THE OPEN UNIVERSITY OF SRI LANKA

FACULTY OF ENGINEERING TECHNOLOGY

DIPLOMA IN TECHNOLOGY – LEVEL 04

FINAL EXAMINATION – 2011/12

MEX4231 – ELEMENTARY MACHINE DESIGN – PAPER II

DATE : ***FEBRUARY 24, 2012***
TIME : ***0930HRS. – 1330HRS.***
DURATION : ***FOUR HOURS***

READ THE FOLLOWING INSTRUCTIONS CAREFULLY BEFORE ANSWERING THE QUESTION PAPER

This question paper has only one question.

Spend about 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, handover all such literature to the supervisors or an invigilator.

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 welcome in the place of written representation.

Any results from calculation should be presented with their correct units, unless they are dimensionless. All such answers should be underlined.

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

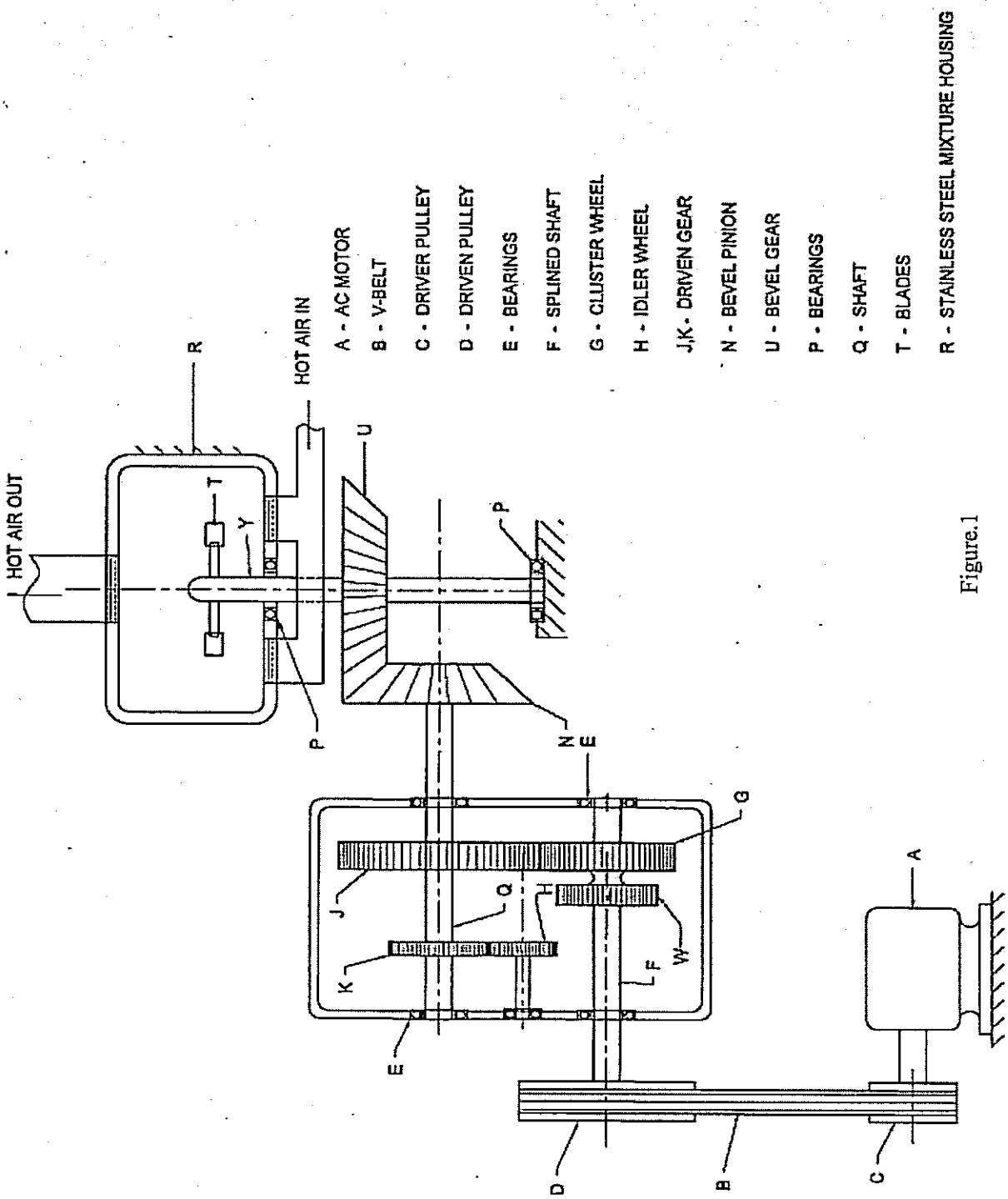

HOT AIR OUT
HOT AIR IN
R
T
Y
U
P
N
E
G
J
Q
H
K
F
W
A
D
B
C
A - AC MOTOR
B - V-BELT
C - DRIVER PULLEY
D - DRIVEN PULLEY
E - BEARINGS
F - SPLINED SHAFT
G - CLUSTER WHEEL
H - IDLER WHEEL
J,K - DRIVEN GEAR
N - BEVEL PINION
U - BEVEL GEAR
P - BEARINGS
Q - SHAFT
T - BLADES
R - STAINLESS STEEL MIXTURE HOUSING

Figure.1

Question

Ceylon Mills produces a range of food items and several consumable products. One of their main products is coffee powder. Coffee powder is prepared by first the beans being roasted by heating it up to a specific temperature and ground into a powdered form in a grinder. Ceylon Mills' engineers have proposed a machine of which the configuration is shown in the Figure.1. The raw coffee beans are fed into a cylindrical container, and hot air is directed through the coffee beans using a suitable ducting system. Used hot air is then sucked out by the duct situated on the top of the container by means of external suction fans. The coffee beans are agitated continuously inside the cylinder using the rotor. This arrangement (without the grinder) is also shown in the Figure.2.

The cylindrical container **R**, into which the raw coffee beans are loaded, is made out of stainless steel, and coffee beans are mixed by the rotating agitator (**T**). The agitator rotates in both directions (clockwise and anticlockwise) from time to time, governed by a timer, in order to maintain the best mixing effect, while coffee beans are being heated uniformly throughout. Pulley **C** on the motor shaft drives the pulley **D** and transmits power to the gear box by means of a suitable V-belt. The horizontal splined shaft **F**, on which the cluster wheel **G** and **W** could be axially moved, is supported by two identical rolling element bearings **E**. The cluster wheel has two wheel segments **G** and **W**. The shaft **Q** which carries the wheels **J**, **K** and **N** is also supported by another pair of rolling element bearings. The pair of bevel gears **N** and **U** changes the direction of drive by 90^0. The direction of rotation of the blade when the wheel segment **G** is in contact with wheel **J**, is opposite to that when the segment **W** is in contact with **H** through **K**. The shaft **Y**, which is an integral part of the bevel gear **U** and whose axis is vertical, holds the agitator in position. Two element rolling bearings (**P**) support this shaft. The container is firmly held to the machine frame to constrain the lateral movements of the shaft. The wheels **G**, **J**, **Q**, **H** are enclosed in a gearbox.

Answer the following questions as if you were the designer of this machine.

1. From looking at the sketch what are the drawbacks of the proposed design? Also recommend any improvements to the proposed design to achieve the objective more effectively.

For the given configuration,

2. Estimate the power required to drive the agitator.

3. Select a suitable motor, and specify the power rating and speed considering the pair of bevel gears to have a speed ratio in the range of 1 to 2.

4. Find the number of teeth on the idler wheel **H**.

5. Select and specify a suitable belt drive system that includes number of belts and standard pulleys. Recommend an initial belt tension, so that the belts can initially be tightened to this value.

6. Determine the minimum diameter of the splined shaft.

7. Determine the important parameters of wheels **G** and **J** selecting a suitable material.

8. Select a suitable key for the driven pulley.

9. Recommend a suitable pair of rolling-element bearings to support the splined shaft on to the gear enclosure.

The following information are provided in support of the design analysis.

1. The dimensions of the blades, arm of the blades and the container are as given in the Figure.2.

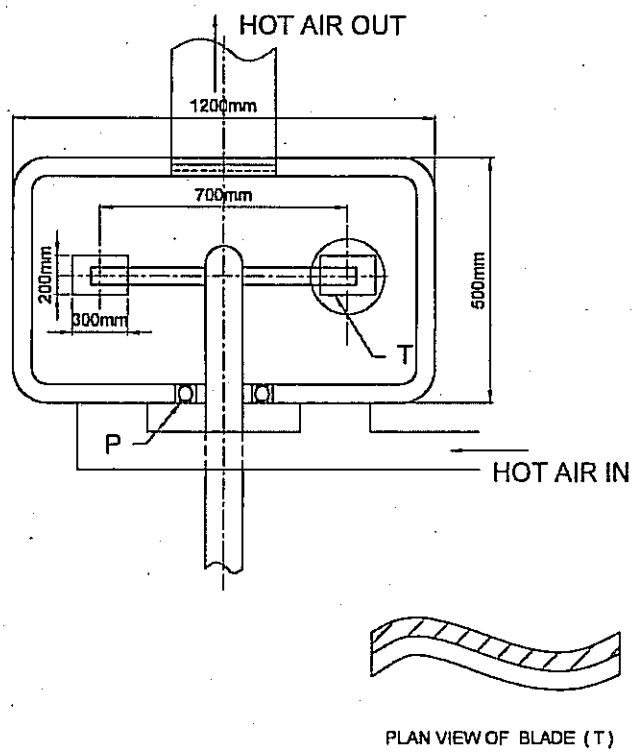


Figure.2

These blades rotate at 60 *rev/min.*

Amount of pressure applies to a blade is 30 kN/m^2 when the container is filled with the mixture to its maximum capacity.

Consider the projected area of a blade as 300 *mm* x 200 *mm*, on which the given pressure applies.

2. All spur gears have a module of 4 *mm.*

3. Axes of all the shafts lie on same vertical plane.

4. Diameter of the splined shaft refers to its minor diameter, and neglect the effects of splines when designing the shaft for strength. Shock and fatigue factors for bending and torsion are 2 and 1.5 respectively. Shaft material has an allowable bending and shear stresses 50 MN/m^2 and 40 MN/m^2 respectively.

5. Splined shaft experiences maximum state of stresses when the pair of gears G and J transmits power.

6. Efficiencies are:

Bevel gears	92%
Spur wheels	94%
Belt drive	90%

7. Ratio of the pulley diameters are in the range of 0.5 to 3 and the center distance between pulleys can be in the range of 200 - 600 mm. This system is required to operate for over 10 hours a day continuously.

8. Pressure angle for any spur gear is 20^o.

9. The velocity ratio of the spur gears can be selected between the range of 0.5 to 2.

10. ASME code equations for shaft design in usual notations are as follows,

$$[\sigma_t] = \frac{16}{\pi d^3}\left[M_b \quad K_b + \sqrt{(M_b\ K_b)^2 + (T\ K_t)^2}\right]$$

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

11. At your request the following tables, manuals, standards, information are available.

    (i) Motor manual
    (ii) BSS for belt drives
    (iii) BSS for keys
    (iv) SKF Catalogues for rolling element bearings, Belts catalogues
    (v) Instructions for design spur and helical gears.

12. Consider a safety factors appropriately.

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