PROBLEM:

An oleo-hydraulic circuit has been designed to lift loads (see figure). It is made using a single stroke cylinder and return by gravity, a sliding vane pump, a security valve at pressure Ps = 150 bar, a flow rate valve and a direction valve with three positions and three ways. Additionally, there is a hydraulic motor that moves a conveyor belt to reposition a new load and a sequence valve.

The system works in three phases regarding the movement of the cylinder (see the table):

- First the elevator (cylinder) with a bore diameter D_b=32 cm moves half of the stroke (L=1.5m) at a speed of v_1=3cm/s, till the charge point against a force F_1=200 kN, while the motor is stopped.

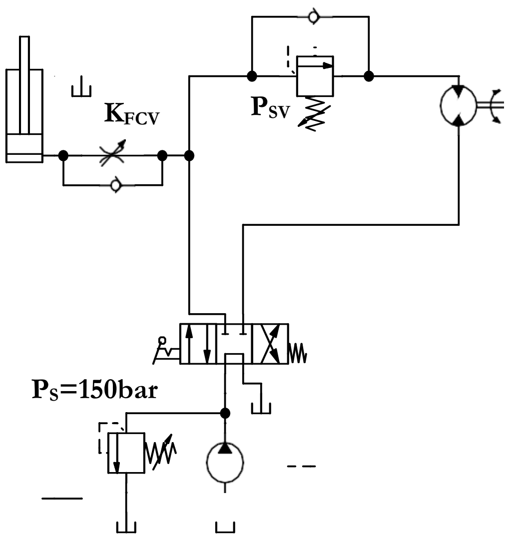
- Then, the load (F_2=925 kN) is elevated and the motor starts to move the conveyor belt (T_M=120 Nm, n_M=1000rpm). During the extent of the cylinder (first two phases) the pump moves at constant rotating speed.

- Finally, during the retract the directional control valve is placed at its right position and the cylinder descends due to gravity but the speed is controlled to v_3=2cm/s with the flow control valve. The pump and the motor work as an open loop hydraulic transmission, being the pump pressure P_{P3}=30bar and n_{P3}=500rpm.

Phase	Time (s)	Stroke (cm)	Velocity (cm/s)	Force (kN)	Motor
Approximation	t1	75	3	200	Stopped
Elevation	t2	75	v_2	925	Runs
Retract	t3	150	2	200	Runs

Determine:

1) During the first phase, pump pressure and flow rate, time of the phase and volumetric and hydraulic efficiencies of the pump.
2) The limiting pressure (P_{SV}) at the sequence valve that allows the starting of the motor at the second phase. Additionally, velocity of the cylinder, time of the phase, constant of volumetric losses of the motor and volumetric and hydraulic efficiencies of the motor and the pump.
3) Constant of losses of the flow control valve to control the descending speed of the cylinder during the third phase. Time of the phase and volumetric and hydraulic efficiencies of the motor and the pump.
4) Efficiency of a complete cycle of the system.



PUMP

$\vartheta_P = 100\ cm^3/rev$

$\lambda_{1P} = 0.25\ (l/min)/bar$

$\lambda_{2P} = 0.00015\ bar/(l/min)^2$

MOTOR

$\vartheta_M = 80\ cm^3/rev$

$\lambda_{1M} = ?\ (l/min)/bar$

$\lambda_{2M} = 0.002\ bar/(l/min)^2$

Directional Control Valve

$K_V = 0.002\ bar/(l/min)^2$