Artificial Lift

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Lecture-59 Surface Pump Units for Jet Pump - Part 3

Centrifugal pumps have been discussed multiple times, particularly during general discussions about pumping. We've also covered their use in ESP applications. Centrifugal pumps are widely employed in various industrial, agricultural, and household applications because of their high flow rates and the ability to generate substantial pressure.

These pumps are versatile and come in sizes ranging from very small to large, making them suitable for various industrial applications. They can operate within a pressure range of approximately 2000 to 3000 psi and can handle up to 3000 barrels per day. Multistage systems can be utilized to increase pressure, making them suitable for single wells or multiple wellbores.

For centrifugal pumps, it's essential to remember key terms like the H-Q curve, the affinity law, NPSH, priming, efficiency curve, system curve, and various components such as staging, volute casing, or diffusers on the suction and pressure sides. These factors are crucial for making the necessary calculations.

Two types of applications are possible with centrifugal pumps: series connection and parallel connection. In a series connection, pumps are connected sequentially, allowing you to increase the pressure or head. In parallel connection, pumps are used simultaneously to increase the flow rate, but the head remains relatively constant.

Double-acting pumps are another type of pump. In a double-acting pump, there are two cavities, C1 and C2.

$$Single\ acting, Q_{th} = \frac{ALN}{60}$$

$$A = \frac{\pi}{4} d^2$$

$$Double\ acting, Q_{th} = \left[\frac{ALN}{60} + \frac{A'LN}{60}\right]$$

$$A' = A - A_p$$

$$Slip = Q_{th} - Q_a$$

$$\%slip = \frac{(Q_{th} - Q_a)}{Q_{th}} X100 = (1 - C_D) X100$$

where A is the piston area, A' is the effective area, L is the stroke length, and N is the speed in rpm or rps. When discussing slip, you need to account for the leakage. Slip is the difference between the theoretical and actual flow rates and can be calculated as a percentage. CD represents the discharge coefficient, typically ranging from 95 to 98, indicating low leakage.

The theoretical work done is an essential aspect of centrifugal pumps, as it measures the work required to deliver a specific amount of fluid at a given pressure.

$$Theoritical\ Workdone, Hydraulic\ power, HP = \rho Q_{th} g H_{st}$$

$$H_{st} = H_d + H_s$$

$$HP = \rho \left(\frac{ALN}{60}\right) g (H_s + H_d)$$

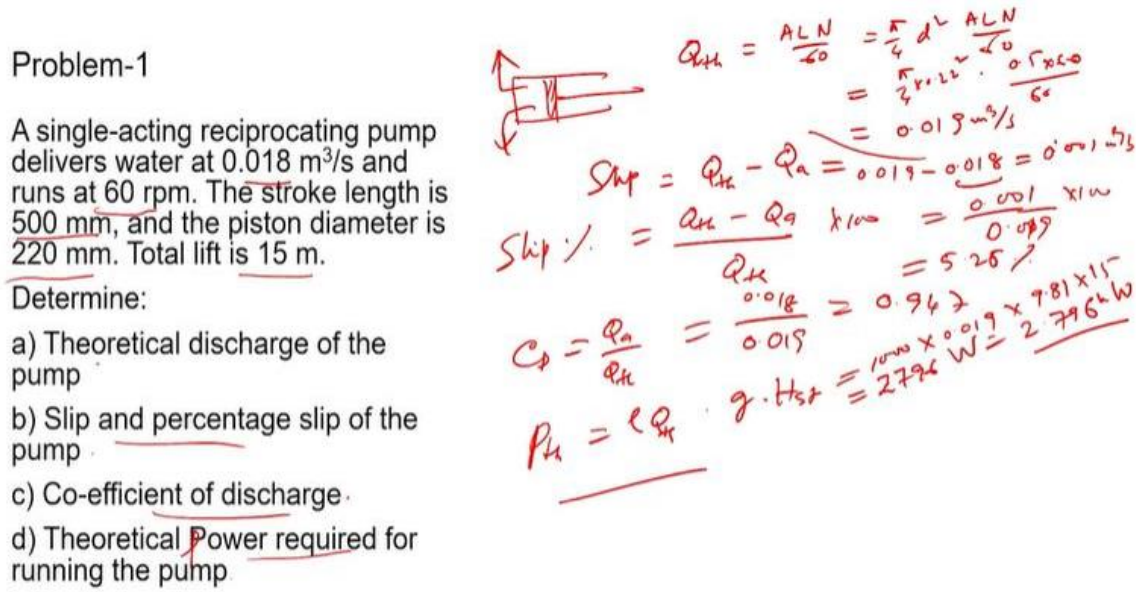
Hydraulic power output, denoted as HP, is calculated using the formula: Hst represents the head for delivery plus the head for suction, combining the static delivery head and suction head. Where AP (cross-sectional area of the piston rod) is ignored as we assume the piston diameter is very small.

The theoretical pump input is calculated as follows:

$$Power\ input = \rho \left(\frac{ALN}{60}\right) g H_{st}$$

$$Actual\ input = \frac{1}{\eta} \rho \left(\frac{ALN}{60}\right) g H_{st}$$

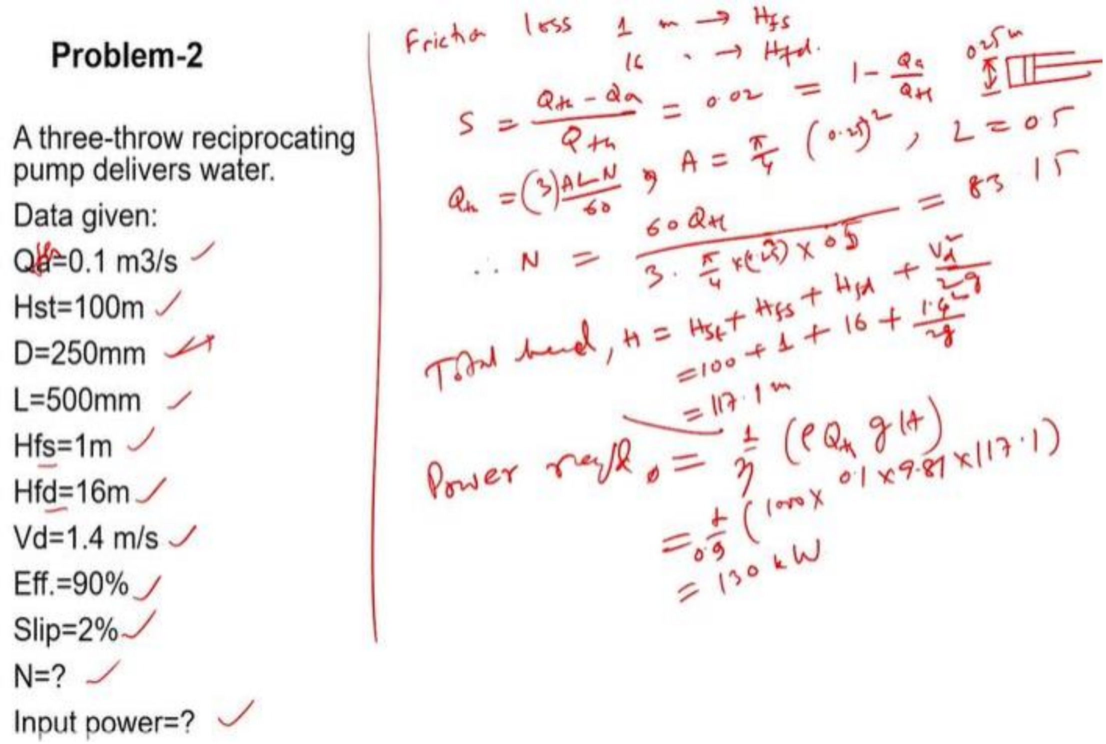
Now, let's solve a problem using this formula. A single-acting reciprocating pump delivers 0.01 cubic meters per second, operates at 60 rpm, has a stroke length of 500 millimeters, a piston diameter of 220 millimeters, and a total lift of 15 meters. Determine the theoretical discharge pump, slip percentage, pump coefficient of discharge, and the theoretical power required to run the pump.



Similar calculations can be carried out for a triple-throw (three-cylinder) pump. However, further details related to data and specific calculations are needed to determine Q, A, Hst, friction loss, and efficiency.

If you have additional data, please provide it, and I can assist with further calculations.

So, A is given as pi by 4 into 0.25 power 2, which results in D equals 250, meaning D equals 0.25 meters or 250 millimeters.



You mentioned a formula related to work done, but there's no specific formula provided.

A triple-x pump's theoretical power is 3 into P equals (pi into d power 2 divided by 4 into L into n) divided by 33000. If you have the mechanical efficiency (eta m or eta volume), the actual flow rate (q actual) can be calculated using: q actual equals q theoretical into eta m.

Do it yourself:

Theoritical HP=?
Theoritical vol Qth=?
For
Pressure =200 psi
D=1.5/12 ft
L=8/12 ft
N=210 rpm

Sol:
HPth= 3P[pi.d^2/4]LN/33000 hp.
Qth=3pi (d^2/4)LN/60 ft3/s
=604LNd^2 b/d

if, d, l in inch then Qth=0.35e Nld b/d , e is mech eff.
HPth=(pd^2)/(168067e)

You also mentioned creating a problem, but it seems you didn't include the problem statement for solving. If you have a specific problem to solve or clarify, please provide the details, and I'd be happy to assist.

Thank you for this pumping lecture, and the next lecture will be on the compression system. Thank you very much.