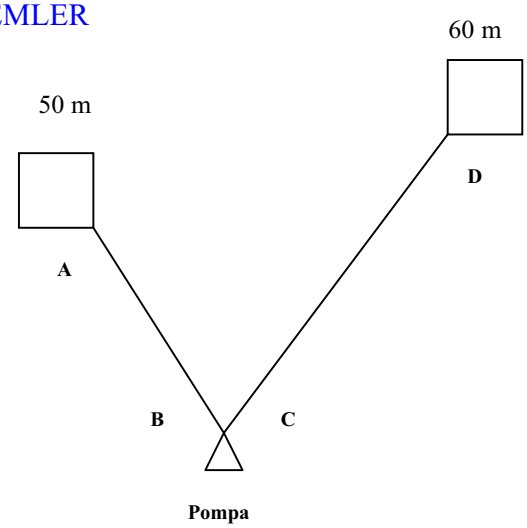
ÇOK HAZNELİ SİSTEMLER



1. **Soru** : Şekildeki sistemle A haznesinden D haznesine Q = 25 lt/s, özgül ağırlığı γ = 0.90 gr/cm^3, kinematik viskozitesi ν=10-3 m^2/s olan yağ akmaktadır. Boru çapı bütün sistemde aynı olup 10 cm dir. Boru uzunlukları L_{AB}=20 m ve L_{CD}=30 m olduğuna göre yersel yük kayıplarını ihmal ederek ;
   a) Akımın rejimini belirleyiniz.
   b) Pompanın sisteme vermesi gereken gücü ve enerji yüksekliğini belirleyiniz. Pompa randıman katsayısı η=0.70 dir.
   c) Sistemin rölatif enerji çizgisini çiziniz.

   Çözüm :

   a) Süreklilik denkleminden

$$\mathbf{V} = \frac{\mathbf{Q}}{\mathbf{A}} = \frac{0.025}{\pi 0.1^2}\mathbf{x}4 = 3.183 \text{ m}^3/\text{s}$$

   Boru içerisindeki akımın rejimi:

$$N_{Re} = \frac{\mathbf{VD}}{\nu} = \frac{3.183\mathbf{x}0.1}{10^{-3}} = 318.3 \quad < \quad 2000 \quad \text{akım laminer}$$

   b) $$\mathbf{h}_{\mathbf{k}_{AB}} = \mathbf{f}\frac{\mathbf{L_{AB}}}{\mathbf{D}}\frac{\mathbf{V}^2}{2\mathbf{g}} = (\frac{64}{\mathbf{N}_{Re}})\frac{\mathbf{L_{AB}}}{\mathbf{D}}\frac{\mathbf{V}^2}{2\mathbf{g}} = 20.76 \text{ m}$$

$$\mathbf{h}_{\mathbf{k}_{CD}} = \mathbf{f}\frac{\mathbf{L_{CD}}}{\mathbf{D}}\frac{\mathbf{V}^2}{2\mathbf{g}} = (\frac{64}{\mathbf{N}_{Re}})\frac{\mathbf{L_{CD}}}{\mathbf{D}}\frac{\mathbf{V}^2}{2\mathbf{g}} = 31.15 \text{ m}$$

Pompanın sisteme vereceği enerji yüksekliği = [(H_D + hk_{CD}) – (H_A – hk_{AB})]

H_{pompa} = [(60 + 31.15) – (50 – 20.76)] = 61.91 m

Pompanın şebekeden çekeceği güç $=N_{nominal} = \frac{\gamma \mathbf{Q}\mathbf{H}_{\mathbf{pompa}}}{\eta}$ = 1990 kg_f.m/s

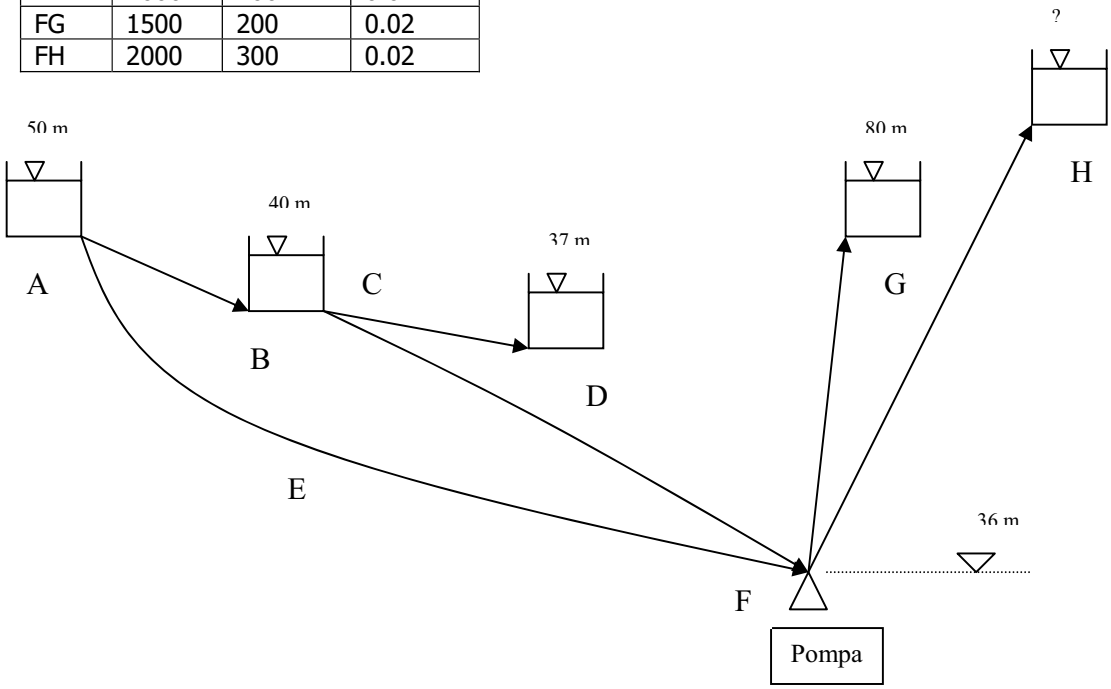
$N_{nominal}$ = 9.81 x 1990 =19521 Watt

$N_{nominal}$ = 1990 / 75 = 26.53 BB.

Pompanın gerçek gücü : $N_{gerçek} = \gamma \mathbf{Q}\mathbf{H}_{\mathbf{pompa}}$ = 900 x 0.025 x 61.91= 1393 kg_f.m/s

Soru : Şekildeki hazne boru sisteminde, haznelerin su yüzü kotları, pompanın zemin kotu ve akın yönleri şekil üzerinde gösterilmiştir. FG borusunun debisi 40 lt/s olduğuna göre diğer boruların debilerini ve H haznesinin su yüzü kotunu belirleyiniz. Pompa randıman katsayısı η = 0.70 olduğuna göre pompanın nominal gücünü ve sistemin rölatif enerji çizgisini çiziniz (Haznelerdeki su seviyeleri sabittir).

Boru	L [m]	D [mm]	f
AB	500	200	0.02
CD	500	150	0.02
CF	500	200	0.02
AEF	1000	200	0.02
FG	1500	200	0.02
FH	2000	300	0.02



Çözüm :

$h_{kAB} = H_A - H_B = 10\ m = 0.02\frac{500}{0.2}\frac{\mathbf{V_{AB}^2}}{2\mathbf{g}}$ $\rightarrow$ $V_{AB} = 1.981$ m/s : $Q_{AB} = 0.0622$ m^3/s

$h_{kCD} = H_C - H_D = 40 - 37 = 3\ m = 0.02\frac{500}{0.15}\frac{\mathbf{V_{CD}^2}}{2\mathbf{g}}$ $\rightarrow V_{CD} = 0.94$ m/s : $Q_{CD} = V_{CD} \cdot A_{CD} = 0.017$ m^3/s

$Q_{AB} = Q_{CD} + Q_{CF}$ $\rightarrow$ $Q_{CF} = Q_{AB} - Q_{CD} = 0.062 - 0.017 = 0.045$ m^3/s

$$\mathbf{V_{CF}} = \frac{\mathbf{Q_{CF}}}{\mathbf{A_{CF}}} = \frac{4\mathbf{Q_{CF}}}{\pi\mathbf{D_{CF}^2}} = \frac{4\mathbf{x}0.045}{\pi 0.2^2} = 1.43 \text{ m/s}$$

$$\mathbf{h_{k_{CF}}} = 0.02\frac{500}{0.2}\frac{1.43^2}{19.62} = 5.21 \text{ m}$$

$(h_k)_{AEF} = (h_k)_{AB} + (h_k)_{CF} = 10 + 5.21 = 15.21\ m = 0.02\frac{1000}{0.2}\frac{\mathbf{V_{AEF}^2}}{19.62}$

V_{AEF} = 1.73 m/s
$Q_{AEF} = V_{AEF} . A_{AEF}$ = 0.054 m^3/s

$H_{GIRIŞ} = H_A - (h_k)_{AEF}$ = 50 – 15.21 = 34.79 m

$Q_{AEF} + Q_{CF} = Q_{FG} + Q_{FH}$
$Q_{FH} = Q_{AEF} + Q_{CF} - Q_{FG}$ = 0.054 + 0.045 – 0.045 = 0.059 m^3/s

$$\mathbf{V_{FG}} = \frac{\mathbf{Q_{FG}}}{\mathbf{A_{FG}}} = \frac{4\mathbf{Q_{FG}}}{\pi \mathbf{D_{FG}^2}} = \frac{4\mathbf{x}0.04}{\pi 0.2^2} = 1.24 \text{ m/s}$$

$$\mathbf{h_{k_{FG}}} = 0.02 \frac{1500}{0.2} \frac{1.27^2}{19.62} = 12.33 \text{ m}$$

$$\mathbf{V_{FH}} = \frac{\mathbf{Q_{FH}}}{\mathbf{A_{FH}}} = \frac{4\mathbf{Q_{FH}}}{\pi \mathbf{D_{FH}^2}} = \frac{4\mathbf{x}0.059}{\pi 0.3^2} = 0.83 \text{ m/s}$$

$$\mathbf{h_{k_{FH}}} = 0.02 \frac{2000}{0.3} \frac{0.83^2}{19.62} = 4.68 \text{ m}$$

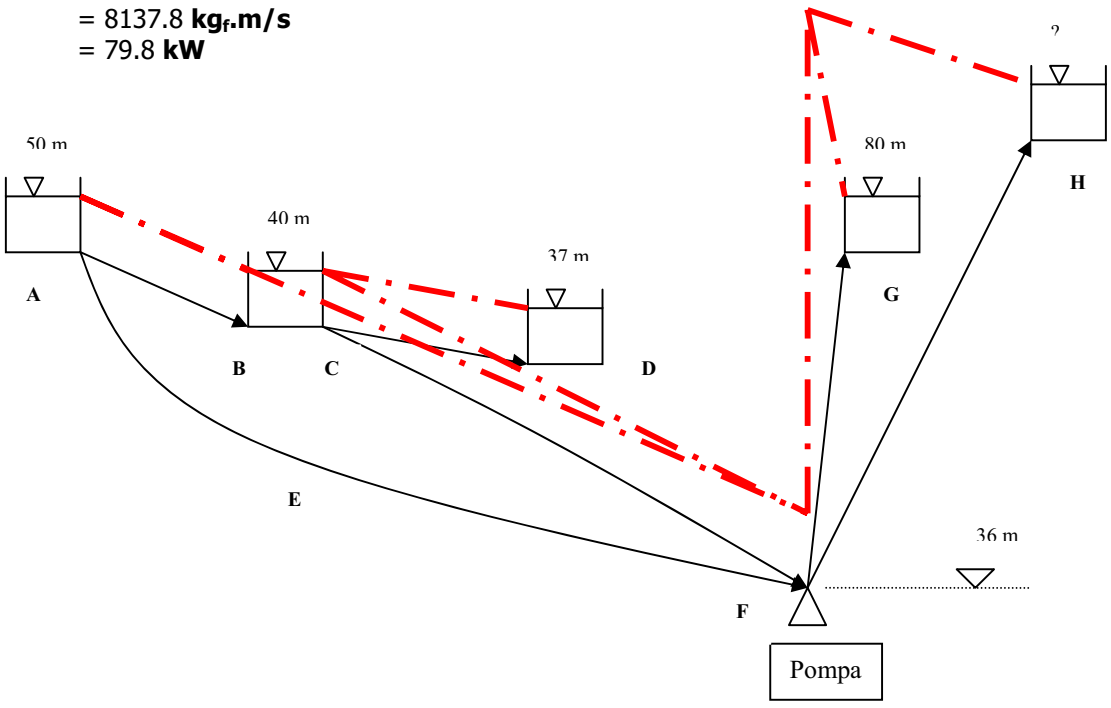
$H_H = H_G - (h_k)_{FG} - (h_k)_{FH}$ = 80 + 12.33 – 4.68 = 87.65 m

$(H_F)_{CIKIŞ} = H_H + (h_k)_{FH}$ = 87.65 + 4.68 = 92.33 m

$H_{Pompa} = (H_F)_{CIKIŞ} - (H_F)_{GIRIŞ}$ = 92.33 – 34.79 = 57.54 m

$$\mathbf{N_{Pompa}} = \frac{\gamma \mathbf{Q H_{Pompa}}}{\eta .75} = \frac{1000\mathbf{x}(0.054+0.045)\mathbf{x}57.54}{0.70\mathbf{x}75} = 108.5 \textbf{ BB}$$

= 8137.8 **kg_f.m/s**
= 79.8 **kW**



Multiple Reservoir Systems / Ex. 3

$$h_{ff_{BD}} = \frac{f_{BD}}{D_{BD}} \cdot \frac{V_{BD}^2}{2g} \cdot L_{BD}$$

$$h_{ff_{BD}} = \frac{0,02}{0,30} \cdot \frac{V_{BD}^2}{19,62} \cdot 1500$$

$$Q_{BD} = V_{BD} \cdot A_{BD} \Longrightarrow V_{BD} = \frac{Q_{BD}}{A_{BD}} = \frac{0,10}{\frac{\pi \times 0,3^2}{4}} = \underline{1,41 \text{ m/sec.}}$$

$$\Longrightarrow \underline{h_{ff_{BD}} = 10,20 \text{ m.}}$$

$$H_D = H_B - h_{ff_{BD}} = 100 - 10,20 = \underline{89,80 \text{m.}}$$

$H_D < H_A = 95 \text{m.} \Longrightarrow$ Flow Direction: $A \longrightarrow D$

$$h_{ff_{AD}} = H_A - H_D = 95 - 89,80 = \underline{5,20 \text{ m.}}$$

$$h_{ff_{AD}} = \frac{f_{AD}}{D_{AD}} \cdot \frac{V_{AD}^2}{2g} \cdot L_{AD}$$

$$5,20 \text{ m} = \frac{0,02}{0,30} \cdot \frac{V_{AD}^2}{19,62} \cdot 1000$$

$$\Longrightarrow \underline{V_{AD} = 1,24 \text{ m/sec.}}$$

$$Q_{AD} = V_{AD} \cdot A_{AD} = 1,24 \times \frac{\pi \times 0,30^2}{4} = \underline{0,0874 \text{ m}^3/\text{sec.}} = 87,44 \text{ lt/sec}$$

$$Q_{DC} = Q_{AD} + Q_{BD} = 0,10 + 0,0874 = \underline{0,1874 \text{ m}^3/\text{sec.}} = 187,44 \text{ lt/sec.}$$

$$h_{ff_{DC}} = \frac{f_{DC}}{D_{DC}} \cdot \frac{V_{DC}^2}{2g} \cdot L_{DC}$$

$$h_{ff_{DC}} = \frac{0,02}{0,40} \cdot \frac{V_{DC}^2}{19,62} \cdot 2000$$

$$Q_{DC} = V_{DC} \cdot A_{DC} \Longrightarrow V_{DC} = \frac{Q_{DC}}{A_{DC}} = \frac{0,1874}{\frac{\pi \times 0,4^2}{4}} = 1,49 \text{ m/sec.}$$

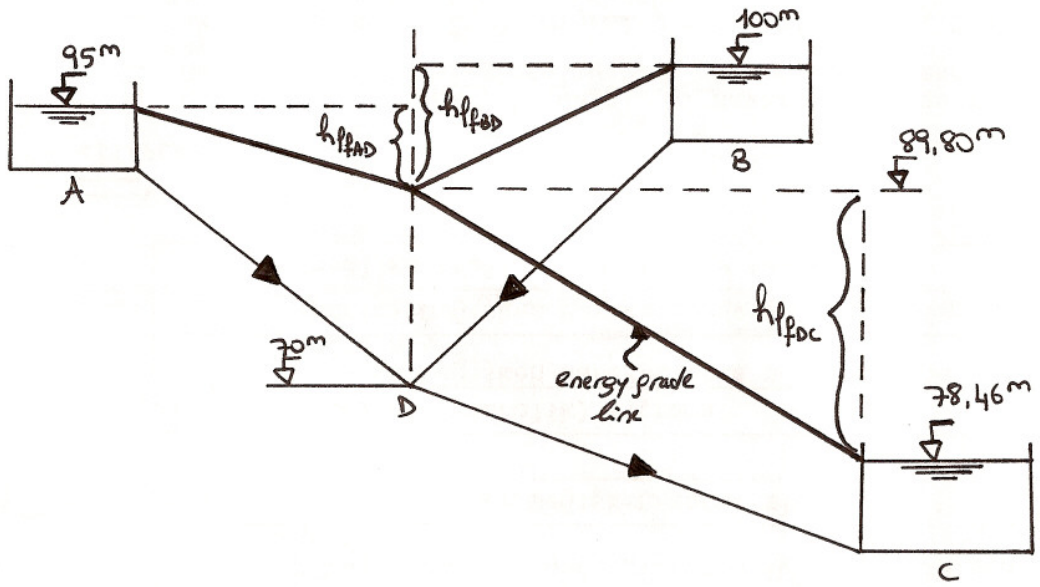
$$\Longrightarrow \underline{\underline{h_{f_{fDC}} = 11,34 \text{ m.}}}$$

$$H_C = H_D - h_{f_{fDC}} = 89,80 - 11,34 = \underline{\underline{78,46 \text{ m.}}}$$

$$\left(\frac{P_D}{\gamma_{water}} + z_D \right) \simeq H_D \quad \left[\frac{V^2}{2g} \ll \frac{P_D}{\gamma_{water}} \right]$$

$$\frac{P_D}{\gamma_{water}} + z_D = 89,80 \text{ m.}$$

$$\frac{P_D}{1 \text{ t/m}^3} + 70 \text{ m} = 89,80 \text{ m.} \Longrightarrow \underline{\underline{P_D = 19,80 \text{ t/m}^2}} = 1,98 \text{ kg/cm}^2$$



Multiple reservoir systems / Ex. 4

$Q = 170\ l/s.$

$H_A = 100\,m \qquad z_D = 65\,m$

$H_C = 84\,m \qquad z_E = 60\,m.$

AD Borusu

$$h_{k_{AD}} = \frac{0.03}{0.4} \cdot \left(\frac{0,170 \cdot 4}{0,4^2 \cdot \pi}\right)^2 \cdot \frac{500}{19.62} = 3.50\,m.$$

$$H_D = H_A - h_{k_{AD}} = 100 - 3,50 = 96.50\,m.$$

$$H_D = z_D + P_D/\gamma = 96.5 = 65 + P_D/\gamma \Rightarrow P_D/\gamma = 31.50\,m.$$

$$\Rightarrow P_D = 3.15\ kg_f/cm^2$$

DE Borularında

$h_{k_1} = h_{k_2} = h_{k_3}$ ve 1. ile 3 borularının çapları, boyları ve pürüzlülükleri aynı olduğundan geçen debileri debi de aynıdır.

$$\frac{f_1}{D_1} \cdot \frac{V_1^2}{2g} \cdot L_1 = \frac{f_3}{D_3} \cdot \frac{V_3^2}{2g} L_3 \qquad D_1 = D_3;\ L_1 = L_3 \Rightarrow Q_1 = Q_3$$

$$f_1 = f_3$$

$$\Rightarrow V_1 = V_3$$

$$\frac{0,03}{0,3} \cdot \frac{V_1^2}{2g} \cdot 1000 = \frac{0,03}{0,3} \cdot \frac{V_2^2}{2g} \cdot 2000$$

$$\Rightarrow V_1 \cong 1.41\, V_2$$

$$Q_{AD} = Q_1 + Q_2 + Q_3 = 2Q_1 + Q_2 = 0,17\ m^3/s$$

$$Q_{AD} = 2\pi \cdot \frac{0,3^2}{4} \cdot 1.41\, V_2 + \frac{\pi \cdot 0,3^2}{4} \cdot V_2 = 0,17$$

$$\Rightarrow V_2 = 0,63\ m/s$$

$$h_{k_2} = \frac{0,03}{0,3} \cdot \frac{0,63^2}{19.62} \cdot 2000 \cong 4\,m.$$

$H_E = H_D - h_{k_2} = 96.5 - 4 = 92,5\,m.$

$\Rightarrow P_E/\gamma = 32.5\,m \quad \Rightarrow P_E = 3,25\ kgf/cm^2$

$h_{k_{EC}} = H_E - H_C = 92.5 - 84 = 8,50\,m.$

$$8.50 = \frac{0,03}{0.2} \cdot \frac{V_{EC}^2}{2g} \cdot 800$$

$\Rightarrow V_{EC} = 1,18\ m/s$

$$\Rightarrow Q_{EC} = 1.18 \cdot \frac{\pi \cdot 0,2^2}{4} = 0,037\ m^3/s \simeq 0,04\ m^3/s$$

$Q_{EB} = Q_{AD} - Q_{EC} = 0,17 - 0,04 = 0,13\ m^3/s$

$$H_B = H_E - h_{k_{EB}} = 92.5 - \frac{0,03}{0,25}\left(\frac{0,13 \cdot 4}{\pi \cdot 0,25^2}\right)^2 \cdot \frac{600}{19.62}$$

$H_B = 65,54\,m.$