The water power

The water power can express by the work done by the pump as follows:

Work = mass flow * the total head against which the flow is moved.

p_w = KQH

where:

p_w: water power (kw)

Q: flow (m^3/min)

H: total head (m)

K: constant (fluid density and units) = 0.163 Kw, m^3/min, m)

$$Ep = \frac{p_w}{p_p}$$

$$P_{HP} = \frac{p_w}{0.745}$$

P_{HP}: power of pump measured by horse power, where p_w in kw.

P_p: pump power

Pump power input:

$$P_p = \frac{P_w}{E_p}$$

Where:

P_p: pump power, and E_p: Efficiency of pump

Example: Determine the water power, pump power, and motor load for a pump system designed to deliver 1.89 m^3/min (500 gpm) flows against a total system head of 50 m. Assume the efficiency of both pump and water is 80%?

Ans

P_w= KQH

P_w= 0.163 * 1.89 *50 = 15.4 kw

$$P_p = \frac{15.4}{0.8} = 19.25\ kw$$

$$P_m = \frac{19.25}{0.8}$$

Solution :

(حل المثال بصورة اوضح)

$E_P = E_m = 80\ \%$

- $P_w = K * Q * H$

$= 0.163 * 1.89 * 50$

$= 15.4\ kw$

$\frac{15.4}{0.745} \Rightarrow 20.6\ Hp$

- $P_P = \frac{P_w}{E_P} \Rightarrow \frac{15.4}{0.8} \Rightarrow P_P = 19.25\ kw$

$\frac{19.25}{0.745} \Rightarrow 258\ hp$

- $P_m = \frac{P_P}{E_m}$

$= \frac{19.25}{0.8} \Rightarrow 24.06\ kw$

$\frac{24.06}{0.745} = 32.2\ Hp$

Example: Find the cost required to operate pump for one day pumping 537.5 m^3/hr against a pressure of 146 kpa if power cost is 0.07 Id/kw.hr, and pump efficiency equal to 90%.

Ans

$$p_m = \frac{p_b}{P.\,eff.}$$

$$H = \frac{p}{\gamma} = \frac{146}{9.81} = 14.6\,m$$

P_w= KQH

$$Q = 537.5 \frac{m^3}{hr} * \frac{1hr}{60\,min} = 8.96\,m^3/min$$

P_w=0.163 *8.96*14.6=21.32 kw

$$p_p = \frac{p_w}{p_{eff.}} = \frac{21.32}{0.9} = 23.69\,kw$$

$$p_m = \frac{p_p}{p_{eff.}} = \frac{23.69}{0.9} = 26.32$$

Total cost = pm * cost

$$=26.32 * 0.07 * \frac{24}{1\,day} = 4422\,Id/day$$

Centrifugal pumps

A pump called centrifugal if it operates with concept of impeller which rotates with specific speed termed as "Angular velocity" (ω) measured by rpm (revolution per minutes).

The angular velocity is proportional with all of flow, head and power of pump.

Q varies with ω ⟶ $Q \alpha \omega$

H varies with ω^2 ⟶ $Q \alpha \omega^2$

P varies with ω^3 ⟶ $Q \alpha \omega^3$

Ex: A Centrifugal pump operates at speed of 1150 rpm and discharge 2.3 m3/ min against a head of 120 kpa, the power required is 8.2 kw , compute:

1) Pump efficiency.

2) The discharge head and power if the pumps speed was changed to 1750 rpm

Ans:

1) $P_w = KQH$

P_w=0.163*2.3*((120)/9.81)=4.586kw

2) $Q \propto \omega$; $Q_1 \propto \omega_1$; $Q_2 \propto \omega_2$; .....

ω

$$p_m = \frac{p_p}{p_{eff.}} = \frac{23.69}{0.9} = 26.32$$

Total cost = pm * cost

$$=26.32 * 0.07 * \frac{24}{1\ day} = 4422\ Id/day$$

$$p_m = \frac{p_b}{P.\ eff.}$$

- التصريف يتناسب طرديا مع السرعة الزاوية

$$\frac{Q_1}{Q_2} = \frac{\omega_1}{\omega_2}$$

- الـ head ... (ارتفاع) ...

$$\frac{H_1}{H_2} = \frac{\omega_1^2}{\omega_2^2}$$

- قدرة المضخة ... (القدرة)

$$\frac{P_1}{P_2} = \frac{\omega_1^3}{\omega_2^3}$$

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ω

$$p_m = \frac{p_p}{p_{eff.}} = \frac{23.69}{0.9} = 26.32$$

Total cost = pm * cost

$$=26.32 * 0.07 * \frac{24}{1\ day} = 4422\ Id/day$$

$$p_m = \frac{p_b}{P.\ eff.}$$

(حل مثال Centrifugal pumps مجموعة ادوات)

① $H = \frac{P}{\gamma} = \frac{120}{9.81} \Rightarrow H = 12.23\ m$

$P_w = K \cdot Q \cdot H$

$= 0.163 * 2.3 * 12.23$

$= 4.58\ kw$

$P_p = \frac{P_w}{E_p} \Rightarrow E_p = \frac{P_w}{P_p} \Rightarrow \frac{4.58\ kw}{8.2\ kw} \Rightarrow E_p = 55.85\%$

② $\frac{H_1}{H_2} = \frac{W_1^2}{W_2^2}$

$\frac{12.23}{H_2} = \frac{1150^2}{1750^2} \Rightarrow H_2 = 28.32\ m$

$\frac{P_{w_1}}{P_{w_2}} = \frac{W_1^2}{W_2^2}$

$\frac{4.58}{P_{w_2}} = \frac{1150^2}{1750^2} \Rightarrow P_{w_2} = 16.13\ kw$

$\frac{Q_1}{Q_2} = \frac{W_1}{W_2}$

$\frac{2.3}{Q_2} = \frac{1150}{1750} \Rightarrow Q_2 = 3.5\ m^3/min.$