LECTURE – 4

THE CONTENTS OF THIS LECTURE ARE AS FOLLOWS:

1.0 FAN LAWS

REFERENCES

FAN LAWS

The fan laws are a set of proportionalities relating each of the following parameters of airflow with fan speed (n), air density (ρ) and impeller diameter (d).

- Air pressure (p)
- Airflow quantity (Q)
- Power developed (P_{pow})

Through extensive experimentation and derivation the following direct proportionalities have been arrived.

For varying speed but with constant air density and impeller diameter:

- Quantity varies directly as the speed

- Pressure varies as the square of the speed

- Power varies as the cube of the speed

- Efficiency is constant

For varying density but with constant speed and impeller diameter:

- Quantity remains constant

- Pressure varies directly as the density

- Power varies directly as the density

- Efficiency is constant

For varying impeller diameter but with constant speed and air density:

- Quantity varies as the cube of the impeller diameter

- Pressure varies as the square of the impeller diameter

- Power varies as the fifth power of the impeller diameter

- Efficiency is constant

The above statements of fan laws can be presented in the form of table as given in Table 1.

Table 1 Fan Laws

Parameters	Variable 'n' Speed	Variable 'ρ' Density	Variable 'd' Impeller Diameter
p	n^2	ρ	d^2
Q	n	Independent	d^3
$\mathbf{P_{pow}}$	n^3	ρ	d^5

Thus, for two fans A and B, having the above mentioned parameters as (p_A, Q_A, $P_{pow,A}$) with variables (n_A, ρ_A, d_A) and (p_B, Q_B, $p_{pow,B}$) with variables (n_B, ρ_B, d_B), the fan law equations can be written as follows:

- $p_A / p_B = (n_A^2 \rho_A d_A^2) / (n_B^2 \rho_B d_B^2)$
- $Q_A / Q_B = (n_A d_A^3) / (n_B d_B^3)$
- $P_{pow,A} / P_{pow,B} = (n_A^3 \rho_A d_A^5) / (n_B^3 \rho_B d_B^5)$

The major function and utility of fan laws is to provide a prediction of performance of one fan when the performance of a similar fan is known to a reasonable level of accuracy. Now, let us discuss the utility of fan laws through an example.

Now, let us assume that we have a fan running at 600 RPM and handling air of density 1.2 kg/m^3. The fan characteristic, input power characteristic and efficiency of this fan along with mine characteristic is shown in Fig. 1.

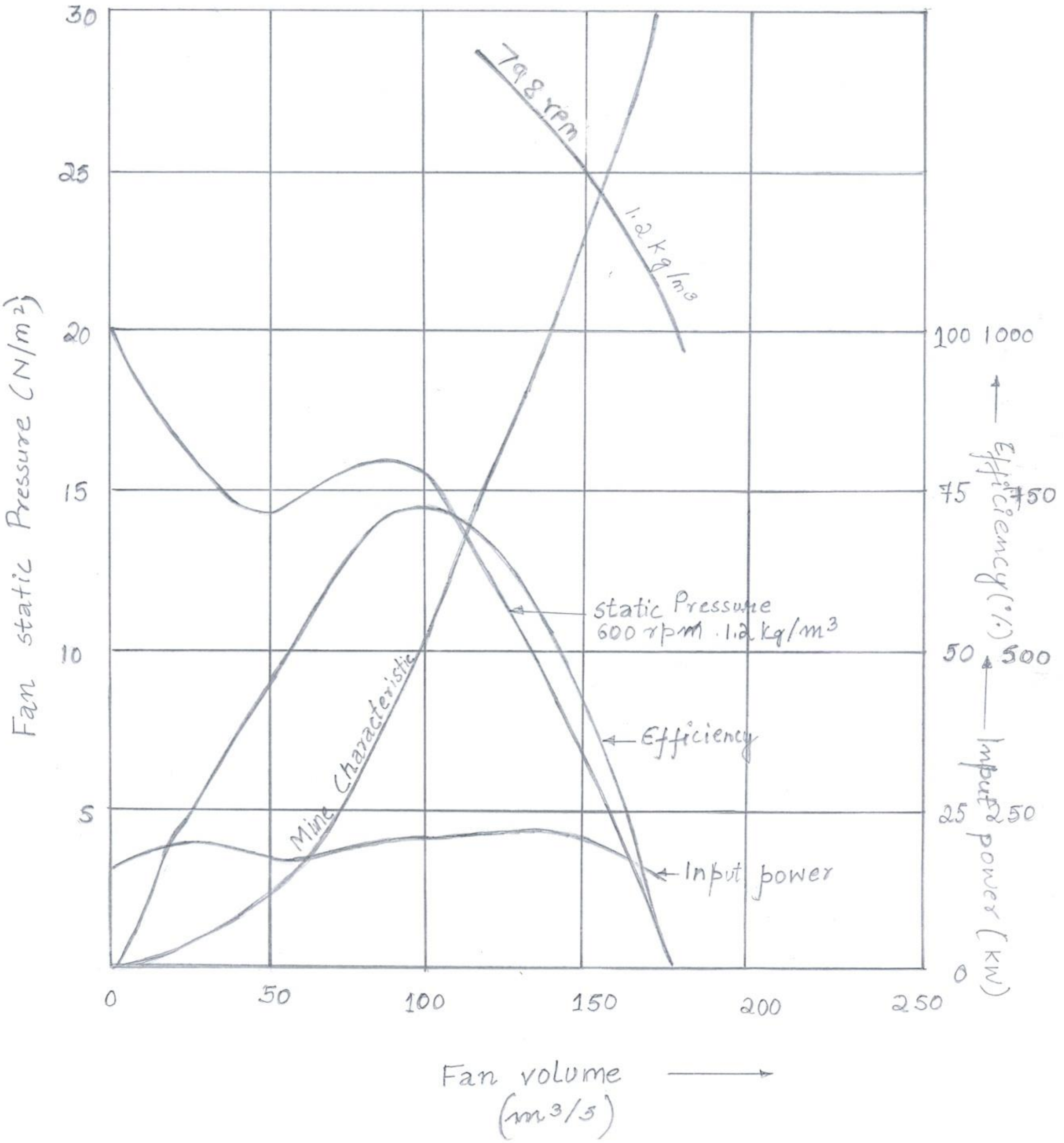

Fig. 1

Now, let us draw new curves for this same fan when it is run at a speed of 798 RPM and handling air at a density of 1.04 kg/m^3.

At the original speed of 600 RPM and air density of .2 kg/m^3, the fan at its design point will deliver 115 m^3/s at 1370 Pa using 225 KW of input power and giving an efficiency of 70.20 %.

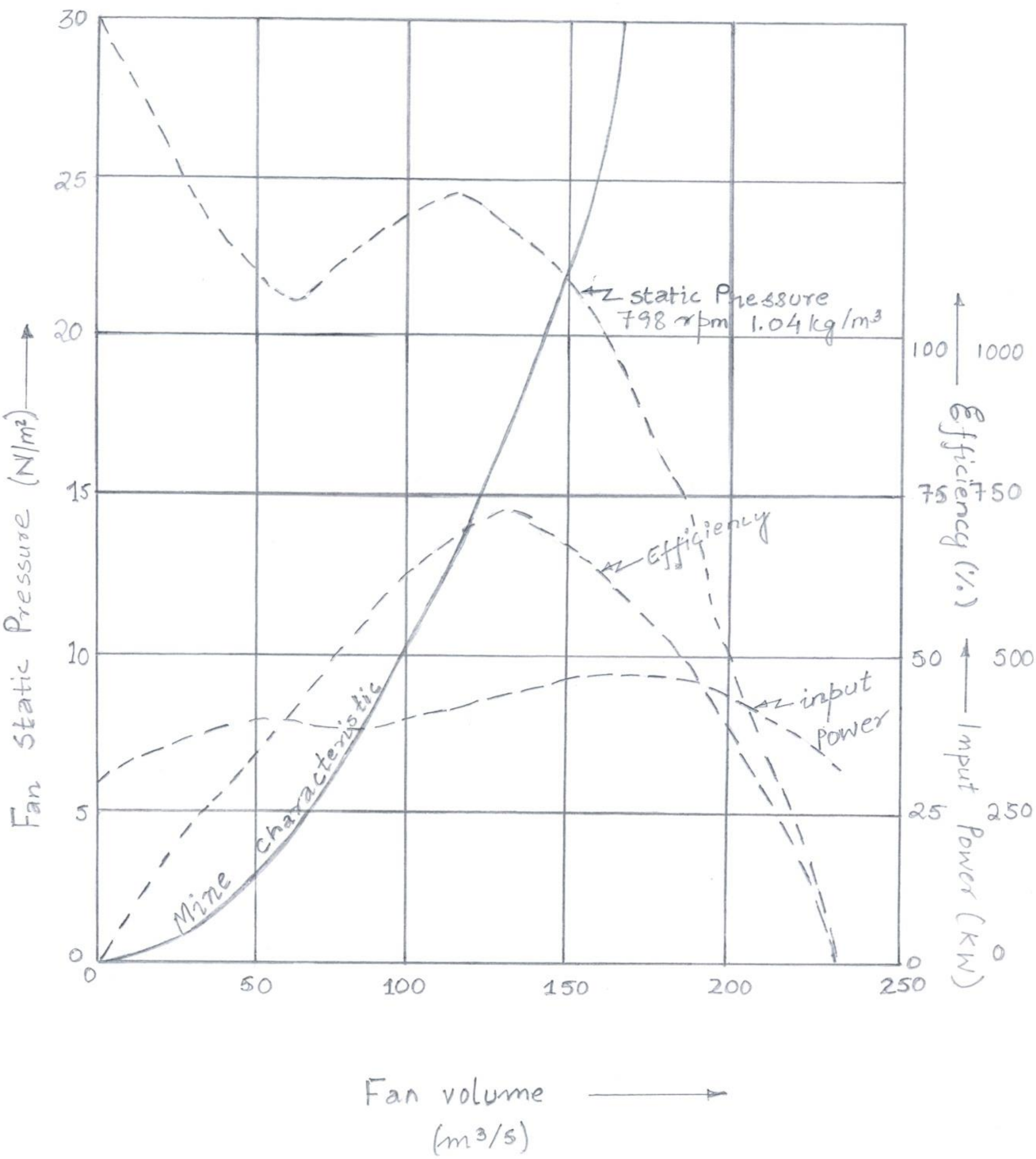

Fig. 2

Now, let us use fan laws to calculate the new quantity, new pressure, new input power and new efficiency for the new speed of 798 RPM and air density of 1.04 kg/m^3.

New quantity = 115 x $\frac{798}{600}$ x 1 = 153 m^3/s

New pressure = 1370 x ($\frac{798}{600}$)^2 x $\frac{1.04}{1.2}$ = 2100 Pa

New input power = 225 x ($\frac{798}{600}$)^3 x $\frac{1.04}{1.2}$ = 459 x 10^3 W = 459 KW

New efficiency = 70.20 % (Remains constant)

In a similar way, other points on the curves for the old conditions can be recalculated for the new conditions. These results can be tabulated and then plotted as shown in Fig. 2.

When we install a fan in a mine, its performance will be determined by the point at which the mine characteristic cuts the fan characteristic. The mine or system characteristic is a curve which shows how the pressure drop across the mine varies as the quantity of air varies. The mine characteristic curve can be drawn using the relation

$P = RQ^2$ which was discussed earlier.

If we know the value of mine resistance (R), we can tabulate the values of 'P' for different values of 'Q'. These values can then be plotted and we get mine characteristic curves. The mine characteristic for low, medium and high resistance is shown in Fig. 3.

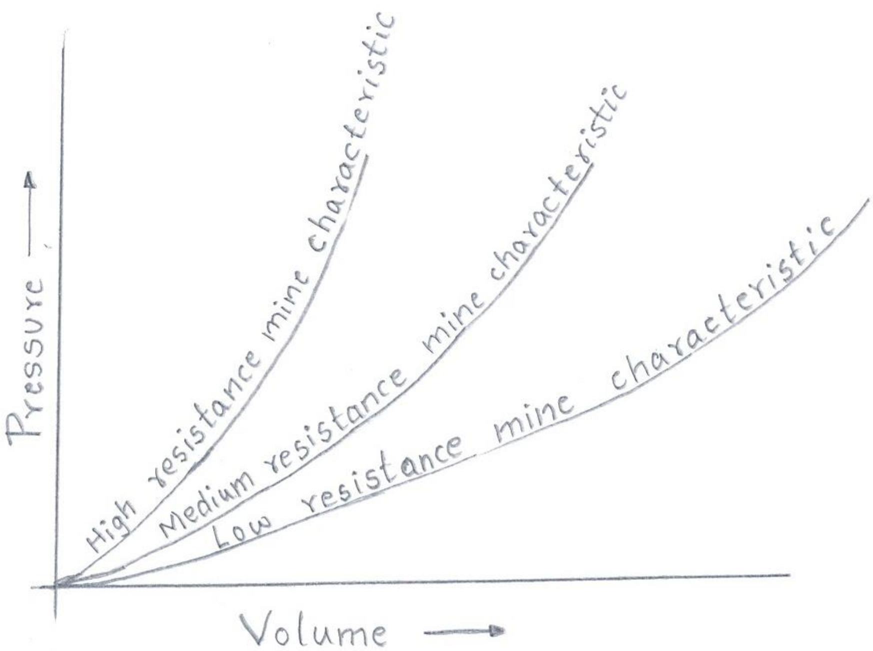

Fig. 3 Mine characteristics for low, medium and high resistance systems

The mine characteristic curve shown in Fig. 1 cuts the 600 RPM fan characteristic at the design point i.e., (115 m^3/s, 1370 Pa). Under this condition, the fan will handle 115 m^3/s if it is not affected by pressure from any other sources. If it attempts to handle more air, it finds it almost impossible or difficult to do so as it produces insufficient pressure to overcome the mine resistance. In a similar way, it cannot handle less air as it would have extra pressure or pressure to spare.

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