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LAMPIRAN

Perhitungan kontrol tegangan

Perhitungan Efisiensi Dengan Kontrol Tegangan 80% :

a. Perhitungan kerugian energi

Diketahui :

d $= 0{,}013m$

$Q = 6{,}20\ {}^{l}/_{m} = 0{,}1033 \times 10^{-3}\ {}^{m^3}/_{s}$

$A = \frac{1}{4} \times \frac{22}{7} \times 0{,}013m = 0{,}13 \times 10^{-3} m^2$

$v_d = {}^{Q}/_{A} = \frac{0{,}1033 \times 10^{-3} {}^{m^3}/_{s}}{0{,}13 \times 10^{-3} m^2} = 0{,}7948\ {}^{m}/_{s}$

$\rho = 1000\ {}^{kg}/_{m^3}$

$\mu = 1{,}002 \times 10^{-3}$

$R_e = \frac{\rho \times v \times d}{\mu} = \frac{1000\ {}^{kg}/_{m^3} \times 0{,}7948\ {}^{m}/_{s} \times 0{,}013m}{1{,}002 \times 10^{-3}} = 10312{,}707$

dari grafik bilangan Reynold didapat $f_d = 0{,}0302$

Maka Kerugian energi karena gesekan :

a. $h1 = f_d \left({}^{Le}/_{d}\right)(v_d^2/2g)$

$= 0{,}0302 \left({}^{1{,}88\ \mathrm{m}}/_{0{,}013m}\right)(0{,}7948\ {}^{m}/_{s}{}^{2} / 2 \times 9{,}81)$

$= 4{,}3095 \times 0{,}0321 = 0{,}1401\ m$

b. $h2 = 7 \times f_d \left({}^{Le}/_{d}\right)(v_d^2/2g)$

$= 7 \times 0{,}0302(20)\ (\ 0{,}7948\ {}^{m}/_{s}{}^{2} / 2 \times 9{,}81)$

$= 4{,}172 \times 0{,}0321 = 0{,}1357m$

c. $h3 = 3\times f_d \left({Le}/{d}\right)(v_d^2/2g)$

$= 3 \times 0{,}0302\ (13)(0{,}7948\ {m}/{s}^2\ / 2 \times 9{,}81)$

$= 1{,}1622 \times 0{,}0321 = 0{,}0378m$

d. $h4 = k(v_d^2/2g)$

$= 1 \times 0{,}0321 = 0{,}0321m$

Total kerugian energi , $h_{l=} h_1 + h_2 + h_3 + h_4$

$h_{l=} 0{,}1383\ m\ + 0{,}1339m + 0{,}0373 + 0{,}0321m$

$=0{,}3457m$

b. Perhitungan persamaan energi

Diketahui :

$\gamma = 9810\ {N}/{m^3}$

$h_{l\,=} 0{,}10m$

$\Delta Z = 0{,}765\text{m}$

Maka :

$$P_A = P_B + \gamma\left[(Z_A - Z_B) + \frac{V_A^2}{2g} + \frac{V_A^2}{2g} + h_l\right]$$

$P_A = 0 + 9810\ {N}/{m^3}\ [(0{,}765\text{m}) + 0 + 0{,}3457m]$

$P_A = 9810\ {N}/{m^3}\ (1{,}1066m)$

$P_A = 10855{,}746\ P_a = 10855{,}746\ \text{N/m}^2$

c. Perhitungan daya hidrolik pompa

P_{hyd} = Q × P dengan Q = 10 l/min dan P = 10855,746N/m^2

P_{hyd} = 0,1033 × 10^{-3} $m^3/_s$ × 10855,746N/m^2

P_{hyd} =0,1033 × 10^{-3} × 10855,746[m^3/s] × [kg / m×s^2]

P_{hyd} = 1,1213[kg × m^2/s^3]

P_{hyd} = 1,1213W

d. Perhitungan efisiensi

η = P_{hyd} / P_l

η = 1,1255W / 15,00W = 0,074 W

η = 7,5 %

Perhitungan Efisiensi Dengan Kontrol Tegangan 85% :

a. Perhitungan kerugian energi

Diketahui :

d = 0,013m

Q = 8,8 $l/_m$ = 0,1466 × 10^{-3} $m^3/_s$

$A = \frac{1}{4} \times \frac{22}{7} \times 0{,}013m = 0{,}13 \times 10^{-3} m^2$

$v_d = {}^{Q}/_{A} = \frac{0{,}1466 \times 10^{-3} m^3/_s}{0{,}13 \times 10^{-3} m^2} = 1{,}1276\ {}^{m}/_{s}$

$\rho = 1000\ {}^{kg}/_{m^3}$

$\mu = 1{,}002 \times 10^{-3}$

$R_e = {}^{\rho \times v \times d}/_{\mu} = \frac{1000\ {}^{kg}/_{m^3} \times 0{,}1466 \times 10^{-3} m^3/_s \times 0{,}013m}{1{,}002 \times 10^{-3}} =$ 14630,73

dari grafik bilangan Reynold didapat $f_d = 0{,}0281$

Maka Kerugian energi karena gesekan :

a. $h1 = f_d \left({}^{Le}/_{d}\right)(v_d^2/2g)$

$$=0{,}0281\left(1{,}88\ \mathrm{m}/_{0{,}013m}\right)(1{,}1276\ {}^{m}/_{s^2}\ /\ 2\times 9{,}81)$$

$$= 3{,}0658 \times 0{,}0648 = 0{,}2633\ m$$

b. $h2 = 7 \times f_d \left({}^{Le}/_{d}\right)(v_d^2/2g)$

$$= 7\ \times 0{,}0281(20)\ (\ 1{,}1276\ {}^{m}/_{s^2}\ /\ 2\times 9{,}81)$$

$$= 2{,}968 \times 0{,}0648 = 0{,}2549m$$

c. $h3 = 3\times f_d \left({}^{Le}/_{d}\right)(v_d^2/2g)$

$$= 3 \times 0{,}0281\ (13)(1{,}1276\ {}^{m}/_{s^2}\ /\ 2\times 9{,}81)$$

$$= 0{,}8268 \times 0{,}0648 = 0{,}0163$$

d. $h4 = k(v_d^2/2g)$

$$= 1 \times 0{,}0648 = 0{,}0648\mathrm{m}$$

Total kerugian energi , $h_{l=}\ h_1 + h_2 + h_3 + h_4$

$$h_l\ = 0{,}1986\ m\ + 0{,}1923m + 0{,}0163 + 0{,}0648\mathrm{m}$$

$$= 0{,}5993m$$

b. Perhitungan persamaan energi

Diketahui :

$\gamma = 9810\ {}^{N}/_{m^3}$

$h_{l\,=}\ 0{,}10m$

$\Delta Z = 0{,}765\mathrm{m}$

Maka :

$$P_A\ = P_B + \gamma\left[(Z_A - Z_B)\ + \frac{V_A{}^2}{2g} + \frac{V_A{}^2}{2g}\ + h_l\right]$$

$$P_A\ = 0 + 9810\ {}^{N}/_{m^3}\ [(0{,}765\mathrm{m})\ +\ 0\ + 0{,}5993m]$$

$P_A = 9810\ {}^{N}/_{m^3}\ (1{,}2742m)$

$P_A = 13383{,}783\ P_a = 13383{,}783 \text{N/m}^2$

c. Perhitungan daya hidrolik pompa

P_{hyd} = Q × P dengan Q = 10 l/min dan P = 13383,783N/m^2

P_{hyd} = 0,1466 × $10^{-3}\ {}^{m^3}/_{s}$ × 13383,783N/m^2

P_{hyd} =0,1466 × 10^{-3} × 13383,783[m^3/s] × [kg / m×s^2]

P_{hyd} = 1,9620[kg × m^2/s^3]

P_{hyd} = 1,9620W

d. Perhitungan efisiensi

η = P_{hyd} / P_l

η = 1,962 W / 18,93 W = 0,0968W

η = 10,36 %

Perhitungan Efisiensi Dengan Kontrol Tegangan 90% :

a. Perhitungan kerugian energi

Diketahui :

d = $0{,}013m$

$Q = 9{,}10\ {}^{l}/_{m} = 0{,}1516 \times 10^{-3}\ {}^{m^3}/_{s}$

$A = \frac{1}{4} \times \frac{22}{7} \times 0{,}013m = 0{,}13 \times 10^{-3} m^2$

$v_d = {}^{Q}/_{A} = \frac{0{,}1516 \times 10^{-3} {}^{m^3}/_{s}}{0{,}13 \times 10^{-3} m^2} = 1{,}1667\ {}^{m}/_{s}$

$\rho = 1000\ {}^{kg}/_{m^3}$

$\mu = 1{,}002 \times 10^{-3}$

$R_e = \rho \times v \times d/\mu = \frac{1000\ {}^{kg}/_{m^3} \times 1{,}1667\ {}^{m}/_{s} \times 0{,}013m}{1{,}002 \times 10^{-3}} = 15136{,}393$

dari grafik bilangan Reynold didapat $f_d = 0{,}0278$

Maka Kerugian energi karena gesekan :

a. $h1 = f_d \left({}^{Le}/_{d}\right)(v_d^2/2g)$

$= 0{,}0278\left({}^{1{,}88\ \mathrm{m}}/_{0{,}013m}\right)(1{,}1667\ {}^{m}/_{s^2}\ / 2 \times 9{,}81)$

$= 3{,}008 \times 0{,}06937 = 0{,}2788m$

b. $h2 = 7 \times f_d \left({}^{Le}/_{d}\right)(v_d^2/2g)$

$= 7 \times 0{,}0278(20)\ (1{,}1667\ {}^{m}/_{s^2}\ / 2 \times 9{,}81)$

$= 2{,}9212 \times 0{,}06937 = 0{,}2699m$

c. $h3 = 3\times f_d \left({}^{Le}/_{d}\right)(v_d^2/2g)$

$= 3 \times 0{,}0278\ (13)(1{,}1667\ {}^{m}/_{s^2}\ / 2 \times 9{,}81)$

$= 0{,}08112 \times 0{,}06937 = 0{,}0752m$

d. $h4 = k(v_d^2/2g)$

$= 1 \times 0{,}06937 = 0{,}06937\mathrm{m}$

Total kerugian energi , $h_{l=} h_1 + h_2 + h_3 + h_4$

$h_l = 0{,}20866\ m + 0{,}202m + 0{,}0562m + 0{,}06937\mathrm{m}$

$= 0{,}6932m$

b. Perhitungan persamaan energi

Diketahui :

$\gamma = 9810\ {}^{N}/_{m^3}$

$h_{l\ =} 0{,}10m$

$$\Delta Z = 0{,}765\text{m}$$

Maka :

$$P_A = P_B + \gamma\left[(Z_A - Z_B) + \frac{V_A^2}{2g} + \frac{V_A^2}{2g} + h_l\right]$$

$$P_A = 0 + 9810\,{}^{N}/_{m^3}\,[(0{,}765\text{m}) + 0 + 0{,}6932m]$$

$$P_A = 9810\,{}^{N}/_{m^3}\,(1{,}30123m)$$

$$P_A = 14305\ P_a = 14305\ \text{N/m}^2$$

c. Perhitungan daya hidrolik pompa

P_{hyd} = Q × P dengan Q = 10 l/min dan P = 14305N/m^2

$P_{hyd} = 0{,}1516 \times 10^{-3}\,{}^{m^3}/_{s} \times 14305\ \text{N/m}^2$

$P_{hyd} = 0{,}1516 \times 10^{-3} \times 14305[\text{m}^3/\text{s}] \times [\text{kg / m}\times\text{s}^2]$

$P_{hyd} = 2{,}1687\ [\text{kg} \times \text{m}^2/\text{s}^3]$

$P_{hyd} = 2{,}1687\text{W}$

d. Perhitungan efisiensi

$\eta = P_{hyd} / P_l$

η = 2,1687W / 19,58 W = 0,110 W

η = 11,07 %

Perhitungan Efisiensi Dengan Kontrol Tegangan 10 :

a. Perhitungan kerugian energi

Diketahui :

$d = 0{,}013m$

$Q = 10\,{}^{l}/_{m} = 0{,}1666 \times 10^{-3}\,{}^{m^3}/_{s}$

$$A = \frac{1}{4} \times \frac{22}{7} \times 0{,}013m = 0{,}13 \times 10^{-3}m^2$$

$$v_d = {Q}/{A} = \frac{0{,}1666\times 10^{-3} m^3/s}{0{,}13\times 10^{-3} m^2} = 1{,}2815\ {m}/{s}$$

$$\rho = 1000\ {kg}/{m^3}$$

$$\mu = 1{,}002\times 10^{-3}$$

$$R_e = {\rho \times v \times d}/{\mu} = \frac{1000\ {kg}/{m^3}\times 0{,}1666\times 10^{-3} m^3/s \times 0{,}013 m}{1{,}002\times 10^{-3}} = 16626{,}74$$

dari grafik bilangan Reynold didapat $f_d = 0{,}027$

Maka Kerugian energi karena gesekan :

a. $h1 = f_d \left({Le}/{d}\right)(v_d^2/2g)$

$$=0{,}027\left(1{,}88\ \text{m}/{0{,}013m}\right)(1{,}2815\ {m}/{s^2}\ /\ 2\times 9{,}81)$$

$$= 2{,}9067\times 0{,}0837 = 0{,}3268\ m$$

b. $h2 = 7\times fd\left({Le}/{d}\right)(v_d^2/2g)$

$$= 7\ \times\ 0{,}027(20)\ (\ 1{,}2815\ {m}/{s^2}\ /\ 2\times 9{,}81)$$

$$= 2{,}772\times 0{,}0837 = 0{,}3163m$$

c. $h3 = 3\times fd\left({Le}/{d}\right)(v_d^2/2g)$

$$= 3\times 0{,}027(13)(1{,}2815\ {m}/{s^2}\ /\ 2\times 9{,}81)$$

$$= 0{,}7722\times 0{,}0837 = 0{,}0881m$$

d. $h4 = k(v_d^2/2g)$

$$= 1\times 0{,}0837 = 0{,}0837\text{m}$$

Total kerugian energi , $h_{l=}\ h_1 + h_2 + h_3 + h_4$

$$h_l = 0{,}3268m\ + 0{,}3163m + 0{,}0881m + 0{,}0837\text{m}$$

$$= 0{,}8149m$$

b. Perhitungan persamaan energi

Diketahui :

$\gamma = 9810\ {}^{N}/_{m^3}$

$h_{l\,=}\ 0{,}10m$

$\Delta Z = 0{,}765\text{m}$

Maka :

$$P_A = P_B + \gamma\left[(Z_A - Z_B) + \frac{V_A^2}{2g} + \frac{V_A^2}{2g} + h_l\right]$$

$$P_A = 0 + 9810\ {}^{N}/_{m^3}\ [(0{,}765\text{m}) + 0 + 0{,}8149m]$$

$$P_A = 9810\ {}^{N}/_{m^3}\ (1{,}3885m)$$

$$P_A = 13621{,}5101\ P_a = 13621{,}5101\ \text{N/m}^2$$

c. Perhitungan daya hidrolik pompa

P_{hyd} = Q × P dengan Q = 10 l/min dan P = 13621,5101 N/m^2

$P_{hyd} = 0{,}1666 \times 10^{-3}\ {}^{m^3}/_{s} \times 13621{,}5101\ \text{N/m}^2$

$P_{hyd} = 0{,}1666 \times 10^{-3} \times 13621{,}5101\ [\text{m}^3/\text{s}] \times [\text{kg / m} \times \text{s}^2]$

$P_{hyd} = 2{,}2693\ [\text{kg} \times \text{m}^2/\text{s}^3]$

$P_{hyd} = 2{,}2693\ \text{W}$

d. Perhitungan efisiensi

$\eta = P_{hyd} / P_l$

$\eta = 2{,}582\text{W} / 25\ \text{W} = 0{,}09\ \text{W}$

$\eta = 10{,}30\ \%$

Komponen-komponen

System	ID-No.	Component name	Function
W-PUR	V103	Hand valve	Throttle valve
W-PUR	FIC/B102	Flow sensor	Flow measurement
W-PUR	V104	Stop valve	Return flow stop
W-PUR	LIC/B121	Pressure sensor	Level measurement
W-PUR	V102/YS M102	2/2-way solenoid valve	Drain valve
W-PUR	B103	Tank	Flocculant /chlorine tank
W-PUR	V113	Hand valve	Dosage of flocculants / chlorine
W-PUR	V114	Hand valve	Dosage of flocculants / chlorine
W-PUR	B102	Tank with overflow	Sedimentation tank
W-PUR	LSH/B124	Capacitive proximity sensor	Limit switch for maximum level
W-PUR	LSL/B123	Capacitive proximity sensor	Limit switch for minimum level
W-PUR	AIC/B120	Chlorine sensor	Measurement of chlorine content
W-PUR	LAH/S122	Float switch	Overfill protection for Tank B102
W-SUP	V210/YZ M210	2/2-way solenoid valve	Protection valve
W-SUP	NCS M201/P201	Pump	Feed pump for Tank B202
W-SUP	PI 203	Pressure gauge	Pressure display
W-SUP	LAH/S212	Float switch	Overfill protection --› closure V210
W-SUP	B201	Tank	Storage tank
W-SUP	LSL/B213	Capacitive proximity sensor	Limit switch for minimum level
W-SUP	FIC/B202	Flow sensor	Flow measurement
W-SUP	LAH/S222	Float switch	Overfill protection
W-SUP	LIC/B221	Ultrasonic sensor	Level measurement
W-SUP	B202	Tank	Elevated tank
W-SUP	YS M222/V222	2-way ball valve with pneumatic rotary actuator	Consumer valve
W-SUP	YS M223/V223	2/2-way solenoid valve	Valve for water wastage simulation
W-SUP	V204	Hand valve	Bypass valve for filling of sewage network
W-SUP	V221	Hand valve	Consumer valve
W-SUP	V201	Hand valve	Inlet restrictor valve for elevated tank
W-SUP	V205	Hand valve	Drain valve
W-SUP	FIC/B220	Flow sensor	Flow measurement

W-PUR: Water Purification System

W-SUP: Water Supply System

(lanjutan)

System	ID-No.	Component name	Function
WW-TRA	NS M351	Screw feeder	Dosage of solids
WW-TRA	X B351	Capacitive proximity sensor	Pulse generator for screwing drive
WW-TRA	B303	Tank	Storage tank
WW-TRA	Q304	Pipe	Sewage conduit overflow
WW-TRA	B305	Hopper for screw feeder	Solids tank
WW-TRA		Gravity sewer	Wastewater discharge
WW-TRA	LIC/B311	Ultrasonic sensor	Level measurement
WW-TRA	B301	Tank with overflow	Overflow tank
WW-TRA	LSL/B313	Capacitive proximity sensor	Limit switch for minimum level
WW-TRA	V310	Hand valve	Throttle valve
WW-TRA	YSM302/V302	Gate valve with pneumatic actuator	Sludge discharge
WW-TRA	YC M303/V303	Proportional media valve (pinch valve)	Throttle valve
WW-TRA	FIC/B302	Flow sensor	Flow measurement
WW-TRA	LAH/S322	Float switch	Overfill protection
WW-TRA	LIC/B321	Ultrasonic sensor	Level measurement
WW-TRA	B302	Tank with overflow	Sedimentation tank
WW-TRA	LSL/B323	Capacitive proximity sensor	Limit switch for maximum level
WW-TRA	NCSM301/P301	Pump	Feed pump for Tank B302
WW-TRA	V301	Hand valve	Throttle valve
WW-TRA	V305	Hand valve	Drain valve
WW-TRA	V315	Hand valve	Drain valve
WW-TRE	B403	Tank	Dosage tank
WW-TRE	AIC/B410	Dissolved oxygen sensor	Measurement of oxygen content
WW-TRE	V413	Hand valve	Dosage of chemicals
WW-TRE	V414	Hand valve	Dosage of chemicals
WW-TRE	FIC/B402	Flow sensor	Flow measurement
WW-TRE	V401	Hand valve	Inlet restrictor valve
WW-TRE	B401	Tank	Aeration tank
WW-TRE	LIC B411	Pressure sensor	Level measurement
WW-TRE	V410	Hand valve	Drain valve
WW-TRE	NCS M402	Air blower	Aeration
WW-TRE	NCS M401/P401	Pump	Recirculation pump
WW-TRE	LAH/S412	Float switch	Overfill protection
WW-TRE	LSH/B414	Capacitive proximity sensor	Limit switch for maximum level
WW-TRE	LSL/B413	Capacitive proximity sensor	Limit switch for minimum level

WW-TRA: Wastewater Transport System

WW-TRE: Wastewater Treatment System

(lanjutan)

System	ID-No.	Component name	Function
WW-TRE	B402	Tank with overflow	Sedimentation tank
WW-TRE	LAH/S422	Float switch	Overfill protection
WW-TRE	LSL/B423	Capacitive proximity sensor	Limit switch for minimum level
WW-TRE	V405	Hand valve	Drain valve
all	NCS M501/P501	Pump	Submersible pump
all	B501	Systainer	Main storage tank
all	V501	Hand valve	Throttle valve
all	LSL/S512	Float switch	Dry running protection

WW-TRE: Wastewater Treatment System