FM_exp7_Preethika

October 11, 2021

###

Exp 7 CENTRIFUGAL PUMP TEST RIG

0.0.1 Objective:

- Study of centrifugal pump characteristics

0.0.2 Aim:

- To determine:
  - Total head
  - Discharge
  - Pump Output
  - Overall efficiency
  - Pump efficiency
- To plot the following performance characteristics:
  - Head Vs Discharge.
  - Pump efficiency Vs Discharge

0.0.3 Introduction:

The hydraulic machines, which convert the mechanical energy into hydraulic energy, are called pumps. The hydraulic energy is in the form of pressure energy. If the mechanical energy is converted into pressure energy by means of centrifugal force acting on the fluid, the hydraulic machine is called centrifugal pump.

0.0.4 Theory:

The centrifugal pump works on the principle of forced vortex flow, which means that an external torque rotates a certain mass of liquid, the rise in pressure head of the rotating liquid takes place. The rise in pressure head at any point of the rotating liquid is proportional to the square of tangential velocity of (i.e. rise in pressure head = $V_2/2g$ or $\frac{\omega_2 r_2}{2g}$ the liquid at that point. Thus at the outlet of the impeller where radius is more, the rise in pressure head will be more and the liquid will be discharged at the outlet with a high- pressure head. Due to this high-pressure head, the liquid can be lifted to a high level.

0.0.5 Procedure:

Starting Procedure: 1. Clean the apparatus and make all tanks free from dust. 2. Close the drain valve provided. 3. Fill sump tank ¾ with clean water and ensure that no foreign particles

are there. 4. Open flow control valve given on the water discharge line and control valve given on suction line. 5. Ensure that all On/Off Switches given on the panel are at OFF position. 6. Now switch on the main power supply and switch on the pump. 7. Set the desired RPM of pump with the speed control knob provided on the control panel. 8. Operate the flow control valve to regulate the flow of water discharged by the pump. 9. Operate the control valve to regulate the suction of the pump. 10. Record discharge pressure by means of pressure gauge, provided on discharge line. 11. Record suction pressure by vacuum gauge, provided at suction of the pump. 12. Record the power consumption by energy meter, provided in panel by measuring time for 10 or 20 pulses with stopwatch. 13. Measure the discharge by using measuring tank and stopwatch. 14. Repeat the same procedure for different discharge with constant speed. 15. Repeat the same procedure for different speeds of pump. 16. Repeat the procedure for reciprocating pump.

Closing Procedure : 1. When experiment is over, open gate valve provided on the discharge line. 2. Reduce the RPM of the pump to zero. 3. Switch OFF the pump. 4. Switch OFF Power Supply to panel. 5. Drain all the tanks.

0.0.6 Formula:

1. Input Power

$$P_{ip} = \frac{P}{t_p} * \frac{3600}{EMC}$$

2. Shaft Power

$$P_{sh} = P_{ip} * \eta_{motor}$$

3. Discharge

$$Q = \frac{A^* R}{t} \text{ m}^3/\text{s}$$

$$\boldsymbol{R} = \frac{R_1 - R_2}{100}$$

4. Total Head

$$H = 10 * \left[P_d + \frac{P_s}{760} \right] + h_{PG}$$

5. Output Power

$$P_{op} = \frac{\omega * Q * H}{1000}$$

6. Overall efficiency

$$\eta_o = \frac{P_{op}}{P_{ip}} * 100$$

7. Pump efficiency

$$\eta_P = \frac{P_{op}}{P_{sh}} * 100$$

0.0.7 Observations:

DATA:

EMC = 3200 Pulses/kW-hr.

A = 0.128 m^2

η_{motor} = 9810 $kg/m^2.sec^2$

motor = 0.8

hPG = 1 m

[17]:
```
import numpy as np
from matplotlib import pyplot as plt
```

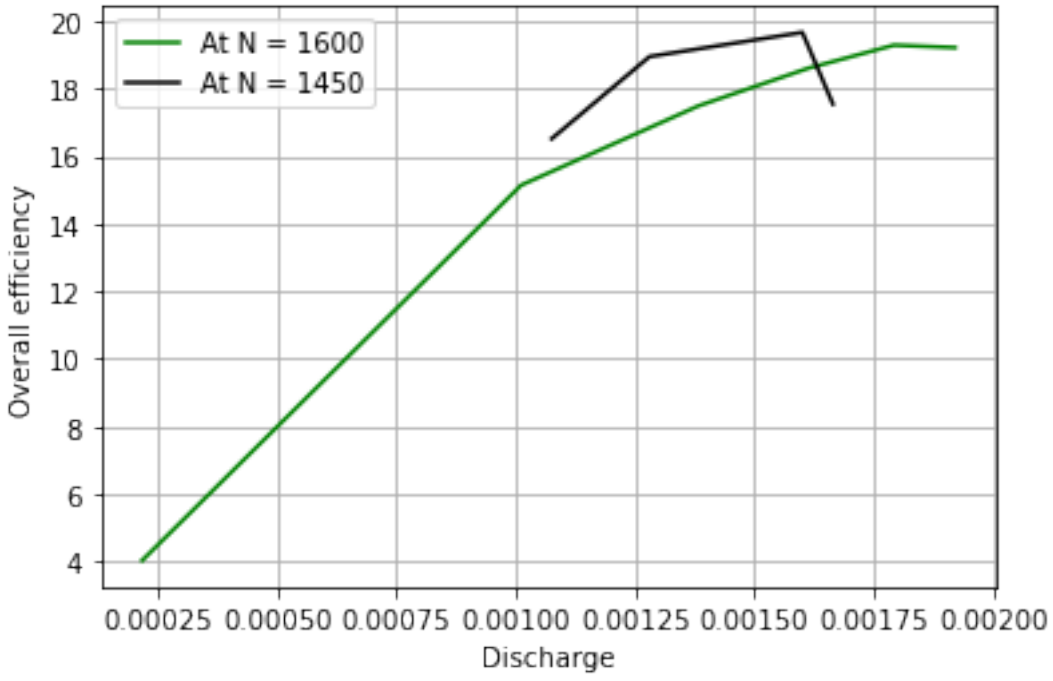
[3]:
```
N = np.array([1450,1462,1467,1472,1480,1480,1600,1603,1603,1605,1606,1608])
Pd = np.array([0,0.05,0.1,0.15,0.18,0.2,0.25,0.2,0.15,0.1,0.05,0])
Ps = np.array([99,90,88,48,25,11.1,11.1,42,55,80,111.1,133.3])
R1 = np.array([10,20,20,20,20,20,20,20,20,20,20,20])
R2 = np.array([23,32.5,30,28.4,32.8,32.2,21.7,27.9,30.8,32.6,34,35])
t = np.full(
    shape=12,
    fill_value=10,
    dtype=np.int)
P = np.array([8,8,8,8,8,8,6,6,6,6,6,6])
tp = np.array([42,42,43,45,49,53,35,29,27,26,25,25])
R = (R2-R1)/100
```

[4]:
```
emc = 3200
A = 0.128
omega = 9810
eta_m = 0.8
hpg = 1
```

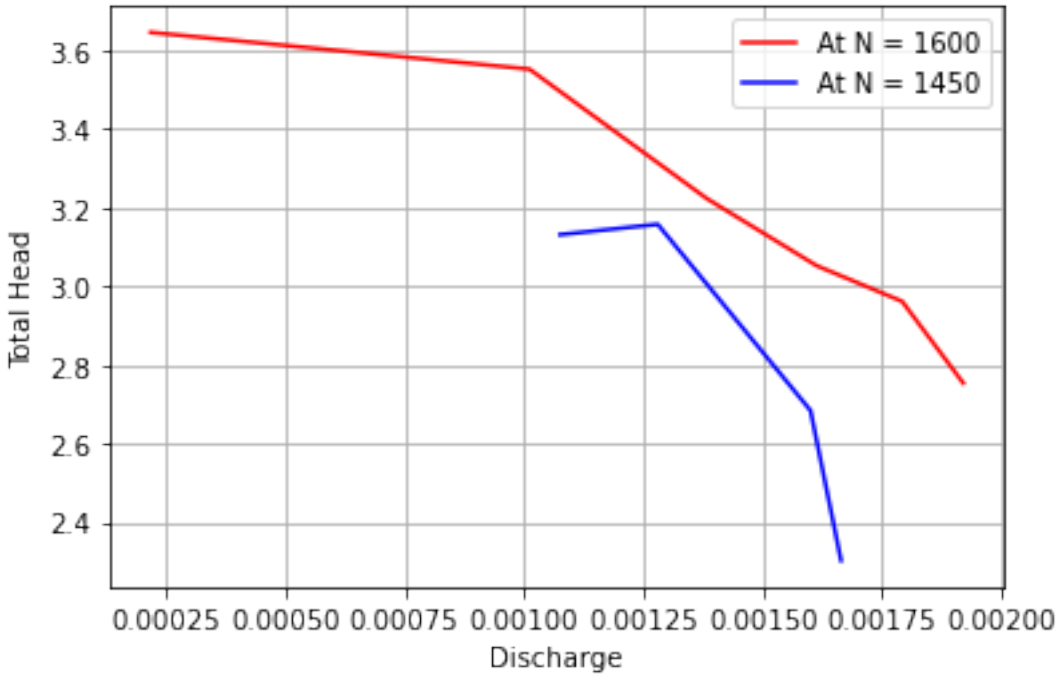
[14]:
```
Q = A*R/t                          #Discharge
H = 10*(Pd + Ps/760) + hpg         #Total head
Pip = (P/tp) * (3600/emc)            #Input power
Psh = Pip*eta_m                    #shaft power
Pop = omega*Q*H/1000               #output power
eta_p = (Pop/Psh)*100            #Pump efficiency
eta_o = (Pop/Pip)*100             #Overall efficiency
print("The discharge is {} m3/s".format(Q))
print("The total head is {} m".format(H))
print("Input power = {}kW".format(Pip))
print("shaft power = {}kW".format(Psh))
print("Output power = {}kW".format(Pop))
print("Overall efficiency = {} %".format(eta_o))
print("Pump efficiency = {} %".format(eta_p))
```

```
The discharge is [0.001664  0.0016    0.00128   0.0010752 0.0016384 0.0015616
0.0002176
 0.0010112 0.0013824 0.0016128 0.001792  0.00192  ] m3/s
The total head is [2.30263158 2.68421053 3.15789474 3.13157895 3.12894737
3.14605263
 3.64605263 3.55263158 3.22368421 3.05263158 2.96184211 2.75394737] m
Input power = [0.21428571 0.21428571 0.20930233 0.2        0.18367347 0.16981132
 0.19285714 0.23275862 0.25       0.25961538 0.27       0.27      ]kW
shaft power = [0.17142857 0.17142857 0.16744186 0.16       0.14693878 0.13584906
 0.15428571 0.1862069  0.2        0.20769231 0.216      0.216     ]kW
Output power = [0.03758779 0.04213137 0.03965305 0.03303099 0.05029064
0.04819531
 0.00778307 0.03524165 0.04371749 0.04829742 0.05206776 0.05187115]kW
Overall efficiency = [17.54096842 19.66130526 18.94534737 16.51549642
27.38046221 28.38168344
  4.03566495 15.14085726 17.48699621 18.60344994 19.28435649 19.21153684] %
Pump efficiency = [21.92621053 24.57663158 23.68168421 20.64437053 34.22557777
35.47710429
  5.04458119 18.92607158 21.85874526 23.25431242 24.10544561 24.01442105] %
```

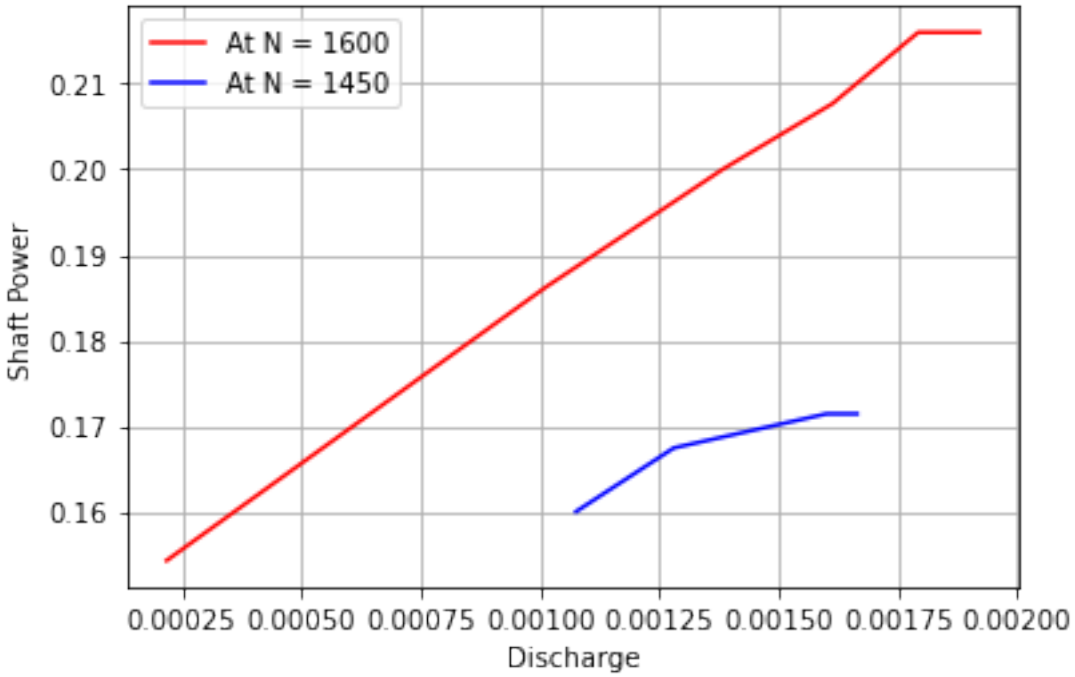
[51]:
```
plt.plot(Q[6:],eta_o[6:],label="At N = 1600",color="green")
plt.plot(Q[0:4],eta_o[0:4],label="At N = 1450",color="black")
plt.xlabel("Discharge")
plt.ylabel("Overall efficiency")
plt.legend()
plt.grid()
plt.show()
```



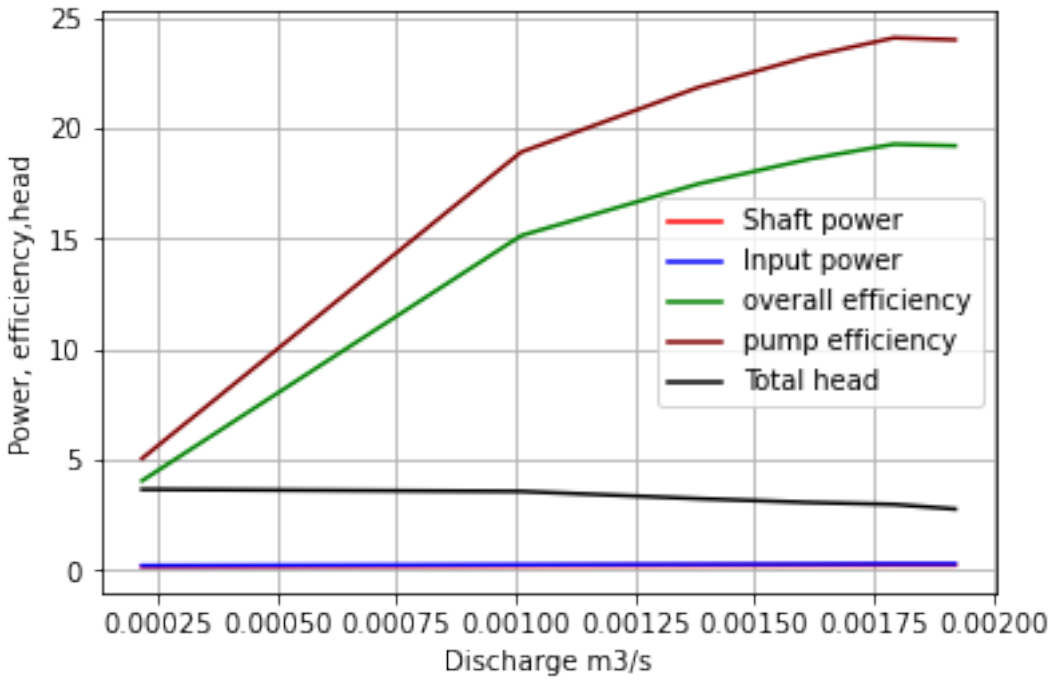
[54]:
```
plt.plot(Q[6:],H[6:],label="At N = 1600",color="red")
plt.plot(Q[0:4],H[0:4],label="At N = 1450",color="blue")
plt.xlabel("Discharge m3/s")
plt.ylabel("Total Head")
plt.legend()
plt.grid()
plt.show()
```



[59]:
```
plt.plot(Q[6:],Psh[6:],label="At N = 1600",color="red")
plt.plot(Q[0:4],Psh[0:4],label="At N = 1450",color="blue")
plt.xlabel("Discharge m3/s")
plt.ylabel("Shaft Power")
plt.legend()
plt.grid()
plt.show()
```



[86]:
```
#combined characteristic curve @N=1600 rpm
plt.plot(Q[6:],Psh[6:],label="Shaft power",color="red")
plt.plot(Q[6:],Pip[6:],label="Input power",color="blue")
plt.plot(Q[6:],eta_o[6:],label="overall efficiency",color="green")
plt.plot(Q[6:],eta_p[6:],label="pump efficiency",color="maroon")
plt.plot(Q[6:],H[6:],label="Total head",color="black")
plt.xlabel("Discharge m3/s")
plt.ylabel("Power, efficiency, head")
plt.legend()
plt.grid()
plt.show()
```



0.0.8 Calculations:

0.0.9 Inferences:

- The output power increases with the discharge and the rpm of the pump.
- The overall efficiency also shows a similar trend.
- In these two speeds, all value for water head pump from the start to the end of the experiment is decreasing. This is because due to starting point of the discharge pressure where we slowly decreased the amount of pressure in certain gap, and as expected that to affect the value of total head.
- The pump efficiency is always greater than overall efficiency.

0.0.10 Industrial Applications:

- he centrifugal pumps have a wide range of models depending on the application needs, industry requirements and viscosity. By applying a centrifugal force, water or other fluids are pushed using a rotating impeller. Undoubtedly, these are the perfect choice in delivering liquids from one location to another in numerous industries.
- For applications such as petrochemicals, hydrocarbons, food and beverage production, chemicals, paints, cellulose, and sugar refining, these centrifugal pumps are used by the chemical and process industries. In the mining industry, bitumen and minerals from clay and sand are separated by these centrifugal pumps which are used as froth pumps.

[ ]: