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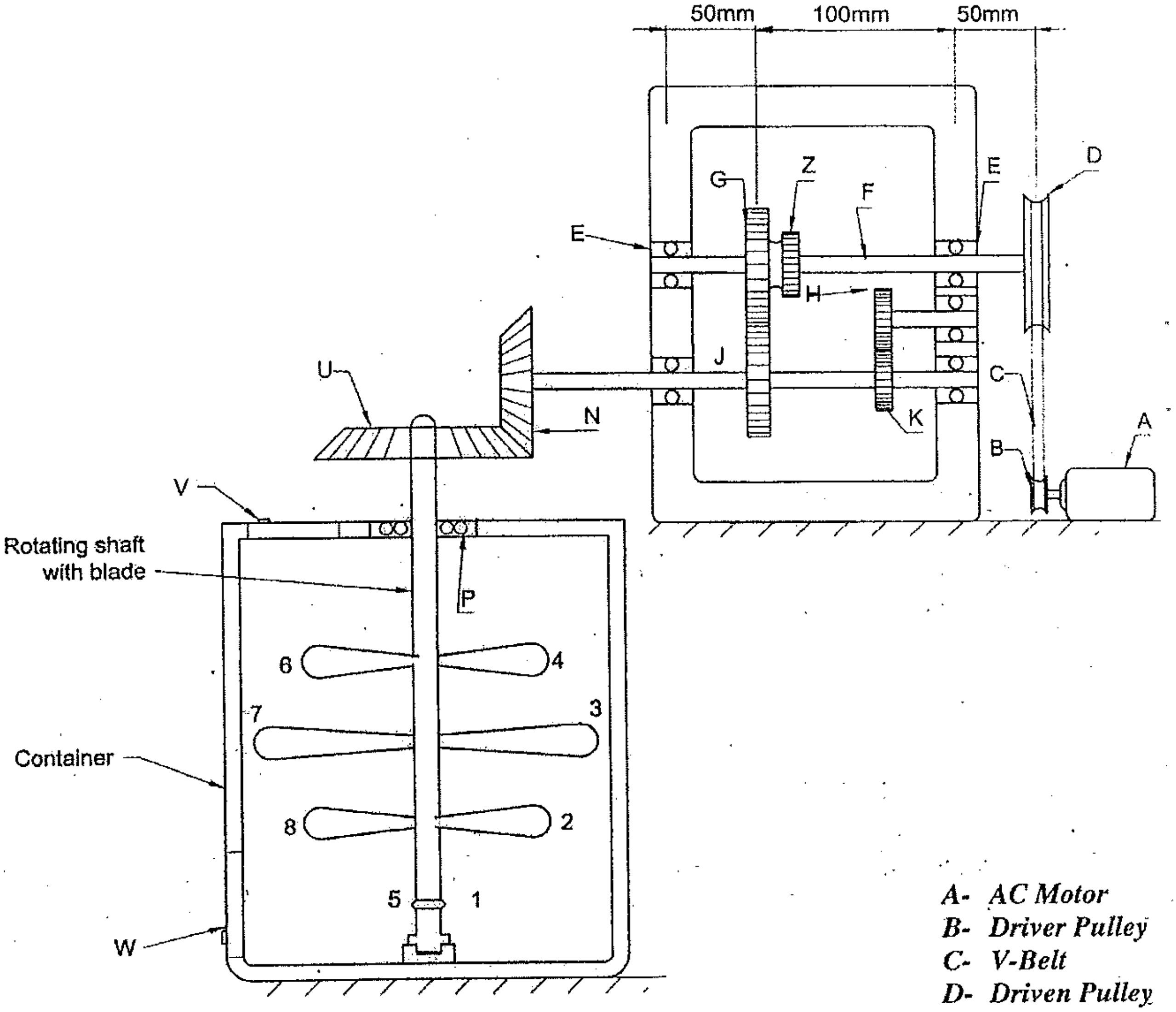
The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Mechanical Engineering

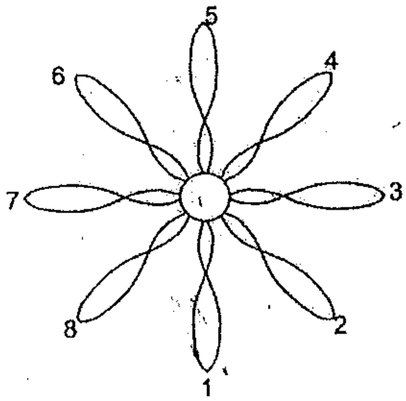
Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: DMX5577/MEX5277 Machine Design-Paper II**
Academic Year	: 2017/18
Date	: February 20, 2019
Time	: 0930 -1330hrs
Duration	**: 4 hours**

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 of 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 in the form of neatly drawn sketches placed against the answer help present the answers clearly. .
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- Driver Pulley
C- V-Belt
D- Driven Pulley
E- Bearings
F- Splined shaft
G- Cluster Wheel
H- Idler Wheel
J, K- Driven Gears
N- Bevel Pinion
U- Bevel Gear
P – Bearing
V- Loading Lid
W- Unloading Lid



PLAN VIEW OF THE
SHAFT AND BLADE ASSEMBLY
(Blade Shape is not Drawn Accurately)

Question

A company which produces food items like fruit juice, jam, cordials, etc. intends to expand its production. In the process of expansion, the company needs a high 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 the production of juice and also can be stored for future use. The Fig.*Q*1 shows the layout of the proposed blender. The blender consists of a mixing chamber that meets the capacity requirement and has a vertical rotating shaft to which blades are fixed for the purpose of blending action.

The blender is driven by the motor *A* through the gear mechanism shown in the figure. The pulley *B* on the motor shaft drives the pulley *D* by means of a suitable V – belt drive system. The horizontal splined shaft *F,* mounted on two a metal enclosure by two identical rolling element bearings, *E* carries a cluster wheel having two wheel segments *G* and *Z*. The shaft *Q*, which caries the wheels *J*, *K* and *N* is mounted on the same enclosure through another pair of identical rolling element bearings. The bearings are lubricated by the oil inside the enclosure. When the wheel segment *G* is in contact with the wheel *J*, power transmits to the rotor blades through a pair of bevel gears *N* and *U*, where N is coupled to the rotor bade shaft, to which eight blades are firmly fitted as in the figure. Whereas, when *Z* is in contact with the idler wheel *H*, power is transmitted through *K* to the same pair of bevel gears in order to reverse the direction of motion to obtain the complete mixing effect.

As shown in the plan view of the shaft and the blade assembly, a pair of blades fitted diametrically opposite as four pairs fixed at different levels and equidistant.

Answer the following questions.

1. From looking at the sketch what are the drawbacks of the proposed design? Assume that the method of transmitting power is not changed.
2. Estimate the power required to drive the blender.
3. Select a suitable motor power rating and its speed.
4. Find the number of teeth on the idler gear *H*.
5. Select a suitable belt drive system and standard pulleys. Find the initial tension of belt/s.
6. Determine the minimum diameter of the splined shaft.
7. Select a suitable key for the driven pulley.

8. Select an appropriate pair of rolling element bearings to support the splined shaft. Also, determine their rated life.

9. Determine the important parameters of wheel G and J selecting a suitable material.

10. Explain any modifications that you feel necessary to improve this drive mechanism.

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

1. The Fig.$Q1$-B shows the important dimensions of the blades.

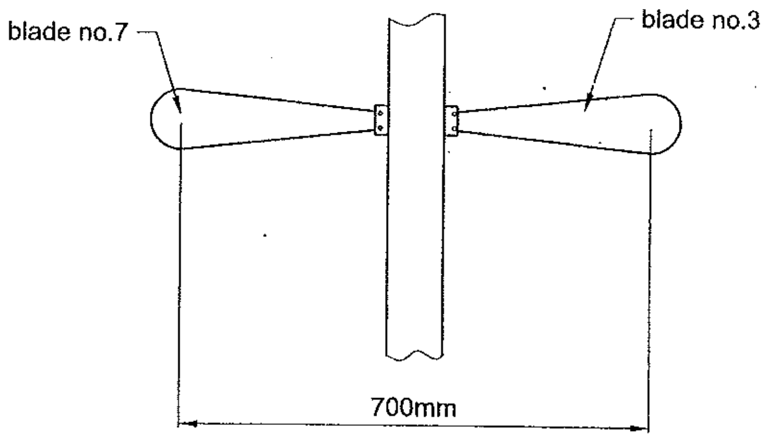


Fig.$Q1$-B

The maximum rotational speed of the blades with rotor is restricted to 100 *rev/min.* and it reaches this speed within 0.25 seconds from the instant of switching on the motor.

A single blade is applied by fluid pressure of 8 KN/m^2 when the container is filled with food slices to its maximum level, and this amount of pressure is applied to the projected area of the blade, which is 250 cm^2. The distance between the centres of gravity of blade 3 and blade 7 is 700 mm as shown in the Fig.$Q1$-B. All blades are identical and for calculation of rotational inertia it can be considered that the radius of gyration of each blade is 350 mm from the axis of rotation.

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

3. Efficiencies of the wheels can be considered as given below.

   Efficiency of bevel wheels = 94%
   Efficiency of spur wheels = 94%
   Efficiency of Belt drive = 90%

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

5. Belt drive has an approximate speed ratio of 2.5 and centre distance between pulleys is approximately 500 *mm*. This system is required to operate for over 16 hours a day and in continuous service.

6. Diameter of the splined shaft refers to its minor diameter, and neglect the effects of splines when designing the shaft for strength.

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. Assume that the splined shaft experiences maximum state of stress when the pair of wheels G and J transmits power.

10. ASME code equation for shaft design in usual notation are as follows:

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

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11. Consider safety factors appropriately.