UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: July 2016

Module Number: ME 5303 **Module Name: Mechanical Engineering Design**

[Three Hours]

[Answer **all questions**, each question carries ten marks]

Q1. a) i) What do you mean by Design for Excellence?

ii) Briefly explain the DFM guidelines.

[3.0 Marks]

b) With the aid of suitable examples, explain how ergonomics is important for machine design. What are the negative effects that would occur due to the negligence of ergonomics during the design stage?

[2.0 Marks]

c) i) What are the basic families of engineering materials available at present?

ii) Briefly describe the properties of each material family that you have mentioned above.

iii) "The evolution of material has advanced engineering design throughout the history". By taking any engineering product as an example, justify the above statement.

[5.0 Marks]

Q2. a) Elaborate the importance of using standard components for machine design.

[2.0 Marks]

b) Sketch a system with a hole and a shaft illustrating the followings.

i) Zero line

ii) Upper and lower deviations of both shaft and the hole

ii) Tolerance zones and allowances

[3.0 Marks]

c) Calculate the dimensions and allowance for a medium force fit on a 200mm shaft. The medium fit could be achieved with a shaft of r6 and a hole of H7.

Note:

200mm are in the steps between 180mm to 250mm.

The relative magnitude of tolerance grades are shown in Table Q2.

Refer to the following equations.

$i = 0.45\sqrt[3]{D} + 0.001D$

$Upper\ limit\ for\ the\ shaft\ (es) = {}^{1}/_{2}\{(46 + 0.4D) + 49\}$

[5.0 Marks]

Q3 a) Draw a turning movement diagram of a four stroke engine with the mean resisting torque indicated in the same graph. Point out the maximum and the minimum speed of the flywheel on the graph. Give reasons to your answer.

[2.0 Marks]

b) One of the stress induce in the flywheel is Tensile Stress. It is induce by the centrifugal force. Starting from ***Figure Q3.*** show that $\sigma_t = \rho v^2$.

Where; σ_t -- $Tensile\ stress$

ρ — $Density\ of\ flywheel\ material$

v — $Linear\ velocity\ of\ flywheel$

[3.0 Marks]

c) A four stroke diesel engine is coupled with an electric generator. The generator supply power to three motors of 24kW each. The overall efficiency of the electric system is 40% and the engine runs at 240 rpm. The engine produce maximum energy of 11,4500Nm and minimum of 15,945Nm during it's one complete cycle. The tensile stress developed on the rim of the flywheel of the engine is 5.2MPa and the total fluctuation of speed is to be limited to ±1.5% of the mean speed. The Flywheel is made out of cast iron with the density of $7220kg/m^3$.

i) Calculate the power generated by the diesel engine.
ii) Find the diameter of the flywheel.
iii) Find the dimensions of the cross-sectional area of the flywheel. Take the width as twice as the thickness.

Note: Maximum fluctuation of energy of the flywheel is given by $\Delta E = m.R^2.\omega^2.C_s$ *. All letters have their usual meanings.*

[5.0 Marks]

Q4. a) Gear tooth failures are very significant to be considered. What are the possible ways of gear tooth failures?

[2.0 Marks]

b) As an Engineer you are requested to design an automatic gate operating system having an electric motor with a gear system. Briefly describe the key factors that you would consider for the gear system design.

[3.0 Marks]

c) The name plate of the electric motor that should be used for the gate operating system mentioned in above *Q4.b)* is shown in ***Figure Q4***. Up to 690rpm reduction is required for the system by using two spur gears. Due to the limited space availability the maximum length of the meshed gears should be 300mm.

i) Explain how you select the module value for the gear design.
ii) Find the face width of the gears.
iii) Calculate the number of teeth on the gear that is connected to motor.

Note:

Teeth has 20^o*stub involute profile, the static stress for the gear materials are 60MPa and face width can be assumed as 5 times the module. Take 1hp = 0.75 kW*

The tooth form factor y can be taken as;

$$y = 0.175 - \frac{0.841}{No\ of\ teeth}$$

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Velocity factor can be taken as;

$$C_v = \frac{3}{3 + v}$$

Lewis equation;

$$W_T = \sigma_w \, b.\pi.m.y$$

[5.0 Marks]

Q5. a) i) Classify the types of bearings according to the direction of the load to be supported.

ii) Discuss the applications of sliding contact bearings.

[2.0 Marks]

b) Briefly explain the importance of bearing characteristic number and bearing modulus.

[2.0 Marks]

c) A journal bearing should to be designed for a steam turbine of a coal power plant. The specifications of the turbine are shown in ***Figure*** Q5. Estimated load on the journal is 20000N. Manufacturer has instructed to use SAE 40 as the lubricant and working temperature is 130 C^o. Ambient temperature of the oil is 30 C^o and maximum bearing pressure for the pump is $15N/mm^2$. If rise of temperature of the oil is limited to 5 C^o , calculate the artificial cooling requirement.

Note:

*Refer **Table** Q5, 1cSt=0.001 kg/m-s*
Maximum length for the journal is 160mm
Design value for ZN/P is 14
l/d is between 1 and 2
Clearance ratio is 0.001
Heat dissipation coefficient is 1232 $W/m^2/C^o$
Specific heat of the oil is 1900 $J/kg/C^o$
Friction Coefficient$(\mu) = \frac{33}{10^8}\left(\frac{ZN}{P}\right)\left(\frac{d}{c}\right) + k$

[6.0 Marks]

Table Q2

Tolerance grade	IT 5	IT 6	IT 7	IT 8	IT 9	IT 10	IT 11	IT 12	IT 13	IT 14	IT 15	IT 16
Magnitude	7 i	10 i	16 i	25 i	40 i	64 i	100 i	160 i	250 i	400 i	640 i	1000 i

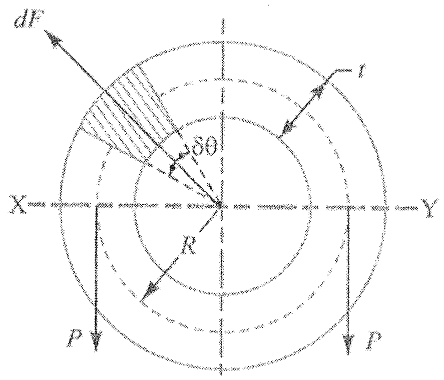

Figure Q3

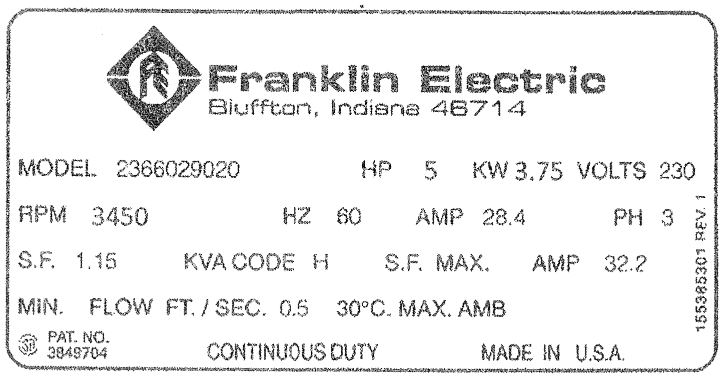

Figure Q4

General Specifications

Frame	PYR	AYR	BYR
Initial pressure (psig/bar)	650/45	700/48	700/48
Initial temperature (F/C)	750°/400°	825°/440°	900°/482°
Exhaust pressure (psig/bar)	100/6.9	vac-100/6.9	vac-100/6.9
Speed (rpm)	5000	7064	6675
Wheel pitch diameter (inch/mm)	12/305	14/360	18/460
Number of stages (impulse type)	1	1	1
Inlet sizes (ANSI, inch)	3"	3"	3", 4"
Exhaust size (ANSI, inch)	6"	6"	8"
Range of capacities (hp/kW)	200/150	750/560	to 1400/1044
Shipping weight (lb/kg)	550/250	870/400	1275/580

Figure Q5

Table Q5

SAE grade	ISO grade	Abs Viscosity in cSt 40°C	100°C	130°C
10W	32	32.6	5.57	3.20
20W	68	62.3	8.81	5.01
SAE 30	100	100	11.9	6.25
SAE 40	150	140	14.7	8.0
5W-20	46	138	6.92	4.17
10W-30	68	66.4	10.2	5.7
10W-40	100	77.1	14.4	8.4