BENGAL ENGINEERING AND SCIENCE UNIVERSITY, SHIBPUR

M.E. 1st. Semester Examination, 2013 (held in December, 2013)

Sub. : **Hydraulic Control System I**

Branch : Engineering Mechanics | Code No : **AM 912**

Time : 3 hrs. | Full marks : 70

(i) Answer any **five** questions

(ii) All questions carry equal marks.

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1. What is the functional difference between a 'Gear Pump' and a 'Piston Pump'? Why only odd numbers of pistons are used in piston Pump? Describe, with a neat sketch, the working principle of an Axial Piston Pump.

   A hydrostatic transmission system consists of a variable capacity pump and fixed capacity motor. The maximum flow between the pump and motor is 500 ml/sec and the motor capacity is 25 ml/rev. The maximum allowable circuit pressure is 70 bar. Volumetric efficiencies of both pump and motor are 90% and the mechanical efficiency of motor is 80%. Determine the maximum power, maximum speed and maximum torque available at the output shaft.

2. In a hydraulic circuit a positive displacement pump of capacity 82 ml/rev and running at 1500 r.p.m. drives a vane motor of maximum capacity 66 ml/rev. The volumetric efficiency and mechanical efficiency of both pump and motor are 90% and 84 % respectively. The pressure drop between the pump and motor on high pressure side is 17 bar and the relief valve is set at 135 bar. If the motor is subjected to a constant torque load of 34 Nm, determine (i) the minimum motor speed and the pressure drop across the motor at this speed, (ii) the maximum motor speed and the associated motor capacity and (iii) the theoretical maximum power that can be transmitted and the speed range associated with it.

3. Describe with a neat sketch the working principle of a simple pressure relief valve. What is 'pressure override'?

   An asymmetric actuator of area ratio 1:2 has to transmit a load of 100 kN during forward stroke. The cylinder has a bore of 10 mm. The direction of motion of the actuator is controlled by 4-way tandem centre solenoid valve which causes a pressure drop of 2 bar in each of the pressure line and return line. The pressure relief valve has a sleeve of 10 mm diameter and rectangular drain port of 10 mm width along the axis of the sleeve and extended over full length of circumference of the sleeve. Draw the hydraulic circuit and determine the stiffness of the mechanical spring of the relief valve, if the maximum override is not exceed 5%. Also determine the maximum discharge through the relief valve assuming specific gravity of the working fluid to be 0.8.

4. With the help of a neat sketch and standard symbol, describe the working principle of a pressure reducing valve. Give one example of practical applications of it.

   In a 100 kN vertical hydraulic press the workpiece is to be held tight against a horizontal force of 20 kN. Both clamping cylinder of 50 mm bore and power cylinder of 200 mm bore have area ratio of 1:2 each. Assume pressure loss in each line of each valve to be 3 bar and negligible pipe losses. Draw a suitable hydraulic circuit and determine set pressure in each pressure control valve.

5. State and explain the specifications used to describe the transient response behaviour of a second order control system against a unit step input. Hence deduce expressions for each of them.

   Find damping ratio, natural frequency, rise time and settling time of a second order system working against a unit step input such that the maximum overshoot does not exceed 0.2 and the peak time is 6 ms.

6. With the help of circuit diagrams describe the working principle of (a) counterbalance circuit and (b) regenerative circuit. Give one example of practical applications of each.

   A double-acting hydraulic cylinder of 100 mm bore is used in a regenerative circuit. The relief valve is set at 70 bar. The area ratio of the actuator is 1 : 2 and the pump flow rate is 100 lit/min. Find the cylinder speed, load carrying capacity and power delivered to the load during (i) extension of rod and (ii) retraction of rod. Assume the load to be equal to maximum load carrying capacity of the cylinder.

7.(a) State and explain Nyquist stability criterion. The open loop transfer function of a closed loop system is given by,

$$G(s)H(s) = \frac{K}{s(s+1)(2s+1)}$$

   Using Nyquist criterion determine the critical value of gain K so that the corresponding closed loop system is stable.

(b) Draw the asymptotes and sketch Bode plots of each of the following systems whose transfer functions are given by,

   (i) $4/(1+0.3s)$ (ii) $2/(1+0.2s^2)$ (iii) $0.1/(1+0.1s)^2$

8. With the help of neat sketch and/or standard symbol write short notes on **any three** of the following:

   (i) Pressure Compensated Flow Control Valve, (ii) Solenoid Valve, (iii) Meter-In and Meter-Out Circuits, (iv) Rotary Motor, (v) Hydraulic Integral Controller.