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FANS

by

K.S. Gan & K.S. Ho
Forest Research Institute Malaysia

Introduction

A fan is an important component that makes up a dust extraction system in a wood processing plant. It generates the suction in the system that draws dust through the hoods. If the fan is too small the airflow will be too low. Fortunately, fan selection does not always have to be perfectly accurate; fans have some built-in flexibility since their capacity increases with higher fan speeds although this also increases its power consumption. Speeding up the fan is the standard remedy for systems with inadequate airflow.

The ducts before and after the fan can almost be considered part of the fan itself. These ducts establish smooth airflow into and out of the fan so the fan can do the maximum work of moving dust laden air. Poor design of these ducts can lead to turbulence and uneven flow patterns at the fan inlet and outlet, and the capacity of fan will be lower than expected for the fan size and speed.

This paper will discuss briefly the fan commonly used for dust extraction in the wood processing industry and fan selection criteria. It should be useful both as a general background and when selecting a new fan for a new or existing dust extraction system.

Fan types

A fan is a rotary bladed machine which continuously supplies energy to the air passing through it. There are three main components in a fan: the impeller, the means of driving it and the casing.

In order to cover a wide range of applications, fans are manufactured in a variety of types. They can be classified into five main categories as given below;

(i) Centrifugal fan
(ii) Axial fan
(iii) Propeller fan
(iv) Mixed flow fan
(v) Cross flow fan

For a dust extraction system in woodworking plants, the most commonly used fan is the radial centrifugal fan. In this type, the impeller may have a conventional backplate and shroud or may be of the paddle-bladed type with flat blades attached directly to a spider hub. This latter type is particularly suitable for handling sawdust or wood refuse in the extraction system (Figure 1).

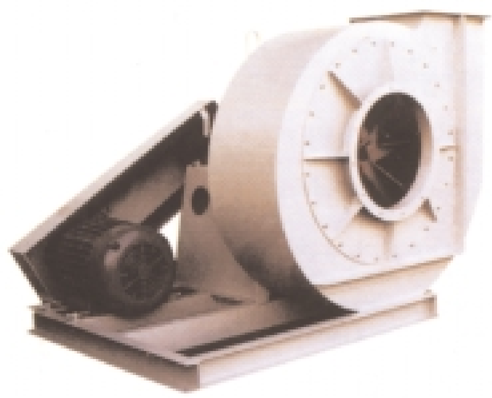

Figure 1. Radial centrifugal fan

Fan and system curves

Fan selection involves choosing the correct fan to match the suction requirements of the dust extraction system. The fan must move the correct quantity of dust laden air against the resistance to air-flow cause by friction and turbulence in the system. The relationship between flow rate and resistance for both the extraction system and the fan can be plotted to help select the proper fan. The plots are call ‘rating curves’.

Extraction system curve

The pressure loss or resistance to airflow through the extraction system is proportional to the square of air velocity or flow rate through the hood and ducts. Therefore, to double the airflow rate, a pressure four times as much is required from the fan. Once a system is designed, and duct diameters and length chosen, the amount of static pressure or suction that a fan must develop to extract different quantities of air can be estimated. Figure 2 shows an example of a system curve.

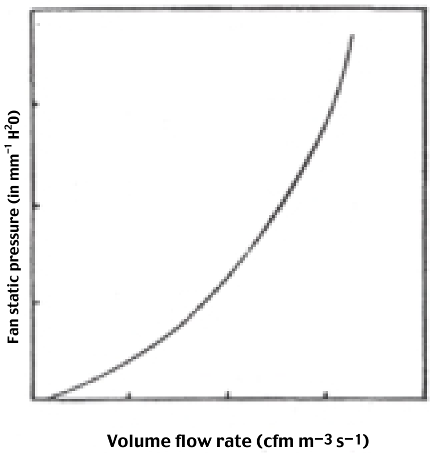

Figure 2. Extraction system curve

Fan curves

Normally three curves are used to describe the performance of a fan. They are the static pressure curve, brake horsepower curve and fan efficiency curve.

(i) Static pressure curve

The quantity of air that a fan will deliver at a given rotation speed depends on the resistance it is working against. As a general rule, the higher the resistance the less air a fan will move. All values of fan output and the corresponding static pressure for a given rotating speed can be plotted as a fan static pressure rating curve (Figure 3a).

Fan static pressure is the amount of suction and positive pressures that the fan adds to the extraction system. It is equal to the sum of turbulent and friction losses minus the velocity pressure of the air entering the fan inlet.

$FSP = ISP_{inlet}\ I + ISP_{outlet}\ I - VP_{inlet}$

where FSP = Fan static pressure (mm or inches of water)

$ISP_{inlet\ \&\ outlet}$ I = Absolute value of static pressure at fan inlet and outlet

VP_{inlet} =Velocity Pressure of air at fan inlet

(ii) Brake horsepower curve

The amount of electrical power required to spin the fan depends on the fan's output and the system resistance. It can be plotted as the 'brake horsepower curve' on the fan diagram (Figure 3b).This is the amount of

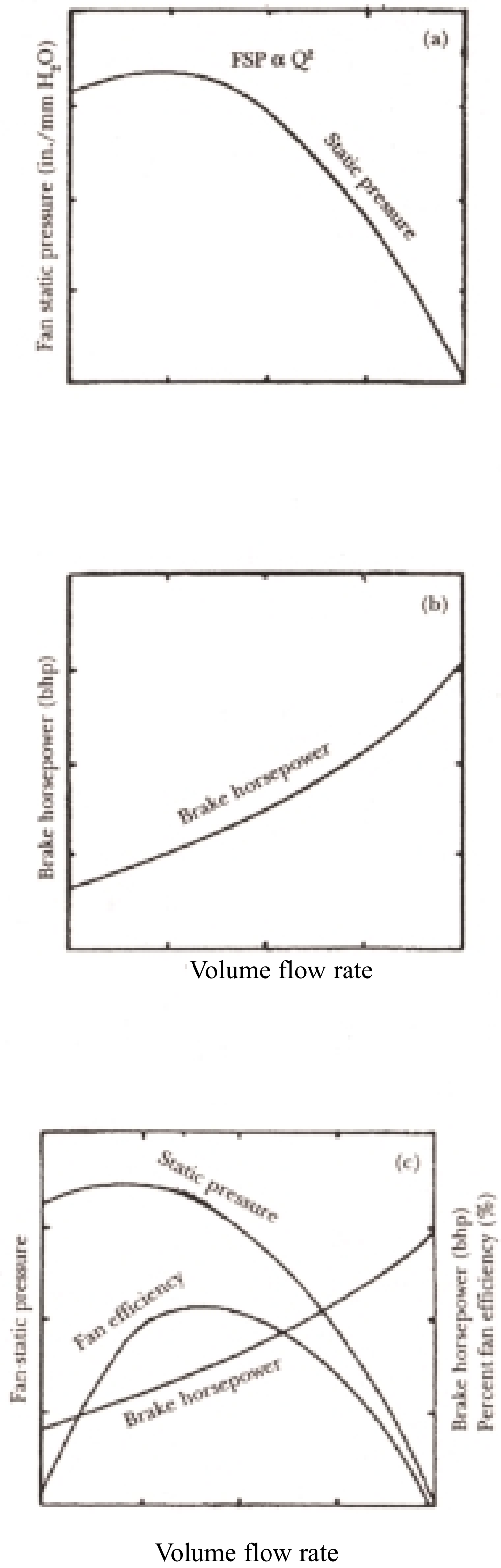

Figure 3. Fan curves: (a) static pressure curve, (b) brake horsepower curve and (c) static pressure and brake horsepower curves along with fan efficiency curve

Table 1.Fan rating table

Source : Bousted Engineering Sdn. Bhd.
Catalogue IMH 83

Class		
I	1000	ft/min Limit tip speed
II	14 000	" "
III	17 000	" "
IV	20 000	" "

ROTOR	33" dia	8.64 ft circ
INLET	19" dia	1.96 sq ft
OUTLET		1.97 sq ft

Type: AM Size: 19

CFM	OV	1" SP RPM	1" SP BHP	2" SP RPM	2" SP BHP	3" SP RPM	3" SP BHP	4" SP RPM	4" SP BHP	5" SP RPM	5" SP BHP	6" SP RPM	6" SP BHP	7" SP RPM	7" SP BHP
2364	1200	431	0.58	574	1.10										
2758	1400	446	0.70	587	1.29	700	1.93								
3152	1600	462	0.85	602	1.51	709	2.19	808	2.95						
3546	1800	478	1.01	617	1.75	725	2.52	817	3.29	904	4.14				
3940	2000	496	1.20	632	2.02	740	2.85	832	3.70	913	4.57	991	5.51		
4334	2200	513	1.42	648	2.31	755	3.22	846	4.14	927	5.08	1000	6.04	1072	7.05
4728	2400	532	1.66	664	2.62	771	3.61	862	4.61	942	5.62	1015	6.64	1082	7.69
5122	2600	550	1.92	681	2.96	786	4.02	876	5.10	957	6.19	1030	7.29	1097	8.40
5516	2800	569	2.21	698	3.35	802	4.48	892	5.63	972	6.79	1045	7.97	1112	9.16
5910	3000	589	2.53	716	3.76	819	4.96	908	6.19	987	7.43	1060	8.68	1127	9.95
6304	3200	608	2.89	734	4.21	836	5.49	924	6.80	1003	8.11	1075	9.42	1142	10.77
6698	3400	629	3.27	752	4.70	853	6.06	940	7.43	1018	8.81	1090	10.23	1156	11.63
7092	3600	649	3.68	771	5.22	870	6.67	956	8.10	1034	9.58	1106	11.05	1172	12.54
7486	3800	670	4.14	790	5.79	888	7.32	974	8.84	1051	10.39	1122	11.93	1187	13.49
7880	4000	691	4.64	809	6.38	906	8.02	991	9.62	1067	11.21	1138	12.86	1203	14.49
8274	4200	714	5.21	828	7.02	925	8.77	1009	10.45	1085	12.11	1154	13.83	1219	15.55
8668	4400	737	5.83	848	7.70	943	9.55	1026	11.33	1102	13.09	1171	14.83	1235	16.65
9062	4600	760	6.52	868	8.44	962	10.39	1045	12.26	1119	14.10	1188	15.91	1252	17.80
9456	4800	785	7.26	888	9.21	981	11.27	1063	13.24	1137	15.16	1205	17.10	1269	18.99
9850	5000	809	8.08	908	10.04	1001	12.20	1082	14.38	1155	16.30	1223	18.29	1286	20.27
10244	5200	834	8.96	929	10.92	1020	13.17	1100	15.35	1173	17.46	1241	19.55	1303	21.65
10638	5400	*	*					*	*	1192	18.72	1258	20.89	1321	23.04
11032	5600	*	*					*	*	1210	20.03	1277	22.29	1338	24.50
11426	5800	*	*					*	*	1229	21.36	1294	23.73	1356	26.06
11820	6000	*	*					*	*	1248	22.81	1313	25.25	1375	27.68
12214	6200	*	*					*	*	1267	24.28	1332	26.85	1393	29.34
12608	6400	*	*					*	*	1286	25.81	1351	28.47	1411	31.10

CFM	OV	8" SP RPM	8" SP BHP	9" SP RPM	9" SP BHP	10" SP RPM	10" SP BHP	12" SP RPM	12" SP BHP	14" SP RPM	14" SP BHP	16" SP RPM	16" SP BHP	18" SP RPM	18" SP BHP	20" SP RPM	20" SP BHP	22" SP RPM	22" SP BHP
2364	1200																		
2758	1400																		
3152	1600																		
3546	1800																		
3940	2000																		
4334	2200																		
4728	2400	1148	8.76	1213	9.94	1275	11.08												
5122	2600	1158	9.51	1220	10.67	1281	11.92												
5516	2800	1174	10.35	1232	11.51	1288	12.79	1402	15.45										
5910	3000	1189	11.22	1248	12.50	1303	13.76	1409	16.42	1514	19.33								
6304	3200	1204	12.12	1262	13.47	1318	14.83	1420	17.55	1520	20.47	1618	23.57						
6698	3400	1219	13.06	1277	14.49	1333	15.93	1436	18.83	1531	21.77	1625	24.87	1716	28.17				
7092	3600	1234	14.04	1293	15.55	1348	17.07	1451	20.12	1545	23.18	1634	26.34	1723	29.63	1810	33.12		
7486	3800	1249	15.06	1307	16.65	1363	18.24	1465	21.42	1560	24.66	1648	27.89	17.33	31.27	1816	34.75	1899	38.42
7880	4000	1265	16.15	1322	17.79	1378	19.46	1481	22.83	1575	26.21	1664	29.62	1746	32.97	1826	36.57	1906	40.22
8274	4200	1281	17.26	1338	19.00	1393	20.73	1496	24.25	1590	27.78	1678	31.36	1761	34.94	1839	38.43	1916	42.25
8668	4400	1296	18.45	1354	20.25	1408	22.08	1510	25.72	1605	29.39	1693	33.10	1776	36.88	1855	40.63	1928	44.27
9062	4600	1312	19.68	1369	21.53	1424	23.45	1526	27.25	1620	31.08	1708	34.87	1791	38.84	1869	42.76	1944	46.70
9456	4800	1329	20.97	1385	22.94	1440	24.87	1541	28.86	1635	32.81	1723	36.85	1806	40.90	1884	44.96	1959	49.03
9850	5000	1345	22.29	1402	24.35	1456	26.40	1557	30.49	1650	34.62	1738	38.81	1821	42.95	1899	47.21	1974	51.45
10244	5200	1362	23.71	1418	25.82	1472	27.96	1573	32.20	1666	36.51	1753	40.78	1836	45.14	1914	49.52	1989	53.90
10638	5400	1380	25.20	1435	27.33	1488	29.59	1589	33.99	1681	38.42	1768	42.87	1851	47.37	1929	51.91	2004	56.46
11032	5600	1397	26.77	1452	28.97	1505	31.23	1604	35.85	1697	40.41	1784	45.04	1866	49.66	1944	54.36	2019	59.03
11426	5800	1414	28.38	1469	30.71	1522	33.01	1621	37.75	1712	42.47	1800	47.24	1882	52.06	1958	56.79		
11820	6000	1432	30.05	1487	32.46	1539	34.85	1637	39.71	1729	44.65	1816	49.52	1897	54.49	1974	59.42		
12214	6200	1450	31.82	1504	34.32	1556	36.82	1654	41.69	1745	46.84	1831	51.88	1913	56.98	1990	62.14		
12608	6400	1468	33.70	1522	36.22	1574	38.77	1671	43.69	1762	49.13	1847	54.37	1928	59.55	2005	64.85		

The fan tests are conducted in standardised airways, which means that the test system is idealised, approximating to long straight ducts fixed with minimum changes of cross-sectional area axially to the fan inlet or the fan outlet or both.

Unless a fan is installed in a similar manner to the test arrangement stated, reduced flow rate and efficiency may result. Bends of any kind close to the fan inlet and outlet should be avoided. Figure 6 gives soirne idea of the effect of bend close to the inlet of a centrifugal fan.

Fan laws

These is a series of equations that govern the operation of a fan. It helps one to modify a fan's operation to match the system requirement. However, it is important to not, that these laws apply to the same point of operation o the fan rating curve. They cannot be used to predict othe points on the fan's curve.

These equations are as follows

$$Q_2 = Q_1 * (N_2/N_1)$$

$$FSP_2 = FSP_1 * (N_2/N_1)^2$$

$$BHP_2 = BHP_I * (N_2/N_1)^3$$

Where Q = Airflow rate
N = Revolutions
FSP = Fan Static Pressure
BHP = Brake Horsepower
Subscripts 1 & 2 denote initial and final values

From the above equations, doubling the fan speed will double the airflow rate and increase the fan static pressure and brake horsepower by a factor of four and eight respectively.

Selection of fan

Information needed for the selection of a fan for a dust extraction system is the total volume flow rate and fan static pressure to fulfil the system requirement. Other information such as drive arrangement and intended mounting arrangement or foundation will help to select the most appropriate fan configuration.

Conclusion

Accurate calculation of the system's total volume flow rate and static pressure requirements and good ducting design especially close to fan inlet and outlet are very important to ensure good performance of the selected fan. Deficiencies in performance of the extraction system are more often caused by incorrect calculation of the static pressure requirement and other faults in the system than by fan or motor deficiencies.

Further reading

Industrial Ventilation - A Manual of Recommended Practice. 22nd edition. American Conference of Governmental Industrial Hygienists: Chapter 6.

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