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HYDRAULIC DEPARTMENT

Course project task
№ 25

Initial design data:
Hydraulic rotary drive with throttle control using proportional directional control valve;
Pump station with fixed displacement pump, efficiency 100%;
Maximum supply pressure of the pump station 12 MPa;
Pressure relief valve opening pressure 10 MPa;
Maximum drive torque 150 N×m;
Rotation speed control range: from (not more than) 50 rev/min to (not less than) 1200 rev/min;
Reference operating point: torque 90 N×m, rotation speed not less than 1000 rev/min;
Hydromechanical efficiency of the hydraulic motor 0.95, Volumetric efficiency of the hydraulic motor 0.95

1. Determine the parameters of the actuating hydraulic motor
2. Determine the required mechanical characteristic of the drive
3. Determine the required throughput rate of the proportional directional control valve and select a mass-produced directional control valve
4. Determine the required flow rate of the pump station
5. Build the resulting mechanical characteristic of the drive
6. Design the mechatronic unit with direct mounting of the directional control valve on the hydraulic motor

Note.
To study the designs of commercially available proportional valves and hydraulic motors (see websites: www.boschrexroth.com ,www.atos.com, www.moog.com)

HYDRAULIC CIRCUIT

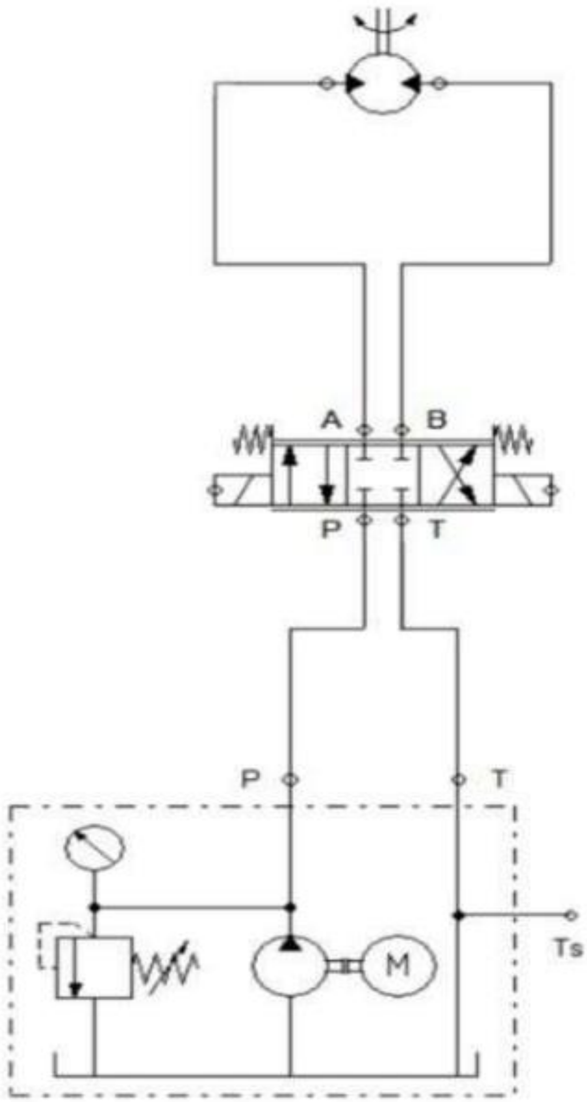
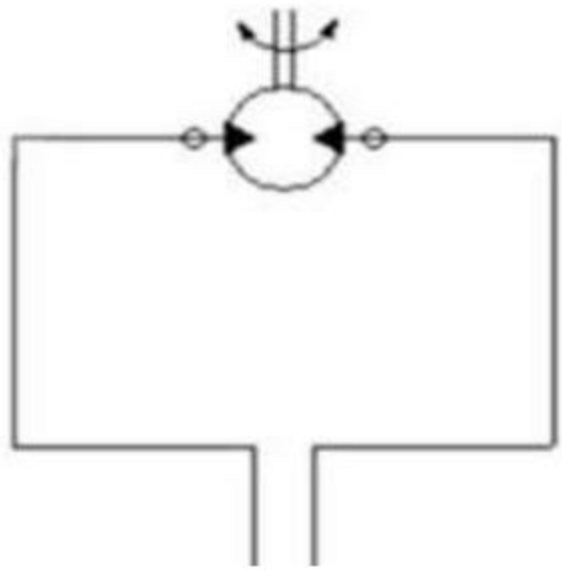


Fig - 1 hydraulic circuit

1. CALCULATION OF THE MOTOR PARAMETERS AND SELECTION OF THE MOTOR



To select a single rod motor as an actuator we should take in consideration the maximum supply pressure of the pump station and the maximum drive load. And we got from the task that Tmax = 150 Nm and Pmax = 12 MPa , by considering several parameters we will be able to find the calculation model for selecting the motor .

Power balance eq:

Nout=Nin* ηmotor

Nin=(P1-P2)*Q

Nout= ω*T=2 π *n*t

2 π *n*T = (P1-P2)*Q* ηmotor

Q=n*qm

2 π*T=Pmax* qm* ηmotor

Qm = $\frac{2\pi * T}{P\max * \eta motor} = \frac{2*3.14*150}{12*10^6*0.95} = 82.67 cm3/rev$

The code for the selected motor;

Bent Axis fixed motor

F10	-	090	-	A	F	-	1	V	-	D

2.calculation of required flow rate and pump selection and pressure relief valve ;

$$Qreq = n \max r\, ev/min * qmcat = 1200 * 93 = 111600cm^3/min = 111.6L/\min$$

FV7	D	S	-	31	-	3	R	00	/	10	N	-	*

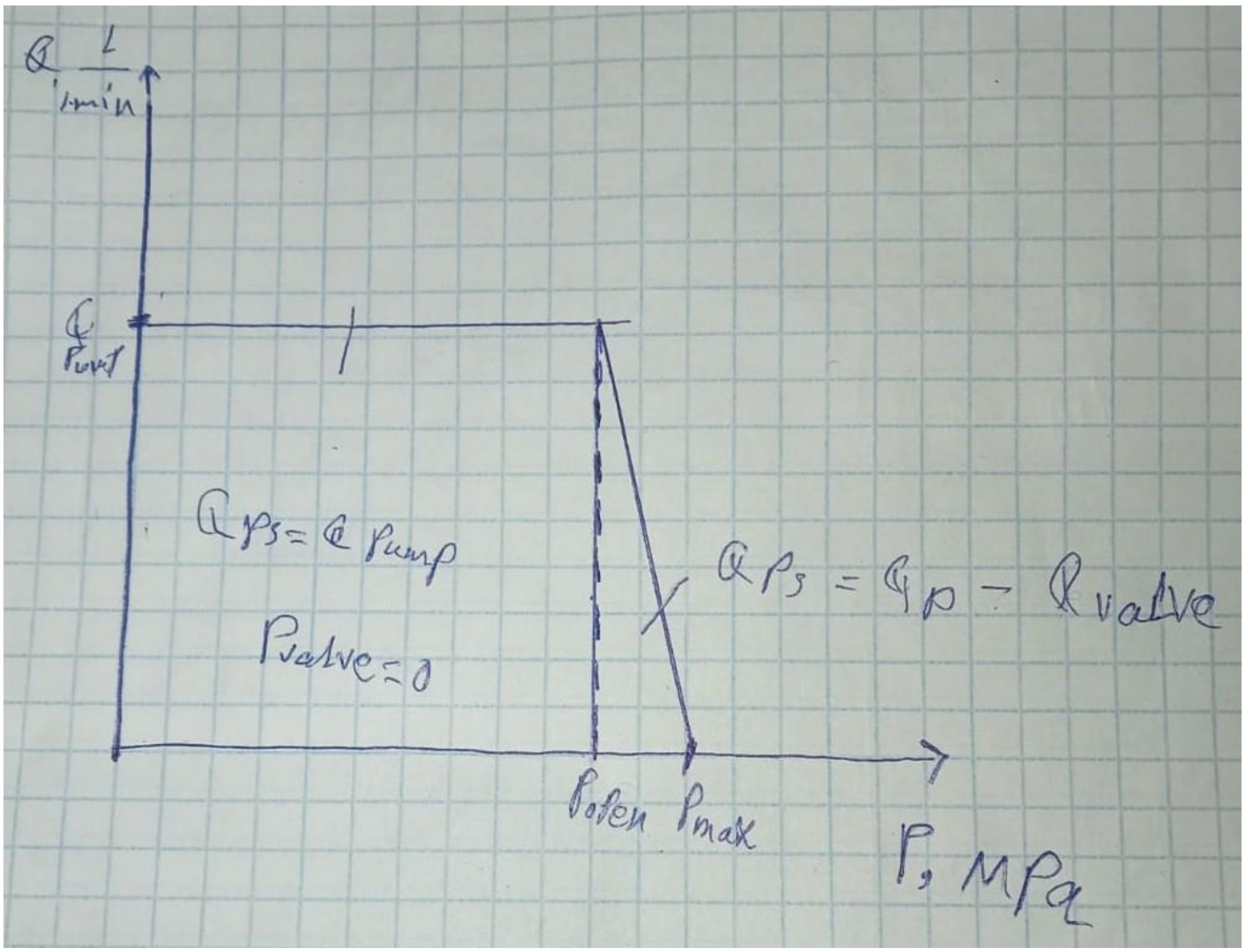
$$Qpump = qm * n = 0.093 * 1500 = 139.5$$

The Code for the selected pressure relief valve for the pump station:

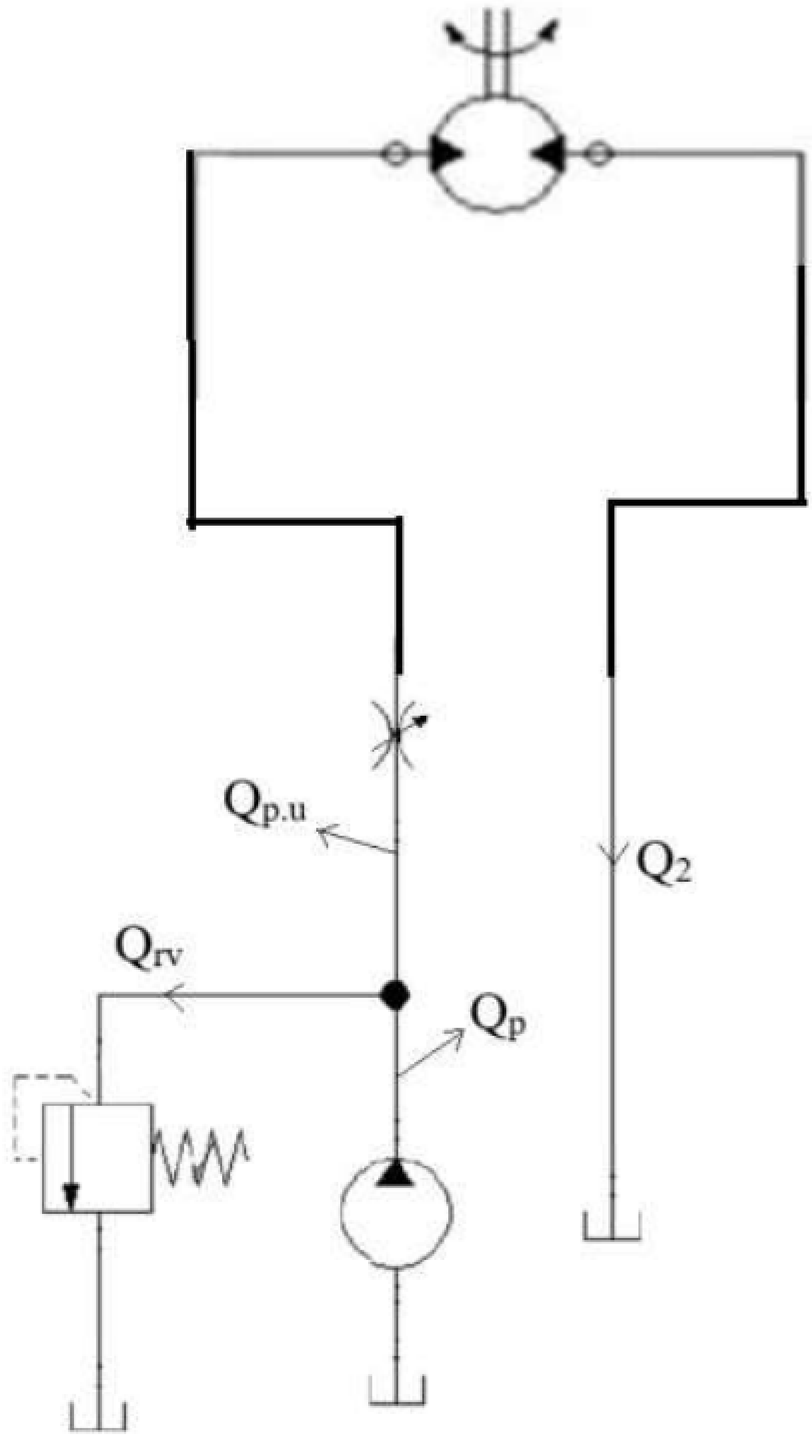
1.$P_{max}^{valve} \geq P_{maks}^{task}$ 2.$Q_{pump} \leq Q_{max}^{valve}$

AGMZO	-	RES	-	P	-	BC	-	10	/	100	/	E	/	T	E-A-BTH	/	NBR low temp

Pump Station Characteristics;



Build required mechanical characteristic Torque to Rotation speed T= f(n)



1. $T = \frac{P1\backslash astqm * \eta hy}{2\pi}$

2. $\Delta Pth = Pp.s - P1$

$$3.\, Q_{th} = \mu f \sqrt{\frac{2\Delta Pth}{\rho}}$$

$$4.\, Q_1 = Q_{th} = \frac{n * qm}{\eta_v}$$

$5.\, P_{ps} = P_{max} - kQ1$ $\qquad k = \frac{P_{max} - P_{open}}{Q_{pump}} = \frac{12-10}{139.5} = 0.014$

By solving those 5 eq. we get T= f(n)

$$T = \frac{q_{m*\eta*P_{max}}}{2\pi} - K * q^2 * n - \frac{q^3 * \rho * n^2}{\eta * 4\pi * \mu^2 * f^2}$$

$$T = 168.736 - 0.014n - 6.063 * 10^{-11} \frac{n^2}{\mu^2 * f^2}$$

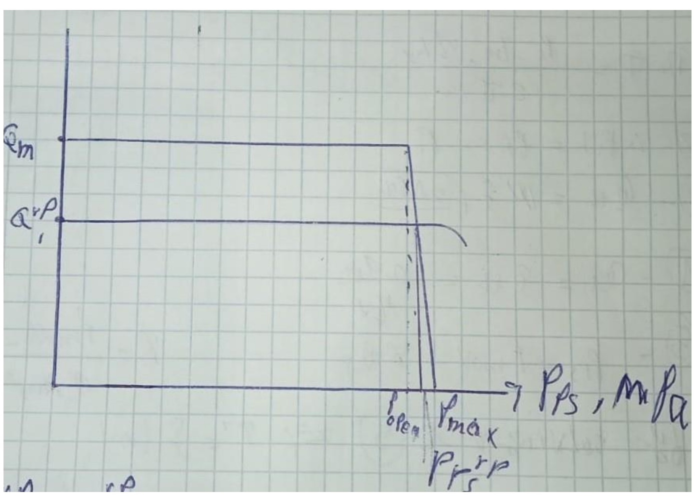
Calculation of μf

Reference point

Trp= 90N.M nrp=1000 rev/m

$$Q1 = \frac{q_{m*n_{rp}}}{\eta_v} = \frac{93 * 1000}{0.95} = 97.89 \ \frac{L}{m}$$

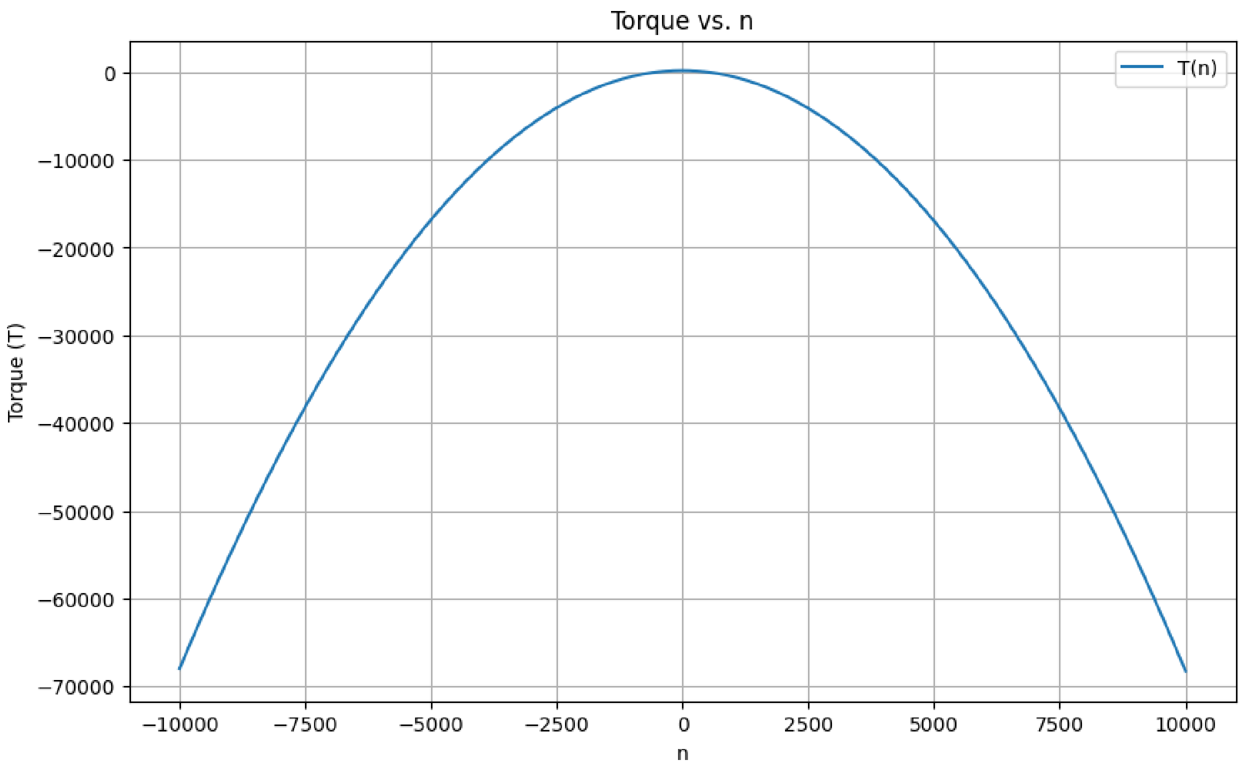
$$P1_{rp} = \frac{2\pi * T_{rp}}{q_m * \eta_{hy}} = \frac{2\pi * 90}{93 * 0.95} = 6.40\, mpa$$



$$\Delta pth = pp.s - p1 \ = 112.5 - 64 = 48.5 bar$$

$$\mu f = \frac{Q_{rp}}{\sqrt{\frac{2\Delta Pth}{\rho}}} = \frac{0.09989}{\sqrt{\frac{2 * 148.5 * 10^5}{900}}} = 9.42 * 10^{-4}$$

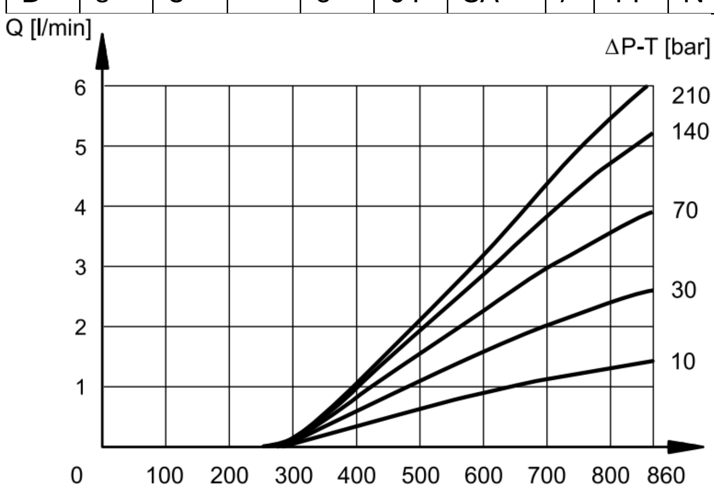
$$T = 168.736 - 0.014n - 6.83 * 10^{-4} n^2$$



Selection of proportional Directional Control Valve;

$$Q_{max}^{valve} \leq Qpump \ ; \ p_{max} \leq P_{max}^{task} \ ; \ Q1rp \cong Q_{mom}$$

D	s	3	-	c	01	SA	/	11	N	-	D24	K1	/	cm	w7	



ΔPP-A-B-T =10 bar

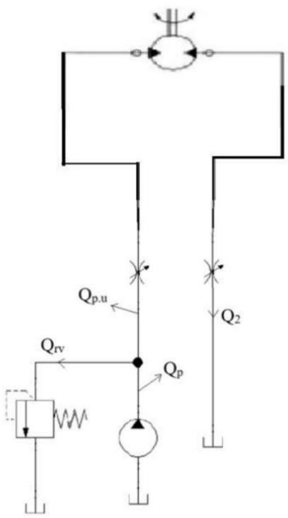
For E – spool

ΔPP-A=ΔPB-T=1/2*ΔPP-A-B-T = 5 bar

$$\mu f P-A\ =\frac{Q_{rp}}{\sqrt{\frac{2\Delta PP-A}{\rho}}}=\frac{97.89}{\sqrt{\frac{2*5*10^5}{900}}}=2.9367$$

$$\mu f B-T\ =\frac{Q_{rp}}{\sqrt{\frac{2\Delta PB-T}{\rho}}}=\frac{97.89}{\sqrt{\frac{2*5*10^5}{900}}}=2.9367$$

Build the resulting mechanical char;



$$1.T\ =\frac{\left((p1-p2)\backslash astqm*\eta\right)}{2\pi}$$

$$2..\Delta Pth1=Pp.s-P1$$

$$3.\Delta Pth2=p2-0=p2$$

$$4..Qth1=\mu f1\sqrt{\frac{2\Delta Pth1}{\rho}}$$

$$5.Qth1=\frac{qm*n}{\eta_v}=Q1$$

$$6.Qth2=Q2=qm*n\ 7.Pp.s=P\ max-K*Q1$$

$$k=\frac{Pmax-Popen}{Qpump}$$

By solving those 8 eq. we get T= f(n) We get ;

$$T = -\frac{(qm)3 * \eta 2 * \rho}{4\pi * (\mu f2)2 * \eta v} + \frac{pmax\backslash astqm * \eta hy}{2\pi} + \frac{k\backslash astqm2 * n}{2\pi} + \frac{(qm)3 * \eta 2 * \rho * \eta hy}{4\pi * (\mu f2)2}$$

By substituting number ;

$$T = 61.32 * 10^{-9} + 177.6 * 10^{12} + 19.27 * 10^{9}n + 58.5 * 10^{19}$$