phi) + \mu_c . F . \frac{DC}{2}$$

Now H_C may be taken as 0.147

$$\therefore \quad 550 \times 1000 = 60 \times 1000 \times 21 \tan(12^\circ - 6') + 6.147 \times 60 \times 1000 \times \frac{D_2}{2}$$

Gives $D_C = 63.5\,\text{mm}$

Check for Maximum Stress :

$$f_s = \frac{16 M_{t_1}}{\pi d_c^3} = \frac{16 \times 270}{\pi \times (0.038)^3} = 25.2\frac{\text{MN}}{\text{m}^2}$$

The stress due to column action is :

$$f_c = \frac{F}{A}\left[\frac{1}{1 - \left(\frac{L}{K}\right)^2 \left(\frac{F_{yp}}{4\pi^2 . CE}\right)}\right]$$

Assuming one end fixed and other end free, C = 0.5.

$$L = 450\text{ mm},\ K = 0.25 \times d_c = 9.5\text{ mm}$$

$$\frac{L}{K} = \frac{450}{9.5} = 47.4,\ A = \frac{\pi}{4}d_c^2 = \frac{\pi}{4}(0.038)^2 = 0.00113\text{ m}^2$$

$$E = 210\text{ GN/m}^2$$

$$F_{yp} = 265\text{ MN/m}^2$$

$$F_C = \frac{60 \times 1000}{0.00113}\left[\frac{1}{1 - \dfrac{(47.4)^2 \times 265 \times 10^6}{4 \times 0.25 \times \pi^2 \times 210 \times 10^9}}\right]$$

$$= 73.4\text{ MN/m}^2$$

Check for Combined Stresses :

$$f_{s\max} = \frac{1}{2}\sqrt{f_c^2 + 4f_s^2}$$

$$= \frac{1}{2}\sqrt{(73.4)^2 + 4 \times 25.2^2}$$

$$= 44.8\text{ MN/m}^2 < 52.5\text{ MN/m}^2$$

$$f_{c\max} = \frac{1}{2}\left[\sqrt{f_c^2 + 4f_s^2} + f_c\right]$$

$$= \frac{1}{2}[89.6 + 73.4] = 81.5\text{ MN/m}^2$$

and $81.5\text{ MN/m}^2 < 87.5\text{ MN/m}^2$

$$\therefore \quad F = \frac{\pi}{4}\left(d_o^2 - d_c^2\right) \times P_b \times Z$$

$$66 \times 1000 = \frac{\pi}{4}\left(46^2 - 38^2\right) \times 14 \times Z$$

$Z = 8.15$ say 9 threads.

$\therefore$ Length of nut $= P \times Z = 8 \times 9 = 72\text{mm}$.

Check for Shear :

$$W = \pi d_o t Z f_s$$

$$f_s = \frac{60 \times 1000}{\pi \times 46 \times 4 \times 9}$$

$$= 11.5\,N/mm^2 < 21\,N/mm^2 \text{ for C.I.; } \left(t = \frac{p}{2}\right)$$

Q. 5. Design a double riveted butt joint with two cover plates for the longitudinal seam of a boiler shell, 0.75m dia, to carry a maximum steam pressure to 1.05 N/mm², the allowable stresses are $f_t = 35.0$ N/mm² $f_s = 28.0$ N/mm², Assume the efficiency of the joint 75%.

Ans. The thickness of plate is given by,

$$t = \frac{PD}{2f_t n} = \frac{1 \times 1.05 \times 750}{2 \times 35 \times 0.75} = 15\,mm$$

As t is greater than 8 mm, the diameter

$$= 6.05\sqrt{t} = 25\,mm$$

For boiler joints the standard dia. of rivet holes from table 7.2 is 25.5 mm & dia. of rivet is 24 mm.

As the joint is double strap butt joint, the rivets will be in double shear and there will be two rivets per pitch length.

Strength of two rivets in double shear,

$$= 2\pi \times \frac{\pi}{4} d^2 \times f_s \times 1.875$$

$$= 2 \times \frac{\pi}{4}(25.5)^2 \times 28 \times 1.875$$

$$= 53.20\,kN$$

Strength of two rivets in crushing,

$$= 2 \times d \times t \times f_c$$

$$= 2 \times 25.5 \times 15 \times 52.5$$

$$= 40.20\,kN$$

As strength in crushing is less the strength in the crushing will be equated to strength in tearing of plate.

$$40.2 \times 10^3 = (p - d) \times t \times f_t$$

$$= (p - 25.5) \times 15 \times 35$$

$$p = 102\,mm$$

Minimum value of pitch $= 2 \times d$

$$= 2 \times 25.5 = 51\,mm$$

Maximum pitch of double riveted butt joint with two cover plates.

$$= 3.5t + 41.28 = 3.5 \times 15 + 41.28$$

$$= 94\,mm$$

Thus adopt the pitch as 95 mm strength of the solid plate $= p \times t \times f$

$$= 95 \times 15 \times 35.0 = 50\,kW$$

Strength of the point $= \frac{40.2 \times 10^3}{50 \times 10^3} \times 100$

$= 80\%$

Which is more than required efficiency of joint.

Thickness of butt straps of equal width will be,

$$t_1 = 0.625t = 0.625 \times 15$$

$$= 9.4 \text{ mm ; say } 10 \text{ mm}$$

Section-C

Q. 6. Find out the diameter of C.I. pulleys and the thickness and width of a leather belt to transmit 128.7 kW power from a shaft that is directly connected to a stream engine running at 31.4 rad/s to a centrifugal pump with a speed ratio of 1:3.5.

Ans. The proceed with the solution of the problem, let us assume belt speed is 20m/s.

$$V = \frac{D_1 W_1}{2} = \frac{D_1 \times 31.4}{2}$$

$$D_1 = 1.275 \text{ m}$$

Assuming a step of 20%.

$$VR = \frac{D_2}{D_1(1-s)} \quad \therefore \frac{1}{3.5} = \frac{D_2}{1.275 \times 0.98}$$

$$D_2 = \text{Dia. of driven pulley}$$

$$= 0.357 \text{ mm say } 360 \text{ mm}$$

Assuming service factor of 1.2

Design power $= 128.7 \times 1.2 = 154.45 \text{ kW}$

$$F_1 - F_2 = \frac{\text{Power in KW} \times 1000}{V}$$

$$= \frac{154.45 \times 1000}{20} = 7722.5 \text{ N}$$

Now angle of contact on smaller pulley.

$$\theta = \left(\pi - \frac{D_1 D_2}{C}\right) \text{rad}$$

Now centre distance, $C \geq 3.5 \times$ larger dia.

$$C = 3.5 \times 1.275 = 4.46 \text{ mm say } 5\text{m}$$

$$\theta = \pi - \left(\frac{1.275 - 0.36}{5}\right) = 2.96 \text{ rad.}$$

Let us assume $\mu = 0.35$

$$\frac{F_1}{F_2} = e^{\mu\theta} = e^{0.35 \times 2.96}$$

$$\frac{F_1}{F_2} = 2.82$$

$$F_2 = \frac{7722.5}{1.82} = 4243.15\,N\,,$$

$$F_1 = 7722.5 + 4243.15$$

$$= 11965.6\,N$$

Now assuming a working stress of $\frac{31.5}{9} = 3.5\,N/mm^2$ and the belt joined as wire laced by machine for which the efficiency is 0.9.

$$F_t = 3.5 \times 0.9 = 3.15\,N/mm^2$$

Since V is > 10 m/s, therefore effect of centrifugal force must be considered centrifugal stress, $f_c = \rho V^2$

$$= 1000 \times 400$$

$$= 4 \times 10^5\,N/m^2$$

$$= 0.4\,N/mm^2$$

$$b \times t = \frac{F_1}{(F_t - F_c)} = \frac{11965.6}{(3.15 - 0.4)} = 4362.2\,mm^2$$

Now belt thickness t should be ≤ 0.02 X smaller pulley diameter so,

$$t \geq 0.02 \times 360 \text{ or } 7.2\,mm$$

Taking light double ply belt with t = 6 mm

$$b = \frac{4362.2}{6} = 730\,mm$$

Q. 7. (a) A medium steel shaft transmits a torsional moment of 1960 Nm. The diameter of the shaft is 58 mm. Select a standard key and check it for the induced unit shearing and crushing stresses. Obtain the factor of safety of the key in shear and crushing. Assume the material of the shaft and key to be same.

Ans. From table for the diameter of shaft to be 58mm, $16 \times 10 \times 90$ IS 2048 parallel key is selected.

Shearing stress induced in this key,

$$f_s = \frac{2Mt}{dWl} = \frac{2 \times 1960 \times 10^3}{58 \times 16 \times 90} = 47\frac{N}{mm^2}$$

Crushing stress induced in this key

$$f_c = \frac{4Mt}{dlt} = \frac{2 \times 1960 \times 10^3}{58 \times 90 \times 10} = 150\frac{N}{mm^2}$$

The yield stress for shear & crushing are $350\,N/mm^2$ and $425\,N/mm^2$ respectively.

F.O.S. in shear $= \frac{350}{47} = 7.45$

F.O.S. in crushing $= \frac{425}{150} = 2.83$

Q. 7. (b) Determine the length and thickness of sunk key for a shaft of 0.09 m diameter. Assuming that the shearing resistance of the material of the key is same as that of the shaft width of the key is 25 mm and $f^s = 0.4 \times f_c$.

Ans. Torsional resistance of the shaft,

$$= \frac{\pi}{16} d^3 f_s$$

$$= \frac{\pi}{16}(0.09)^3 f_s = \frac{143}{10^6} f_s \text{ N-m}$$

As the shearing resistance of key and shaft are equal,

$$\frac{143}{10^6} \times f_s = \frac{11.25}{10^6} \times l \times f_s$$

Gives, $l = 12.9\text{ cm} = 129\text{ mm}$

Crushing resistance of key,

$$= l \times \frac{1}{2} \times f_c \times \frac{d}{2} = 12.9 \times \frac{t}{2} \times \frac{f_s}{0.04} \times \frac{1}{10^6}$$

$$= \frac{72.5}{10^6} \times f_s \text{Nm}$$

Equating this to shearing stress of shaft,

$$\frac{143}{10^6} = \frac{72.5}{10^6} t.f_s$$

Gives, $t = 1.98$ cm say 20 mm **Ans.**

Section-D

Q. 8. The following data is given for a dry single plate clutch

Power = 18.65 kW

Speed = 1500 rev/min.

Number of springs = 6

$$\text{Ratio} = \frac{\text{Mean radius of function faces}}{\text{Radial width of friction faces}} = 4.6$$

Find : (a) Mean radius and radial width of friction faces

(b) Dimensions of clutch plate

(c) Dimensions of spring

Ans. Mean Radius : Area of friction faces $= 2\pi w r_m$

W = Radial width of friction faces

$$= r_2 - r_1$$

$$P = P_m 2\pi w r_m$$

$$= P_m 2\pi r_m 2 / 4.5$$

Torsional moment to be transmitted,

$$M_t = \frac{9550 \times KW}{n} = \frac{9550 \times 18.65}{1500}$$

$$= 118.74\,\text{Nm}$$

$$M_t = \mu P_z r_m$$

$$Z = 2$$

Let, $P_m = 0.07\,\text{N/mm}^2$ for foredo fabric and $\mu = 0.25$.

$$\therefore \quad 118.74 \times 1000 = 0.25 \times 0.07 \times 2\pi \times r_m^2 \times \frac{1}{4.5} \times 2r_m$$

$$r_m = 135\,\text{mm}$$

(ii) Radial Width :

$$w = \frac{135}{4.5} = 30\,\text{mm}$$

(b) Clutch Plate : The clutch plate is made of high carbon steel 3mm thick. It is provided with radial slots to prevent distortion when the plate becomes hot through slipping.

(c) Spring Design :

Now, $M_t = \mu P_z r_m$

Total axial force, $P = \dfrac{118.74 \times 1000}{0.25 \times 2 \times 135}$

$$= 1795\text{N}$$

Load per spring $= \dfrac{1759}{6} = 293\,\text{N}$

To allow adjustment and for maximum engine torsional moment, this value is increased by 25%, so, design load per spring $= 1.25 \times 293 = 366.25N$ and Now spring is designed.

Q. 9. The layout of a double block brake is shown in fig. The brake is rated at 240 N-m at 600 rev.min. The angle of contact for each shoe is 120°. Assuming **μ=0.3 and condition for service a PV valve of 17.5×10^5 may be assumed. Determine :**

(a) Spring force S required to set the brake

(b) Width of shoes,

Ans.

$$F = \frac{4\mu F_n \sin\theta/2}{\theta + \sin\theta}$$

$$\frac{F}{F_n} = \frac{4\mu \sin\theta/2}{\theta + \sin\theta}$$

$$\mu = 0.3 \text{ and } \theta = 120°$$

$$\frac{F}{F_n} = \frac{4 \times 0.3 \times 0.866}{2.09 + 0.866} = 0.351$$

$$F_n = \frac{F}{0.351} = 2.85F$$

(a) Spring Force : Considering left hand yoke,

$$\Sigma M_L = 0$$

$$S \times 0.3 \times + F_t \times 0.05 - F_n L \times 0.15 = 0$$

$$0.3S + 0.05F_L - F_L \times 0.15 \times 2.85 = 0$$

$$F_L = 0.795S$$

Similar to right hand yoke,

$$\Sigma M_R = 0$$

$$0.3S - 0.05F_R - 0.15F_{nR} = 0$$

$$0.3S - 0.05F_R - 0.13 \times 2.85F_R = 0$$

$$F_R = 0.6285$$

Now total torsional moment capacity of brake is,

$$T_f = (F_L \times F_R) \times r$$

$$F_L \times F_R = \frac{240}{0.10} = 2400N$$

$$S(0.795 + 0.628) = 2400$$

$$S = 1685 N$$

When releasing the brake, the spring is further compressed, therefore the spring release will be greater than S equal to 1685N. This is usually 10 to 15% greater.

(b) Shoe Width : Now $F_{n_L} = 2.85 F_L$

$$F_{n_R} = 2.85 F_R$$

$$F_L = 0.795S = 0.795 \times 1685$$

$$= 1340\text{N}$$

$$F_R = 0.628S = 0.628 \times 1685$$

$$= 1060\text{ N}$$

Maximum normal force is $F_{n_L} = 2.85 \times 1340$

$$= 3840\text{N}$$

If w is the width of shoe, m

Then projected bear area for one shoe is

$$= w \times 2r \sin\theta/2$$

$$= w \times 2 \times 0.10 \times \sin 60^\circ$$

$$= 0.1732\,w\,m^2$$

Now rubbing velocity, $V = \dfrac{\pi DN}{60}$

$$= \frac{\pi \times 0.2 \times 600}{60} = 6.28\text{m/s}$$

Now unit pressure on the shoe,

$$P = \frac{F_{n_L}}{0.1732w} = \frac{3820}{0.1732\,w}\text{N/m}^2$$

$$PV = 17.5 \times 10^5$$

$$\frac{3820}{0.1732\,w} \times 6.28 = 17.5 \times 10^5$$

$$w = 0.079\text{m} \quad \text{say } 0.08\text{m}$$

$$w = 80\text{ m}$$

$$\frac{w}{D} = \frac{80}{200} = 0.4$$

This ratio is usually held between 1/4 and 1/3 in well proportioned brakes, therefore the design is satisfactory.