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The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Mechanical Engineering

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: DMX5577 Machine Design-Paper II**
Academic Year	: 2020/21
Date	: February 13, 2022
Time	: 0930 -1330hrs
Duration	: **4 hours**

General Instructions:

1. This question paper has only one question.
2. Devote about 10 minutes to read the question carefully.
3. Following catalogues and data sheets are provided to you at the examination hall on your request.
   i. Motor catalogues
   ii. BSS for belt drives
   iii. BSS for keys
   iv. SKF Catalogues for rolling element bearings
   v. Instructions for design spur and helical gears.
4. At the end of the examination, hand over all such literature to the supervisor or an invigilator.
5. **Any missing data may be sensibly and reasonably assumed, provided that such data are clearly stated with reasons to accept them.**
6. Any ideas/opinions presented in the form of neatly drawn sketches are welcome in place of written presentation.
7. Any results from calculation should be presented with their correct units, unless they are dimensionless. All such answers should be underlined.
8. **It is important that candidates answer all parts of the question in the given order.**

Question

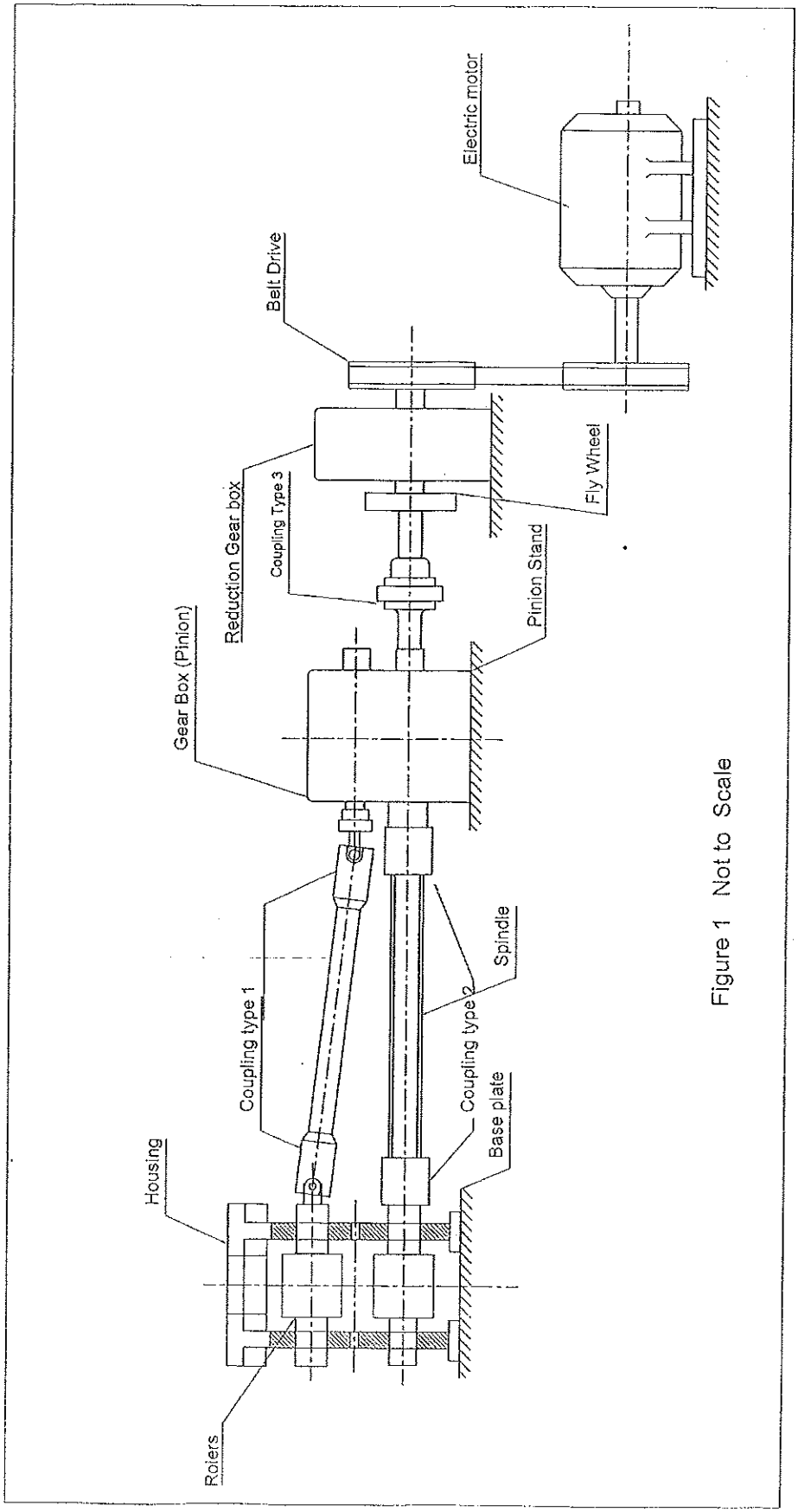

Figure 1 Not to Scale

Rolling is a metal forming process in which metal stock is passed through a pair of rollers to reduce the thickness or to make the thickness uniform. Figure 2 shows a typical horizontal rolling mill, where rolling stock are driven horizontally, while the rolling forces being acted by the two rollers vertically. The pair of rollers, being rotated in opposite directions about their axes, rolls the materials and reduces the material thickness as shown.

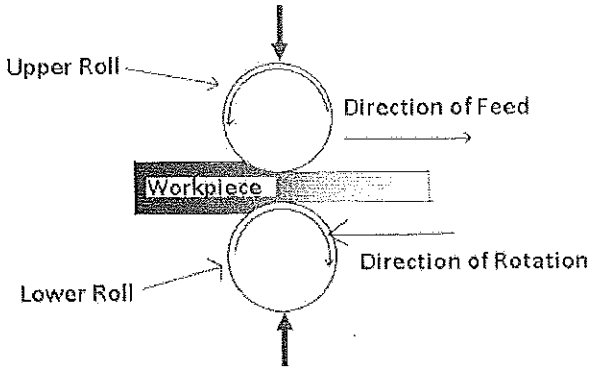

Figure 2

The Figure 1, not drawn to a scale, illustrates the anatomy and major components of a tentatively designed horizontal roller mill and the designer needs to verify several important parameters of the machine components and invite suggestions for any improvements. An electric motor is used as the prime mover, and the motor is connected to a reduction gear arrangement through a V-belt drive. From the reduction gear box, the power is transmitted to a secondary gear arrangement (pinions), which connects two spindles to drive the two rollers with a same speed of rotation. The spindles are directly coupled to the rollers. Three types of couplings as shown in the Figure 1 are appropriately employed to connect different component of the power transmission system. The two rollers are appropriately mounted on to the machine frame which is firmly anchored to the ground.

Following are important details to be used to confirm the design.

1. The equations related to rolling mill.

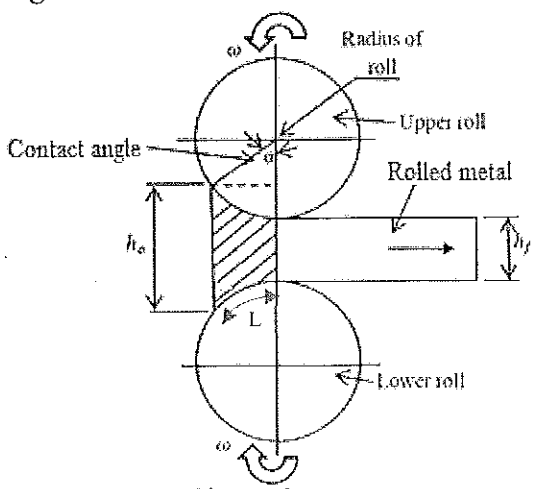

Figure 3

Figure 3 shows a schematic diagram indicating important parameters in rolling,

The roller force F (N): $F = L\ W\ Q\ \sigma$

Contact length between the roll and work L (m): $L = \sqrt{R(h_o - h_f)}$

Power requires to rolling operation P (W): $P = F\ L\ \omega$

Where, W – Width of the work (m)
Q - Pressure multiplying factor
σ – Mean stress (Nm^{-2}) of rolling stock (rolling material)
h_o, h_f – Initial and final thickness
R – Radius of Roller (m)
ω – Angular speed of the rolls (rad/sec)

2. In addition to the data given on separate sheets, you may assume the following.

Mean's stress of rolling stock = 100 x 10^6 Nm^{-2}
Radius of the rollers = 50 *mm*
Width of the work = 50 *mm*
Pressure multiplication factor = 1.2
Initial thickness = 30 *mm*
Thickness after rolling = 24 *mm*
Rotating speed of rolls = 50 *rpm.*
Young's modulus E = 200 x 10^3 Nmm^{-2}

3. Power losses.
   Mesh points – 0.04
   Couplings – 0.03
   Gearings – 0.02
   Belt drive – 0.04

4. Axis of all the shafts in the gear wheels and pulleys lie on a same vertical plane.

5. All the spur wheels have a module of 4 *mm* and a pressure angle of 20°.

6. V-belt drive has a speed ratio of 2 - 4 and centre distance between pulleys is approximately less than 1 *m*. This system is required to operate for 8 hours continuously a day.

7. For power transmission shafts shock and fatigue factors for bending and torsion are 2 and 1.5 respectively.

8. Shafting material has allowable bending and shear stresses 60 MN/m^2 and 50 MN/m^2 respectively.

9. Consider safety factors appropriately.

Answer the following questions.

1. Estimate the motor power required to operate the rolling mill at its full capacity.

2. Select a suitable motor to drive the mill.

3. Illustrate the components of the machine from the motor to the mill and indicate how the speed is reduced at each stage.

4. Design a suitable V-belt drive system incorporating standard pulleys.

5. Neatly sketch the gear arrangement of the reduction gearbox.

6. Design the gear and pinion (1st gear mesh) of the reduction gearbox which the pinion is attached to the input shaft (connects to the driven pulley of the belt drive). All the gears are spur gears.

7. Determine the minimum diameter of the input shaft to the reduction gear box (which the driven pulley is attached).

8. Select a suitable key for the driven pulley.

9. Select an appropriate pair of rolling element bearings to support the input shaft of the reduction gear box.

10. Neatly sketch the gear arrangement of the 2nd gear box (pinions) and state what type of gear are suitable for this application with justification.

11. Suggest the most suitable types of couplings to type 1, type 2 and type 3. Neatly sketch the suggested coupling indicating the important components and justify your selections.

12. From looking at the sketch identify the drawbacks of the proposed design and explain any modifications that you feel necessary to eliminate/minimize such drawbacks.
(Assume that you have no freedom to change the layout but have the discretion to change the dimensions).

.....End of the paper.....