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Experiment Number (4)

The Performance of a Radial Fan

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90/100

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Abstract

Fans are one of types of the turbo machinery which are used to move air continuously with slight increase in static pressure, the performance of the radial fan is analyzed by its performance curves the objective of this experiment was to examine to measure the fan efficiency and measure the performance at constant-speed. The performance for a radial fan depends mainly on the fan blade design (forward, backward). At the end of the experiment, graphs of electrical power, hydraulic power, pressure deference and efficiency as a function of volumetric air flow were plotted. The forward curved blade was used, and it was found that the highest efficiency is considered at speed 100% was 38%.

Results

➢ Cross sectional area $= \frac{\pi}{4} D^2 = \frac{\pi}{4} 0.09^2 = 0.0063585\ m^2$

1) For 80% Fan speed

Table 1 : Raw data of speed 80%

position	T (°C)	dp_F (Pa)	P_el (W)	N (min^{-1})	p_amb (mbar)	dv/dt (m^3/s)	P_hyd (W)	η %	dp_N
0	20.5	206.9799	40.1	2640	902	11.4168	0.6564	1.6369	0.1331
0.5	20.4	207.9212	41.5	2640	902	27.5624	1.5919	3.8359	0.7758
1	20.3	204.0304	46.2	2640	902	90.4227	5.1247	11.0925	8.3528
1.5	20.3	270.5928	58.6	2640	902	202.7703	15.2412	26.0088	42.0036
2	20.2	273.6545	82.6	2640	902	322.6432	24.5258	29.6922	106.3827
2.5	20.3	257.3672	99.5	2640	902	385.3292	27.5475	27.686	151.6847

Table 2 : Calculated data of speed 80%

T (K)	ρ (kg/m^3)	u (m/s)	V_s (m^3/s)	V_s (m^3/h)	P_hyd (W)	η %
293.65	1.070944	0.498564	0.0031701	11.41242125	0.65615	1.6362855
293.55	1.071309	1.203462	0.0076522	27.54797583	1.59106	3.8338743
293.45	1.071674	3.948205	0.0251047	90.3767795	5.12211	11.086827
293.45	1.071674	8.853743	0.0562965	202.6674846	15.2334	25.995621
293.35	1.072039	14.08786	0.0895777	322.47965	24.5133	29.677161
293.45	1.071674	16.82498	0.1069816	385.1338656	27.5336	27.671922

2) For 90% Fan speed

Table 3 : Raw data of speed 90%

position	T (°C)	dp_F (Pa)	P_el (W)	N (min^{-1})	p_amb (mbar)	dv/dt (m^3/s)	P_hyd (W)	η %	dp_N
0	20.6	263.8052	46	2970	902	13.6432	0.9998	2.1734	0.19
0.5	20.59	264.3275	48.2	2970	902	33.3003	2.4451	5.0727	1.1317
1	20.4	259.1912	47.8	2970	902	93.4028	6.7248	14.0686	8.9094
1.5	20.3	341.425	75.7	2970	902	218.6657	20.7383	27.3954	48.8472
2	20.3	328.4289	109.3	2970	902	359.6236	34.9063	31.9363	132.1668
2.5	20.14	328.9729	125.6	2970	902	437.6372	39.9919	31.8407	195.7687

Table 4 : Calculated data of speed 90%

T (K)	ρ (kg/m³)	u (m/s)	V_s (m³/s)	V_s (m³/h)	P_hyd (W)	η %
293.75	1.07058	0.595775	0.0037882	0.99936	2.1725137	13.63764877
293.74	1.070616	1.453998	0.0092452	2.44377	5.0700679	33.28288516
293.55	1.071309	4.078325	0.025932	6.72135	14.061411	93.35531194
293.45	1.071674	9.547804	0.0607097	20.7278	27.381523	218.5549551
293.45	1.071674	15.70525	0.0998618	32.7975	30.006871	359.5025769
293.29	1.072259	19.10895	0.1215043	39.9716	31.82453	437.41535

3) For 100% Fan speed

Table 5 : Raw data of speed 100%

position	T (°C)	dp_F (Pa)	P_el (W)	N (min^{-1})	p_amb (mbar)	dv/dt (m³/s)	P_hyd (W)	η %	dp_N
0	20.6	329.4919	46.7	3300	902	24.6547	2.2565	4.832	0.6203
0.5	20.6	330.9551	46.7	3300	902	36.8905	3.3914	7.2621	1.3889
1	20.5	321.7578	53	3300	902	108.0027	9.653	18.2132	11.9083
1.5	20.36	427.6383	79.8	3300	902	249.3667	29.6219	37.1201	63.5135
2	20.3	436.8183	126.2	3300	902	396.8874	48.1577	38.1598	160.9209
2.5	20.3	404.1272	163.9	3300	902	487.8954	54.7699	33.4167	243.182

Table 6 : Calculated data of speed 100%

T (K)	ρ (kg/m³)	u (m/s)	V_s (m³/s)	V_s (m³/h)	P_hyd (W)	η %
293.75	1.07058	1.076481	0.0068448	2.25531	4.829353	24.6412986
293.75	1.07058	1.610798	0.0102423	3.38973	7.2585168	36.87212691
293.65	1.070944	4.715812	0.0299855	9.64807	18.203897	107.9477636
293.51	1.071455	10.88832	0.0692334	29.6069	37.101327	249.240284
293.45	1.071674	17.32965	0.1101906	48.1333	38.140468	396.6861582
293.45	1.071674	21.30342	0.1354578	54.7422	33.399746	487.6480963

Figures

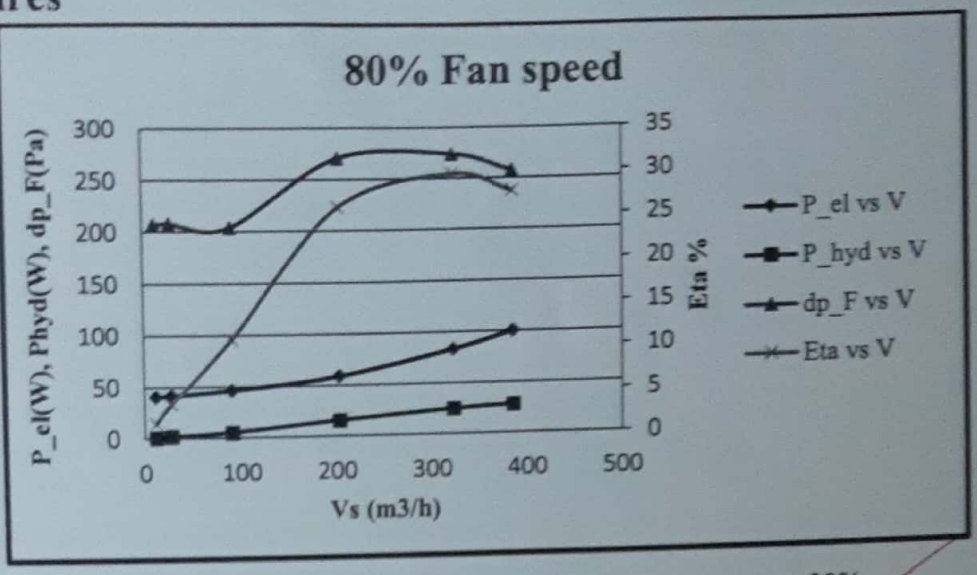

Figure 1 : Fan Characteristics vs volumetric flow rate at 80%

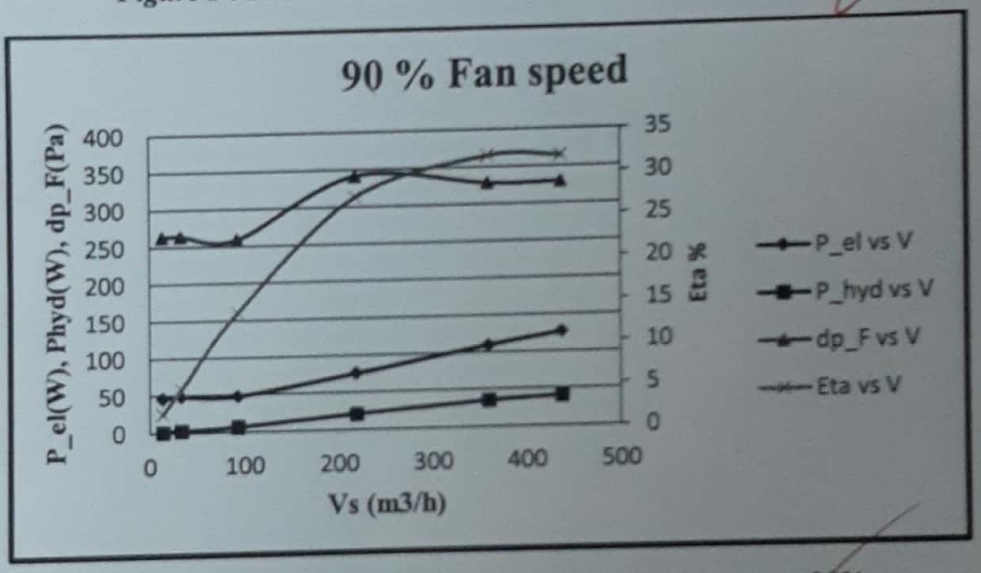

Figure 2 : Fan Characteristics vs volumetric flow rate at 90%

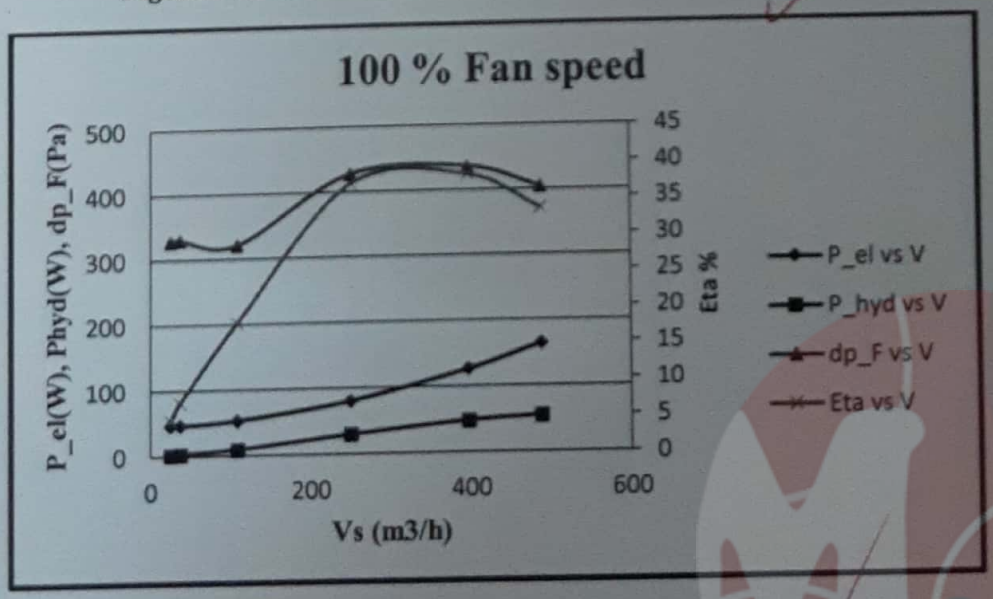

Figure 3 : Fan Characteristics vs volumetric flow rate at 100%

Discussion

In the experiment, we could observe the behavior of the radial fan. After doing various tests with the fan, we understood the operational behavior and its reaction as we opened and closed the valve. knowing that the performance of the beadle in the fan depends on the operating parameters such as how much you open the valve and velocity, electric power, hydraulic power, pressure deference. Efficiency increased with increasing volumetric flow rate. It reached the maximum efficiency at speed 100% with the value of 38% as it shown in table (6) and figure (3). Electric power has higher value than hydraulic power and both are directly proportional to volumetric flow rate as shown in figures. The dynamic pressure is directly proportional to the square of the air velocity. Also, the suction volume flow is proportional to the air velocity. At any constant speed, for example 80% the efficiency when the valve is fully closed is 1.6 % while the efficiency when the valve is fully open is 28 % As we can see in table (2), the efficiency increases as increasing the opening of the valve.

Good.

Conclusion

The test cannot be used to predict the performance of a geometrically similar pump because pump just be used for gases, efficiency increase when valve be fully open and hydraulic power increased as volumetric flow rate, electrical power and speed increased.

References

1) Chemical engineering laboratory "1" (0915361); University of Jordan; faculty of engineering and Technology; Department of Chemical engineering.

2) Noel de nevers, (1991), Fluid Mechanics for Chemical Engineers. third edition, McGraw-Hill, (pp. 164-202).

Appendix

Sample of calculation

- **Taking the first raw of table (2) :(80% speed first trial)**

1) **Temperature in (K)**

→ T(K) = 273.15 + 20.5 = 293.65 K

2) **ρ (kg/m³)**

→ ρ_o = 1.293 Kg/m³ , T_0=273.15 K , P_0=1013 mbar.

→ $\rho = \rho_o \cdot \frac{T_0}{T_1} \cdot \frac{P_{amb}}{P_0} = 1.293 \times \frac{273.5}{293.65} \times \frac{902}{1013}$ =1.070944 Kg/m³

3) **Velocity (m/s)**

→ $u = \sqrt{\frac{2}{\rho} . dp_N} = \sqrt{\frac{2}{1.07094} (0.1331)}$ = 0.498564 m/s

4) **Suction volume flow**

→ $\dot{V}_s = u . A$ = 0.498564 × 0.0063585 = 0.0031701 m³/s = 11.4124 m³/h

5) **Hydraulic power**

→ $P_{hyd} = dp_F . \dot{V}_s$ = 206.9799 × 0.0031701 = 0.65615 W

6) **Efficiency**

→ $\eta = \frac{P_{hyd}}{P_{el}} . 100\% = \frac{0.65615}{40.1} \times 100\%$ = 1.6362855 %