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The Open University of Sri Lanka
Faculty of Engineering Technology

Study Programme	:	Diploma in Technology/Bachelor of Technology (Engineering)
Name of the Examination	:	Final Examination
Course Code and Title	:	**MEX5277/MEX4231 Machine Design [Paper II]**
Academic Year	:	2014/15
Date	:	September 05, 2015
Time	:	0930 hrs. – 1330 hrs.
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 the place of written representation.
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.**

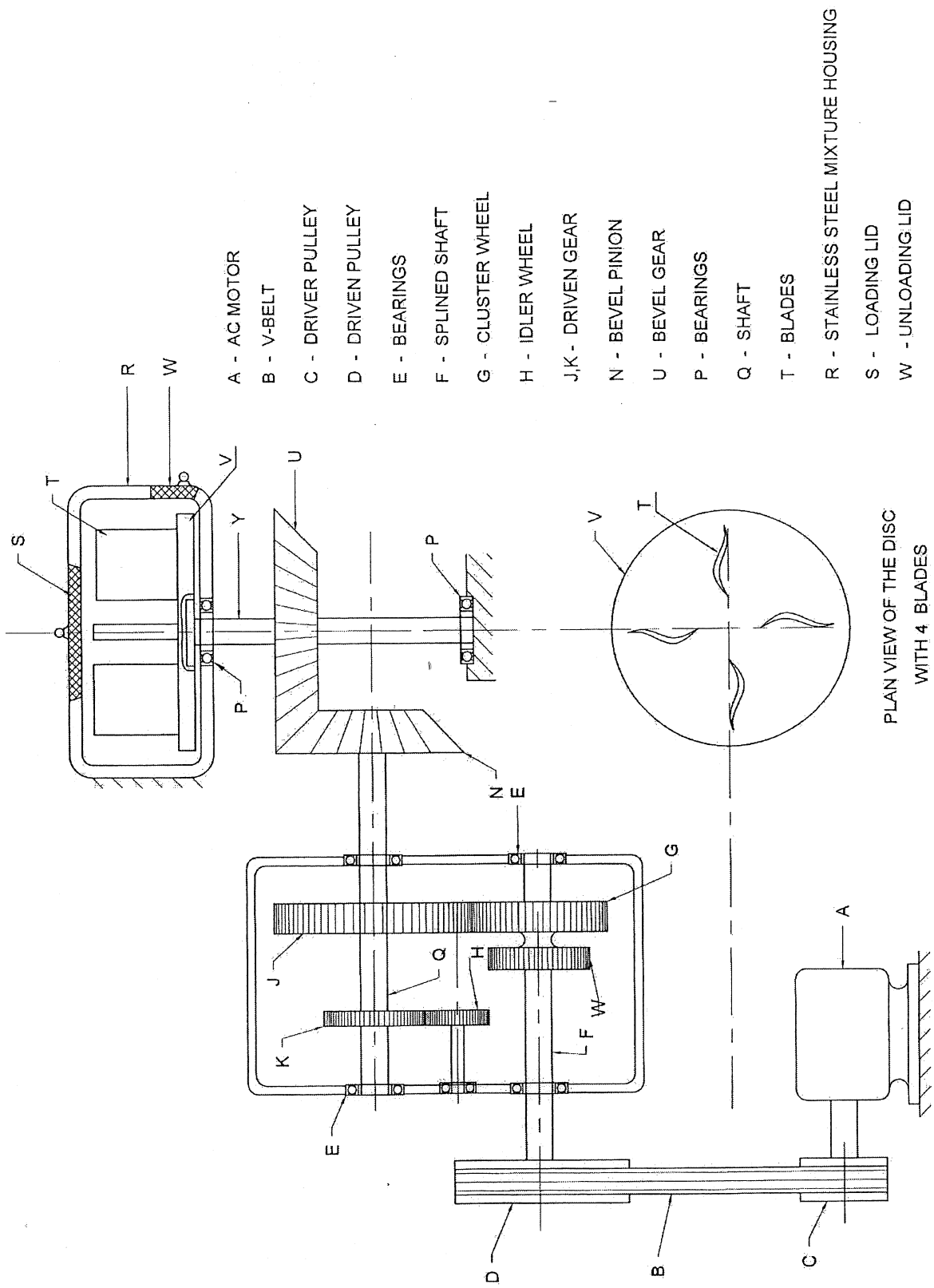
A - AC MOTOR
B - V-BELT
C - DRIVER PULLEY
D - DRIVEN PULLEY
E - BEARINGS
F - SPLINED SHAFT
G - CLUSTER WHEEL
H - IDLER WHEEL
J,K - DRIVEN GEAR
N - BEVEL PINION
U - BEVEL GEAR
P - BEARINGS
Q - SHAFT
T - BLADES
R - STAINLESS STEEL MIXTURE HOUSING
S - LOADING LID
W - UNLOADING LID
V - DISC WHICH BLADES ARE FIXED
PLAN VIEW OF THE DISC
WITH 4 BLADES

FIGURE 1

Question

A company which produces food items such as fruit juice, jams, cordials, etc., intends to expand their production. In the process of expansion, the company needs a higher capacity/ heavy duty blender which can be used to mix and blend fruit slices in order to make fruit pulps. These fruit pulps can be used in production of juice and also can be stored for future use. The Figure 1 shows the layout of the proposed blender. The blender consists of a mixing chamber that meets the capacity requirement and has four (4) blades fixed to a solid disc for the purpose of blending action.

Ingredients loaded to a cylindrical container **R** made out of stainless steel and are churned as the four blades (**T**) rotate. These blades should rotate both directions (clockwise and anticlockwise) in order to obtain the best mixing effect. Pulley **C** on the motor shaft drives the driven pulley **D** by means of a suitable V-belt system. 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 rotation by 90^{o}. 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 disc with four blades. 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, K, H** and **W**are enclosed in a gearbox.

Answer the following questions as if you were the consultant in this exercise.

1. Calculate the power demand of the motor and estimate the design power.
   Note: *Power transmission efficiencies are, Bevel gear: 95%, Belt Drive: 90%, Spur Gear Drive: 95%.*
2. Select a suitable induction motor from the motor catalogue.
3. Find the overall velocity ratio and decide the velocity ratios of the belt drive system, gear box and bevel gear pair.
   Note: *Finalize the velocity ratios of belt drive and spur gear mesh sensibly. Assume the velocity ratio of the bevel gear accordingly, in such a way to obtain the final angular velocity of the mixture, which is 40rpm.*
4. Design the belt drive system completely.
5. Design the pair of spur gears **G** and **J** in the gearbox unit.
6. Find the number of teeth on the idler wheel **H**.
7. Design the shaft **F**.
8. Suggest a suitable keyed joint to couple the wheel **J** to the shaft **Q**.
9. Select two rolling element bearings for shaft **F** on to the gear enclosure.
10. Critically discuss any drawbacks of the proposed design and state how you could improve the design by eliminating such drawbacks.

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

1. The dimensions of the blades and disc are as given in the Figure 2.

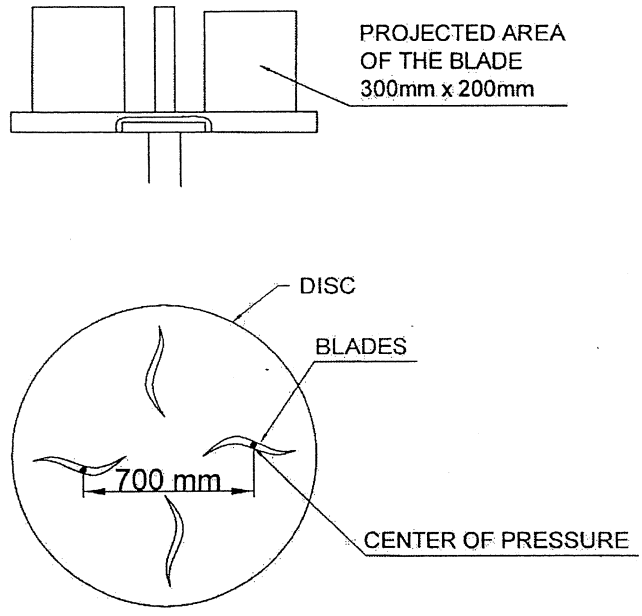

Figure 2

The maximum speed of the disc with blades is restricted to $20 rev/min$. The motor accelerates for $10s$ and attains this angular velocity.

Amount of pressure applies to a blade is $10 kN/m^2$ when the container is filled with the mixture to its maximum capacity. This amount of pressure is applied on to the projected area of the blades, **one of which** is $300mm$ x $200mm$.

The weight and the diameter of the disc are $3kg$ and $1m$ respectively, and you may neglect the weights of the blades.

2. Axes of all the shafts of the gear box lie on same vertical plane.

3. Diameter of the splined shaft refers to its minor diameter, and may neglect the effects of splines when designing the shaft for strength. Shaft material has an allowable bending and shear stresses of $50 MN/m^2$ and $40 MN/m^2$ respectively.

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