UPES

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, December 2017

Program: M. Tech PLE / M. Tech RE   **Semester –** I
Subject (course): Pumps, compressors, selection sizing and specs./Pumps, Compressors and Fans
Max. Marks : 100   **Code :**   MPEG701/MPEG 704
Duration   : 3 Hrs   **No. of page/s:** 4

Note: Attempt all questions, internal choices are given. Section B and Section C, both having <mark>ONE INTERNAL</mark> **choice.**

Section A (4*5=20)

1. Answer following:
    a. Define specific speed of centrifugal pump. Derive an expression for the same (use dimensionless terms)
    b. Discuss effect of suction pressure on volumetric efficiency of reciprocating compressor, draw p-V diagram under different conditions.
    c. Draw H-Q relationship for ideal pumps; also show the effect vane angle β_2 on H-Q curve.
    d. Draw schematic of centrifugal compressor and discuss principle of working.

Section B (4*10=40)

2. Explain shock loss with the help of inlet velocity triangles for both the cases of reduction and increase in discharge from normal discharge.
3. Derive Euler equation for rotadynamic machines
4. Discuss the main and operating characteristics of a centrifugal pump. What is importance of constant efficiency curves?

5. A reciprocating compressor of single stage and double acting type is running at 200 rpm with mechanical efficiency of 85%. Air flows into compressor at the rate of 5 m³/min measured at atmospheric condition of 1.02 bar, 27°C. Compressor has compressed air leaving at 8 bar with compression following polytropic

process with index of 1.3. Compressor has clearance volume of 5% of stroke volume. During suction of air from atmosphere into compressor its temperature rises by 10°C. There occurs pressure loss of 0.03 bar during suction and pressure loss of 0.05 bar during discharge passage through valves. Determine the dimensions of cylinder, volumetric efficiency and power input required to drive the compressor if stroke to bore ratio is 1.5.

<div align="center">**OR**</div>

A centrifugal pump is running at 1000 r.p.m. The outlet vane angle of the impeller is 45° and velocity of flow at outlet is 2.5 m/s. The discharge through the pump is 200 liters/s when the pump is working against a total head of 20 m. if the manometric efficiency of the pump is 80%, determine:

    (i)   Outlet diameter of the impeller, and (ii) the width of the impeller at outlet.

<div align="center">**Section C(2*20=40)**</div>

6. (a) A centrifugal compressor has a pressure ratio of 4:1 with an isentropic efficiency of 80% when running at 15000 rpm and inducing air at 293 K. Curved vanes at the inlet give the air a pre-whirl of 25o to the axial direction at all radii. The tip diameter of the eye of the impeller is 250 mm. The absolute velocity at inlet is 150 m/s and the impeller diameter is 600 mm. Calculate the slip factor.

(b) Derive an expression for the volumetric efficiency of a single stage reciprocating compreesor in terms of the clearance fraction polytropic index of compressor and the pressure ratio.

7. A single stage overhung centrifugal pump as shown in Fig. 1. This Pump is used in the Fluid catalyst & cracking unit of oil refinery and reported about improper functioning. Pump was brought to machine shop for the maintenance and troubleshooting purpose, the detailed specifications of pump given in Table 1. Draw the schematic of centrifugal pump, list all the components and suggest suitable maintenance procedure. Also, explain inspection need to be done prior to dispatch.

Table 1: Specifications of Single stage centrifugal pump

TYPE	SINGLE STAGE CENTRIFUGAL PUMP
EQUIPMENT NO.	20 P 05 A
DEPARTMENT	FCCU (Fluid catalyst & cracking unit)
MODEL NO.	CPK-EM65-315 Se
COUPLING MAKE	UNIQUE
RPM	2950
PUMP FLOW	55.2 m³/hr
PUMP WORKING TEMPERATURE	250 ˚C
MECHANICAL SEAL MAKE	FLOWSERVE
PUMP AXIAL BEARING TYPE	SKF 7311 BECBJ
PUMP RADIAL BEARING TYPE	SKF 311 EC
LUBRICATION OIL	TURBOL 68
HEAD	8m

OR

(a) Table 2 below gives the head-discharge-efficiency characteristics of a centrifugal pump. Two pumps of the above type are connected in parallel to a system. The system characteristics are given in Row 4 of the table. (a) Calculate the operating point when (i) only one pump is working, and ii) when two pumps connected in parallel are working. (b) Calculate the brake power required in both the cases mentioned above.

Table 2: Pump data

Head, H(m)	22	22	21	19	17	15	12	9	6	3
Discharge (L/s) of one pump	0	20	40	60	70	80	92	100	110	120
Efficiency (%)	0	33	57	76	80	81	79	74	62	30
System (H-Q) Characteristics. H_{sys} in m.	12.0	12.4	13.3	14.6	15.4	16.3	17.5	18.4	19.6	20.8

(b) A centrifugal pump with 1.2 m diameter runs at 200 r.p.m. and pumps 1800 liters/s, the average lift being 6 m. the angle which the vanes make at exit with the tangent to the impeller is 26° and the radial velocity of flow is 2.5 m/s. determine the manometric efficiency and the least speed to start pumping against a head of 6 m, the inner diameter of the impeller being 0.6 m.