Tutorial 3

1. We want to design the impeller angle and power requirements for a centrifugal (radial) pump. Our design flow is 400 l/s, and the total head loss through the system is 12 m. The impeller size is set at 500 mm outer diameter, and 250 mm inner diameter. The pump speed is 1200 rev/min and the radial velocity of the inflowing and outflowing water is constant at 4 m/s. Assume a hydraulic efficiency of 90% and a mechanical efficiency of 85%. Calculate:
    a. The ideal pump head (H_{ideal}),
    b. The tangential velocity of the fluid 'whirl velocity' (V_W),
    c. The required impeller outer vane angle (α_2), and
    d. The total input power that must be provided to the pump (P_{in}^{total})

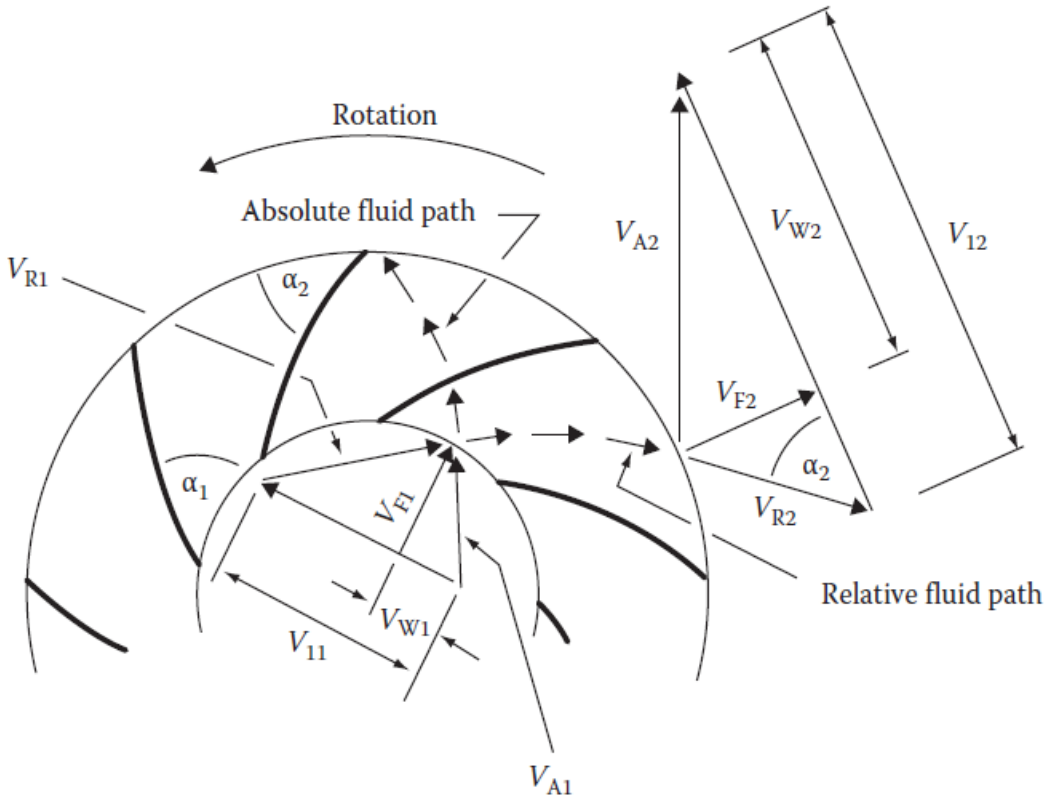

FIGURE 7.2 Velocity diagrams for centrifugal pump.

2. A pump is to deliver 60 L/s through a 200 mm diameter pipeline. The pipe is 150 m long and rises 2 m. The friction factor λ = 0.028. Two pumps are being considered for the duty. Select the more suitable pump, and estimate the hydraulic power required to drive the pump and the specific speed. Should the pump be of radial, axial or mixed flow type? Pump speed is 1385 rev/min. Ignore local losses in the pipeline.

Pump No. 1 Performance Data

Head (m)	8.6	8.35	7.56	6.35	4.95	3.7	2.3
Discharge (L/s)	0	18	39	60	75	88	100
Efficiency (%)	0	52	72	79	75	63	48

Pump No. 2 Performance Data

Head (m)	9.0	8.8	8.1	7.0	6.0	4.5	3.3
Discharge (L/s)	0	18	39	60	75	88	100
Efficiency (%)	0	52	75	76	67	58	46

3. A potential problem for pumps is damage due to cavitation. Calculate the maximum elevation that the following pump can be installed at while still preventing cavitation. The pump speed is 1000 rpm, pump head is 14 m and the required discharge of 150 l/s. Assume p_{atm} = 101.3 kpa, and density of water = 1000 kg/m^3 as usual for this class and a water temperature of 20°C. The pipe has a 200 mm diameter and the total suction losses are 0.3 m. Use the specified speed (N_s) equation to estimate NPSH. The reservoir that the pump is drawing from is located at 100 masl. Comment on what type of pump would be most efficient for this application (centrifugal, mixed or axial).

Table 18-2

Vapor Pressure of Water

Temperature (°C)	Pressure (kPa)	Temperature (°C)	Pressure (kPa)	Temperature (°C)	Pressure (kPa)
0	0.6	21	2.5	30	4.2
5	0.9	22	2.6	35	5.6
8	1.1	23	2.8	40	7.4
10	1.2	24	3.0	50	12.3
12	1.4	25	3.2	60	19.9
14	1.6	26	3.4	70	31.2
16	1.8	27	3.6	80	47.3
18	2.1	28	3.8	90	70.1
20	2.3	29	4.0	100	101.3