THE OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY
DIPLOMA IN TECHNOLOGY – LEVEL 04

FINAL EXAMINATION 2007/2008

MEX4231 / MED2202 – ELEMENTARY MACHINE DESIGN – PAPER II

DATE : 27th April 2008
TIME : 0930 hours to 1330 hours
DURATION : Four hours

READ THE FOLLOWING INSTRUCTIONS CAREFULLY BEFORE ANSWERING THE QUESTION PAPER

This question paper has only one question.

Spent 10 to 15 minutes to read and understand the question carefully.

Wherever appropriate, use catalogues, tables, data sheets and charts provided to you at the examination hall.

At the end of the examination, hand over all such literature to the supervisor or an invigilator. Do not write anything on these literatures.

Any missing data may be sensibly and reasonably assumed, provided that such data are clearly stated with reasons to accept them.

Any ideas/ opinions presented in the form of neatly drawn sketches are encouraged.

Present the calculations and answers to the questions neatly and clearly. Results from calculations should be presented with their correct units, unless they are dimensionless. All such answers should be underlined.

All rough work or/ and any information, which do not require the examiners attention should be cancelled by drawing a cross (X) on it.

It is important the candidate answer all parts of the question listed in that given order in the question.

Question:

Figure 1 shows front elevation of a simplified trimming press which is used in a production line to trim forged hoes made of steel to the final sizes. Figure 2 indicates the final size of a hoe after trimming operation. The maximum thickness of the material to be trimmed is 3 mm. Only the periphery of the hoe is required to be trimmed in a downward operation of the press and the velocity of trimming tool at the beginning of trimming operation is 5 mm/s. The steel used has shear yield strength of 0.35 kN/mm^2.

The press has a fabricated frame with angle iron members. Each vertical column has 2 X L sections. Each top and bottom horizontal beam has basically 2 X U sections. At the four corners, P, Q, R and S of the frame, the members are rigidly fastened. The die is mounted on the bottom beam whereas the cross slide T carries the moving trimming tool T. Two identical power screws, each made of steel and with a single start Acme thread with 5 mm pitch, are supported by thrust bearings at A, B, C and D on the top and bottom beams. Each end of the cross slide has a bronze nut fitted to it, so that the screws transmit power to raise and lower the cross slide.

The motor, which is the prime mover of power transmission system, first delivers power to a belt drive, secondly to a gear train U, V and W and finally to the screws. The gears U and W, which are identical, drive the two screws. The shaft MN supports a driven pulley and pinion wheel of the gear train. At M and N, the shaft is mounted on thrust bearings. This configuration is shown in the given figure.

Under normal working conditions, the cross slide is made to stop at the top most position (below the level of upper beam) until the operator activate the gear train to drive the cross slide in the forward (downward) direction. The movement of the trimming tool is sensed by the machine's control system, so that immediately after the trimming operation the cross slide is driven in the reverse (upward) direction without the operator's influence.

Answer the following:

1. Calculate the trimming force and the power required for the trimming operation. Neglect the weight of the cross slide and the trimming tool.
2. Estimate the motor power and select a suitable electric motor.
3. Design completely a pair of power screw and bronze nut.

4. Propose a suitable V-belt drive system. Assume the centre distance between the two pulleys is less than 0.5 m.
5. Propose a suitable gear train and design any pair of gears in contact from the stand point of strength, wear and dynamic load.
6. Design the shaft MN.
7. Decide the type and specifications of rolling element bearings required at A, C and N.
8. Since each driven pulley rotates in both directions, a single square or rectangular key will not be suitable. Propose a suitable keyed joint that fasten the driven pulley on to the shaft.
9. If each vertical member of the press has a section 100 x 100 x 10 mm, would it be safe when the trimming operation is performed? If not what is the minimum area of cross section the combined L shaped column should have?
10. The given sketch does not propose a method to support the motor and the bearing at M. Provide a neat and clear sketches suggesting the methods of mounting the motor and the bearing.

In order to answer the above questions use

- Data given in the Motor, Key, Bearing and Belt catalogues
- Data in the supporting document for gear design
- Safety factor for power screw 2.5
- Tensile or compressive strength of commercial shafting 800 MPa.
- Desirable speed ratio for belt drive system can be chosen between 3 – 4
- Coefficient of friction between the pulley and belt materials is 0.2
- Operating conditions: Heavy shocks and 8 – 10 hours a day
- Young's Modulus of steel: 210 GPa
- Transmission efficiencies given in the data sheet
- Density of steel as 7,850 kg/m^3
- The weight of the pulley on MN as approximately two-third of that of the gear V

Following information are provided

Assume following transmission efficiencies

Spur Gears	94%
Belt Drive	90%
Power screw	95%

For all shafts, power screw and the nut following information are given.

Material and their mechanical properties

	Material	**Ultimate Tensile / Compressive Strength (MPa)**	**Shear Stress (MPa)**	**Factor of Safety**
Screw	Steel	800	340	2.5
Nut	Phosphor Bronze	552	260	5

Bearing stress for steel and Phosphor Bronze combination = 0.5 x S_{ut}

When there are no key ways for power transmission shafts whose steels have definite specifications, the design stresses are as follows.

Design value of the shear stress = 0.3 x yield stress in tension
= 0.18 x ultimate stress in tension, or whichever smaller.

Design value of the normal stress = 0.36 x ultimate stress in tension, or
= 0.6 x yield stress in tension whichever smaller.

For steel Young's Modulus = 200 GPa

Select one of the following steels for the shaft materials

AISI Number	Yield strength (MN/m^2)	Ultimate tensile Strength MN/m^2
1010	303	366
1018	373	442
1045	532	626
4340	683	766

If key ways are present then above values are to be reduced by 25%

Design of shafts should be made according to the ASME code equation.

A shaft having a diameter *d* when subjected to combined bending and torsion, the equivalent bending and torsional stresses at any point on the shaft are,

$$\sigma_{eq} = \frac{16}{\pi d^3}\left[K_b M + \sqrt{(K_b M)^2 + (K_t T)^2}\right]$$

and $$\tau_{eq} = \frac{16}{\pi d^3}\left[(K_b M)^2 + (K_t T)^2\right]^{1/2}$$

Coefficient of friction between screws and nut is 0.05.

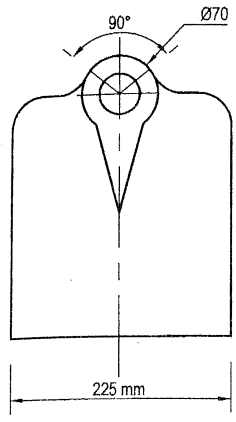

90°
Ø70
225 mm
225 mm

Fig.2

M
Motor
Screw gear
U
V
W
30mm
P
Q
30mm
A
N
B
Bronze nut
100
100
100
T
Screw
i
C
D
S
R
Concrete Slab

Fig.1