2.1 The rotor diameter of a pump is 40 cm. It delivers 3 m3/min while rotating at 1800 rpm. A geometrically similar pump has a diameter of 30 cm and rotates at 3600 rpm. What would be the flow rate of the second pump? Also if the head on the first pump is 15 m, what head would the second pump deliver?

Given:

|  |  |
| --- | --- |
| Pump 1 | Pump 2 |
|  |  |
|  |  |
|  |  |
|  |  |

Solution:

Assume: Geometrically similar

Flow Coefficient φ is same for both pumps.

Head coefficient ψ is same for both pumps

Pump 1 Power

Pump 2 Power

2.2 A pump delivers 2250 gpm against a head of 95 ft when the rotating at 1450 rpm. What would be its specific speed? What type of pump would this be? If the speed of the pump is changed to 1200 rpm, what would be the new head and flow rate?

Given: Pump is 2250 gpm against H = 95 ft rotating at 1450 rpm.

Solution:

@ 1200 rpm

 Head Coefficient:

 = =

 Flow Coefficient:

 = =

2.3 If the centrifugal pump delivers 650 gpm when operating with a head of 120 ft and speed of 1800 rpm, what are the corresponding values of flow rate and head when the speed is changed to 1500 rpm?

Given: A centrifugal pump delivering 650 gpm with *H* = 120 ft ; *N* = 1800 rpm

Solution:

 Head Coefficient

 = =

 *H2* = 83.3 ft.

 Flow Coefficient

2.4 A pump with impeller dimensions of 60 cm is required to deliver 750 liters per second at a head of 30 m when the speed is 850 rpm. A model pump with a diameter of 15 cm runs at 1700 rpm. a) What are the corresponding flow rate and head under dynamically similar conditions? b) If both the model and prototype have efficiencies of 83%, what power would be required to drive the pump? c) Calculate the specific speed of each pump and specify the type of pump.

Given:

|  |  |
| --- | --- |
|  |  |
|  |  |
|  |  |
|  |  |

Solution:

 a)

 b)

 Prototype:

 Model:

 c)

 From prototype data:

 Hence pump

2.5 A turbine operates under a head of 90 ft at 550 rpm while producing a power of 7000 hp. What would the new speed and power be if the head changes to 60 ft. What type of turbine would this be?

Given:

 *H* = 90 ft, *N* = 550 rpm, *P* = 7,000 hp

Solution:

 Lead Coefficient:

 Power Coefficient:

 Kaplan turbine

2.6 A turbine with an impeller diameter of 18” is tested under a head of 25 ft while the flow rate is 18 cfs and the speed is 400 rpm. a) Calculate the specific speed. b) What type of turbine is this? c) If a homologous unit with 38” runner is used under a head of 120 ft, what would be the speed and discharge? d) If the original turbine produces 40 hp, what is its efficiency? e) What is the power produced by the send unit? Assume the same efficiency for both units.

Given:

 *D1*= 18”, *H1* = 25 ft, *Q1* = 18 ft3/s, *N1* = 400 rpm

Solution:

 a)

 b)

 Francis turbine

 c)

 = =

 = =

2.7 A turbine when operating at a head of 80 ft and 160 rpm has an efficiency of 85% when the flow rate is 200 cfs. If the same turbine operates at a head of 40ft what would be the values of speed, flow rate, and brake horsepower under homologous conditions? If another turbine which is homologous to the above has its dimensions exactly half in value, what would be the corresponding values of speed, flow rate, and break horsepower when the net head is still 80’?

Given:

 H=80 ft, N=160 rpm, η=85%, Q=200 cfs

Solution:

 Francis turbine

2.8 The power produced by a hydraulic turbine is 25,000 hp when the head is 120 ft and rotational speed is 80 rpm. A homologous laboratory model of the turbine produces 54 hp when operating at head of 24 ft. Calculate the model speed, model flow rate and the scale ratio.

Given:

 Turbine with power produced = 25,000 hp with *H* = 120 ft and *N*=80 rpm.

 Lab model produces *Pm* = 54 hp with *Hm* = 24 ft

Solution:

 Head:

 Flow:

 Hence a Francis turbine

2.9 The pressure head developed by a fan is 155 mm of water measured by a water manometer. For this hear, the flow rate is 4.5 m3/s, which the rotational speed is 1800 rpm. A larger geometrically similar fan runs at 1500 rpm. If the larger fan is to operate at the same head, find its flow rate.

Given:

Solution:

 Axial flow fan

2.10 An axial flow fan operating at 1450 rpm has a diameter of 1.9 m. The average axial velocity is measured to be 12 m/s. A geometrically similar fan which is one fifth in size is built and tested at 4350 rpm. Assuming dynamically similar conditions, find the flow rate and axial velocity.

Given:

|  |  |  |
| --- | --- | --- |
|  | Prototype | Model |
| D | 1.9 | 0.38 |
| N | 1450 | 4350 |
| Q | 34 |  |
| H |  |  |

Solution:

2.11 A pump rotating at 600 rpm is to be used to pump water between two reservoirs with an elevation difference of 3 m. It is proposed to use a 20 m long pipe of 100 cm diameter. Assume that friction factor is f= 0.02and minor loss coefficient = 0.5. If a flow rate of 0.2 m3/s is expected, what type of pump would be best suited? Also, what would the head be for the given conditions.

Given: N = 600 rpm; z = 3 m; L = 20 m, D = 1m; f = 0.02; K 0.5

Solution: The schematic diagram of the pump and piping system is given below.



N = 600 rpm = 62.8 rad/s.

The energy equation can be written as



After simplification, it becomes



Calculating each of the losses separately,





Hence both hf and hm are negligible. Thus,



To determine the type of pump, the specific speed needs to be calculated.



Hence centrifugal pump

2.12 A centrifugal pump is to be designed to produce a head of 16 m when the rotational speed is 1800 rpm. The shaft power input under these conditions is expected to be 2.8 MW. A model pump is built and tested under dynamically similar conditions with a head of 4 m and a shaft power input of 20 kW. Calculate the model speed and scale ratio. If both the pumps operate at 82% efficiency, estimate the flow rates.

Given:

 Prototype Model

 D

 N 1800 rpm = 60 π 3752 rpm

 Q

 H 16 m 4 m

 P 2.8 MW 20 kW

Solution:

2.13 Use Cordier diagram to estimate the lowest diameter of pump needed to deliver 12 cfs of water when operating at 1800 rpm at a head of 36 ft.

Given:

 12 cfs, N=1800 rpm, H=36 ft

Solution:

 From Cordier diagram Ds=1.7: