CENTRIFUGAL PUMP LAB

PURPOSE: The main purpose of this lab is to measure the pressure versus flow characteristic of a centrifugal pump and to compare this to the theoretical characteristic. Another purpose of the lab is to check pump scaling laws.

PROCEDURE: Set the pump speed at a low level. Set the control valve at its fully closed position. Measure the pump outlet pressure and flow rate through the pump. Repeat for various valve settings. Set the pump speed at a high level and repeat the experiment.

REPORT: Plot the pressure versus flow characteristic of the pump for each speed on the same plot. Compare the measured characteristics with the theoretical characteristics. Plot the pressure coefficient C_P versus the flow coefficient C_Q of the pump for each speed on the same plot. Comment on the results.

CENTRIFUGAL PUMP THEORY

The power output of the pump is:

$$\mathbf{P} = T\ \omega = \Delta\ (\rho Q\ V_T\ R)\ \omega$$

The tangential flow velocities are:

$$V_{IN} = V_N\ \mathrm{Cot}[\alpha] \qquad V_{OUT} = V_B + V_N\ \mathrm{Cot}[\beta]$$

where, relative to the tangential direction, α is the angle of absolute velocity vector and β is the angle of relative velocity vector. The blade and normal velocities are:

$$V_B = R\ \omega \qquad V_N = Q\ /\ [\pi\ 2R\ h]$$

Power output is also

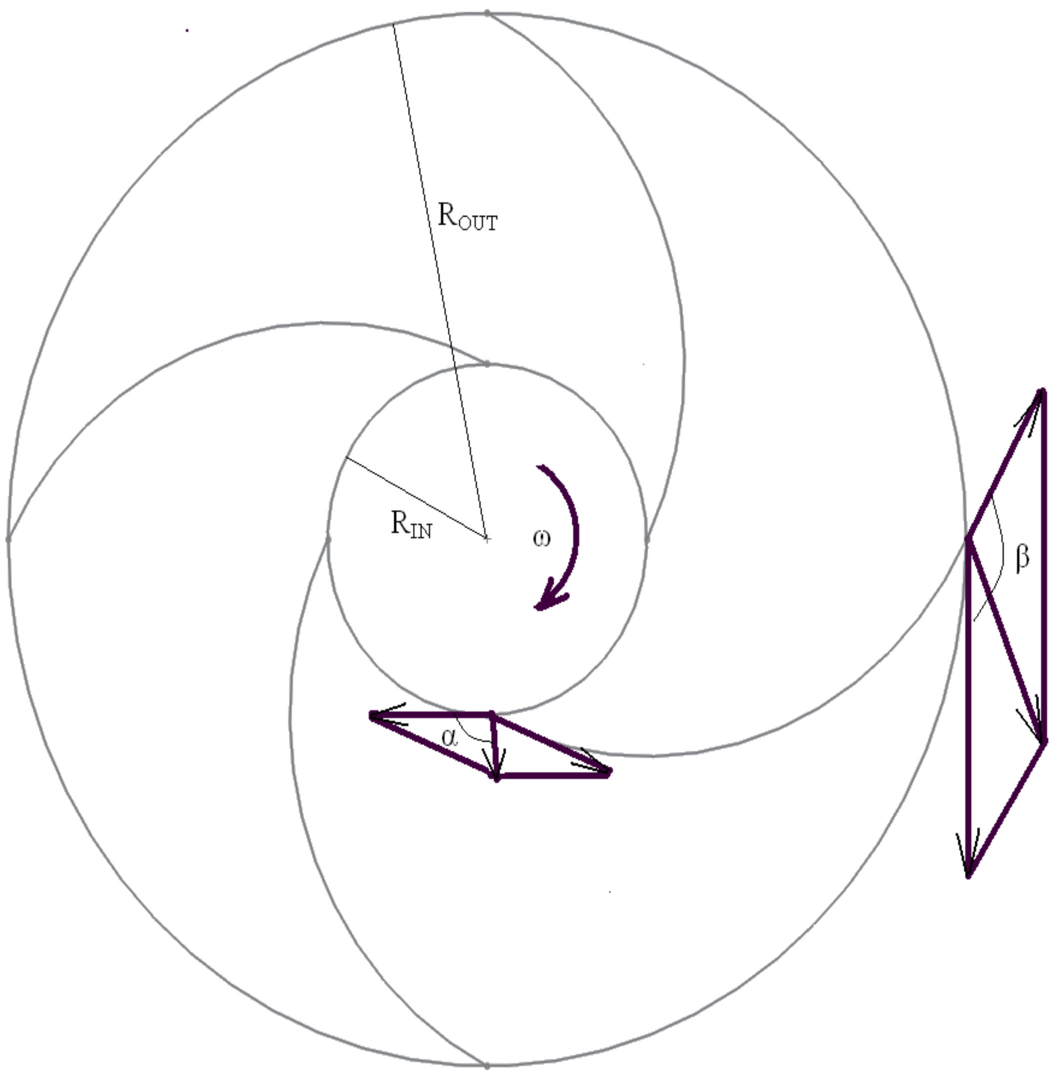
$$\mathbf{P} = P\ Q$$

Manipulation gives

$$P = \mathbf{P}\ /\ Q = \Delta\ (\rho\ V_T\ R)\ \omega$$

$$= \rho\ (V_{OUT}\ R_{OUT} - V_{IN}\ R_{IN})\ \omega$$

$$= \rho\ (\ [V_T V_B]_{OUT} - [V_T V_B]_{IN}\ )$$



R_{OUT}
R_{IN}
ω
α
β

SCALING LAWS FOR PUMPS

For a pump, it is customary to let N be the rotor RPM and D be the rotor diameter. All flow speeds U scale as ND and all areas A scale as D^2. Pressures are set by the dynamic pressure $\rho U^2/2$. Ignoring constants, one can define a reference pressure $[\rho N^2 D^2]$ and a reference flow $[ND^3]$. Since fluid power is just pressure times flow, one can also define a reference power $[\rho N^3 D^5]$. Dividing dimensional quantities by reference quantities gives the scaling laws:

Pressure Coefficient $C_P = P / [\rho N^2 D^2]$

Flow Coefficient $C_Q = Q / [ND^3]$

Power Coefficient $C_{\mathbf{P}} = \mathbf{P} / [\rho N^3 D^5]$

In the lab, the flow rate Q is measured using a V Notch Weir and pressure P is measured with a pressure gage. For the lab pump: R_{IN} = 20.6 mm; R_{OUT} = 66.6 mm; h_{IN} = 10.7 mm; h_{OUT} = 4.8 mm; $\beta_{IN} = 135^\circ$; $\beta_{OUT} = 150^\circ$. Standard practice is to assume that the swirl is zero at the inlet to the pump which implies α is 90° there.

DATA SHEET FOR PUMP

PUMP SPEED =

RUN	PRESSURE	FLOW RATE

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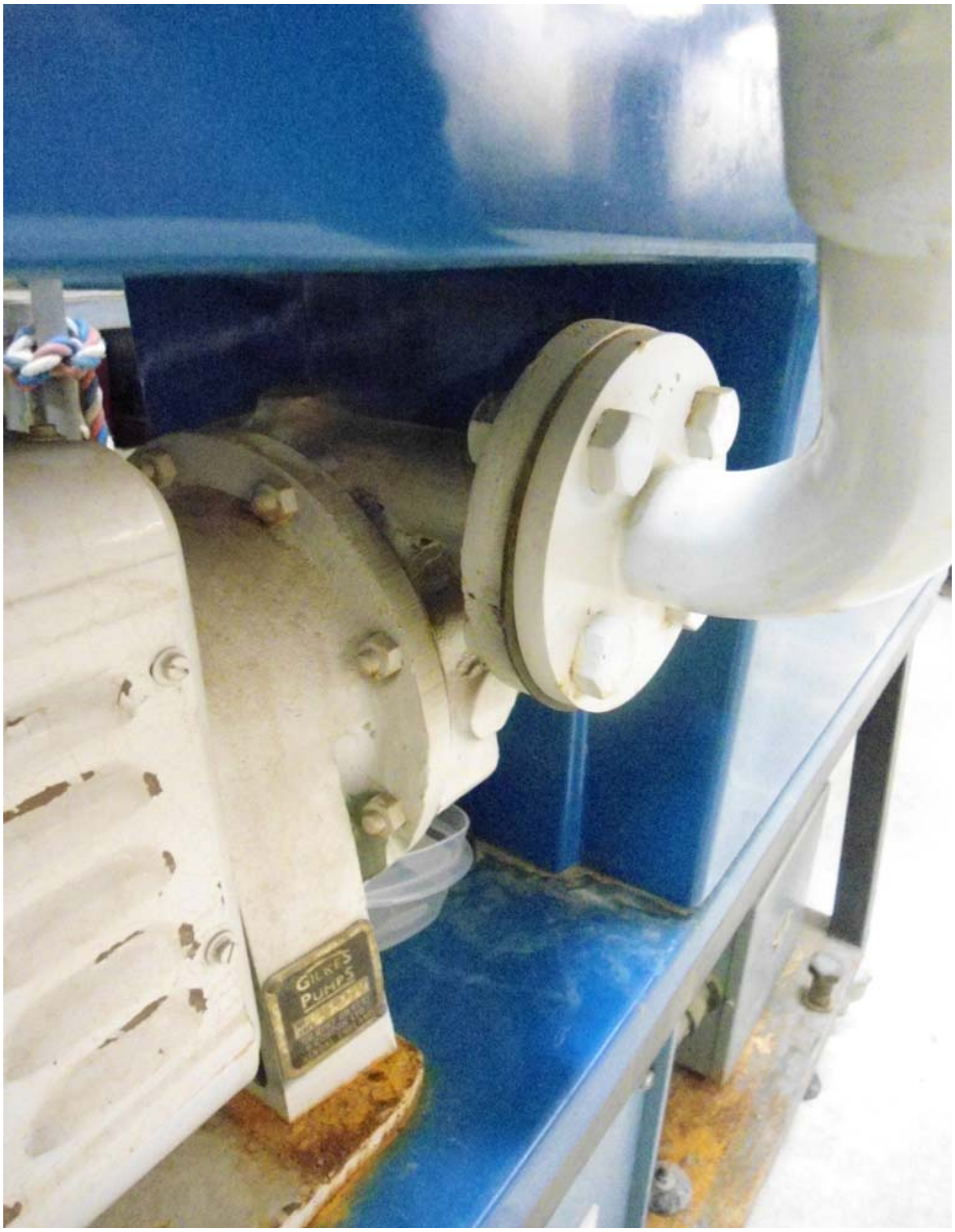
GILKES
PUMPS