DESIGN PURPOSE

Purpose of this document is to calculate the power of the pumps required for emptying the drainage pits in the HEPP powerhouse.

DESIGN INFORMATION

Sump Pit Width .... : $G := 4\ \mathrm{m}$

Sump Pit Length .... : $B := 6\ \mathrm{m}$

Sump Pit Height .... : $H := 10\ \mathrm{m}$

Pumping Head .... : $\Delta H := 15\ \mathrm{m}$

Pump Efficiency .... : $\eta := 75\ \%$

Pipe Dimensions .... : $D := DN200x8mm$

Total Pipe Length .... : $\Delta L := 20\ \mathrm{m}$

Water Temperature .... : $T := 15\ °\mathrm{C}$

Water Density .... : $\rho := 1000\ \frac{\mathrm{kg}}{\mathrm{m}^3}$

Kinematic Viscosity .... : $\upsilon = 1.1384\ \frac{\mathrm{mm}^2}{\mathrm{s}}$

1. VOLUME, FLOW RATE and SPEED CALCULATIONS

Pit Geometry

Pit Width $G = 4000\ \mathrm{mm}$

Pit Length $B = 6000\ \mathrm{mm}$

Pit Height $H = 10000\ \mathrm{mm}$

Pit Volume $W := G \cdot B \cdot H = 240\ \mathrm{m}^3$

Flow Rate and Speed

It is assumed that pit shall be drained in 1 hour.

Drainage Time $t := 1\ \mathrm{hr}$

Flow Rate $Q := \frac{W}{t} = 240\ \frac{\mathrm{m}^3}{\mathrm{hr}}$

Pipe Inner Diameter $D := 202.74\ \mathrm{mm}$

Pipe Area $A := \frac{\pi \cdot D^2}{4} = 322.8262\ \mathrm{cm}^2$

Drainage Speed $V := \frac{Q}{A} = 2.0651\ \frac{\mathrm{m}}{\mathrm{s}}$

2. HEADLOSS CALCULATIONS

Reynolds Number Calculation

Wet Perimeter $L_w := \pi \cdot D = 636.9265$ mm

Hydraulic Diameter $d_h := 4 \cdot \frac{A}{L_w} = 202.74$ mm

Reynolds Number $R_e := V \cdot \frac{d_h}{\upsilon} = 367775.5$

Turbulent Flow

The roughness coefficient should be calculated according to the flow condition;

Turbulent Flow $\frac{1}{\sqrt{\lambda}} = -2 \cdot log \left(\frac{2.51}{R_e \cdot \sqrt{\lambda}} + \frac{k}{d_h \cdot 3.72} \right)$

Laminar Flow $\lambda := \frac{64}{R_e}$

Pipe Type "Seamed Steel Pipe"

Absolute Roughness $k = 0.045$ mm

Roughness Coefficient $\lambda = 0.0161$

Friction Losses

It is assumed there will be $n := 4$ elbow and $y := 1$ valve in 20 m length pipe.

Inlet Loss $K_1 := 0.2 \cdot \frac{V^2}{2\ g_e}$ $K_1 = 0.0435$ m

Friction Loss $K_2 := \lambda \cdot \frac{\Delta L}{D} \cdot \frac{V^2}{2\ g_e}$ $K_2 = 0.3447$ m

Elbow Loss $K_3 := n \cdot (15 \cdot \lambda) \cdot \frac{V^2}{2\ g_e}$ $K_3 = 0.2097$ m

Valve Loss $K_4 := y \cdot 0.19 \cdot \frac{V^2}{2\ g_e}$ $K_4 = 0.0413$ m

Outlet Loss $K_5 := 1 \cdot \frac{V^2}{2\ g_e}$ $K_5 = 0.2174$ m

Total Head Loss $H_k := \sum K = 0.8566$ m

Minimum Pumping Head

Pumping Head $\Delta H = 15$ m

Total Head Loss $H_k = 0.8566$ m

Minimum Pumping Head $H_T := H_k + \Delta H = 15.8566$ m

3. PUMP MOTOR CALCULATION

Pump Flow Rate $Q = 240 \frac{m^3}{hr}$

Pump Efficiency $\eta = 75 \%$

Pumping Head $H_T = 15.8566 m$

Water Density $\rho = 1000 \frac{kg}{m^3}$

Gravity $g_e = 9.8066 \frac{m}{s^2}$

Total Pressure $P := H_T \cdot \rho \ g_e = 1.555 \ bar$

Pump Power $PG := \frac{Q \cdot P}{\eta} = 13.8222 \ kW$

Electrical pump motor is selected as 15 kW.

4. CONCLUSION

In each of the two drainage pits, two pumps will be used, one as main and one as backup. The total required electrical power when one main pump in each pit working is calculated as 30 kW. For worst case scenario power is calculated as 60 kW for all four pumps working together.

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