LECTURE – 5

THE CONTENTS OF THIS LECTURE ARE AS FOLLOWS:

1.0 CHARACTERISTIC CURVES OF FAN

Every fan has certain characteristics or in other words distinguishing qualities with respect to the work it is able to perform under different conditions. This is true for any other machine also.

1.1 Comparison of the Characteristics of a Runner and a Mountaineer

Le Roux (1972) has given a very good analogy of characteristic curve of fan with that of a person. According to him, if a series of race is performed by a runner and a mountaineer to see who could cover the maximum ground in one hour, one would probably find that the long distance runner would easily win on a level ground. But as the steepness of the ground on which the race was run is increased slowly, the difference on the distance covered by the two becomes lesser. If the ground is very steep, the mountaineer might win. On a near vertical mountain cliff, the mountaineer will be able to proceed slowly whereas the long distance runner will not be able to move at all. The difference between the running characteristic of these two men can be represented by means of characteristic curves as shown in Fig. 1.

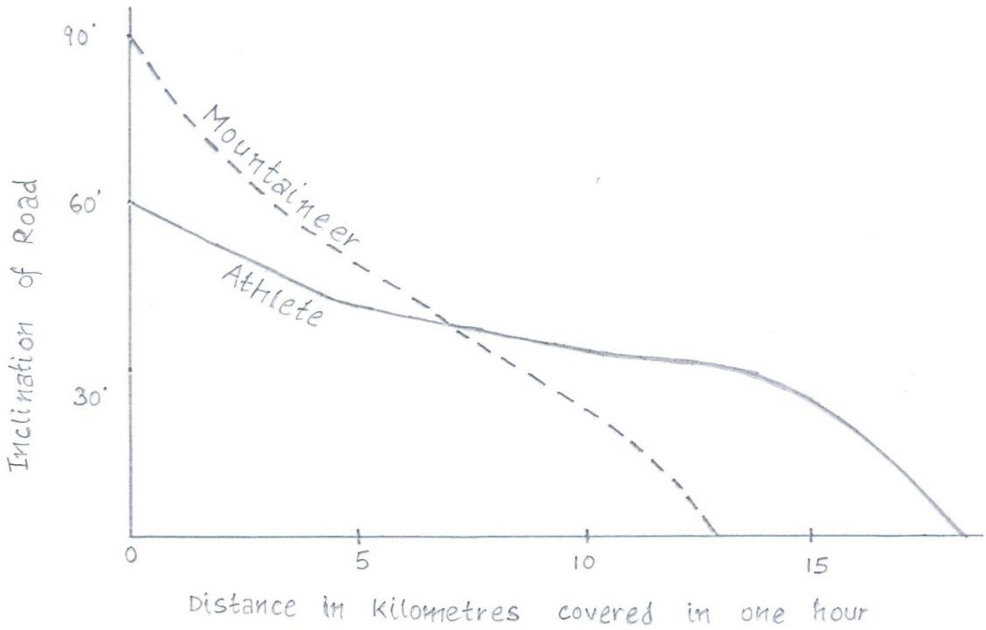

Fig. 1Running characteristics of mountaineer and athlete (after Le Roux, 1972)

The curves shown in Fig. 1 can help us to determine which man should be sent to carry an urgent message, if the gradient of the terrain is known.

1.2 What Does a Fan Characteristic Curve Give?

Fan characteristic curves indicate:

- how much air a fan can deliver at any particular pressure.

- how much power is required to drive the fan for each pressure and quantity.

2.0 PRESSURE QUANTITY CURVE

The characteristic curve of a fan is shown in Fig. 2. It is important to know that these curves are applicable for a particular fan when it is driven at a speed of 600 rpm and is handling air of density 1.2 kg/m^3.

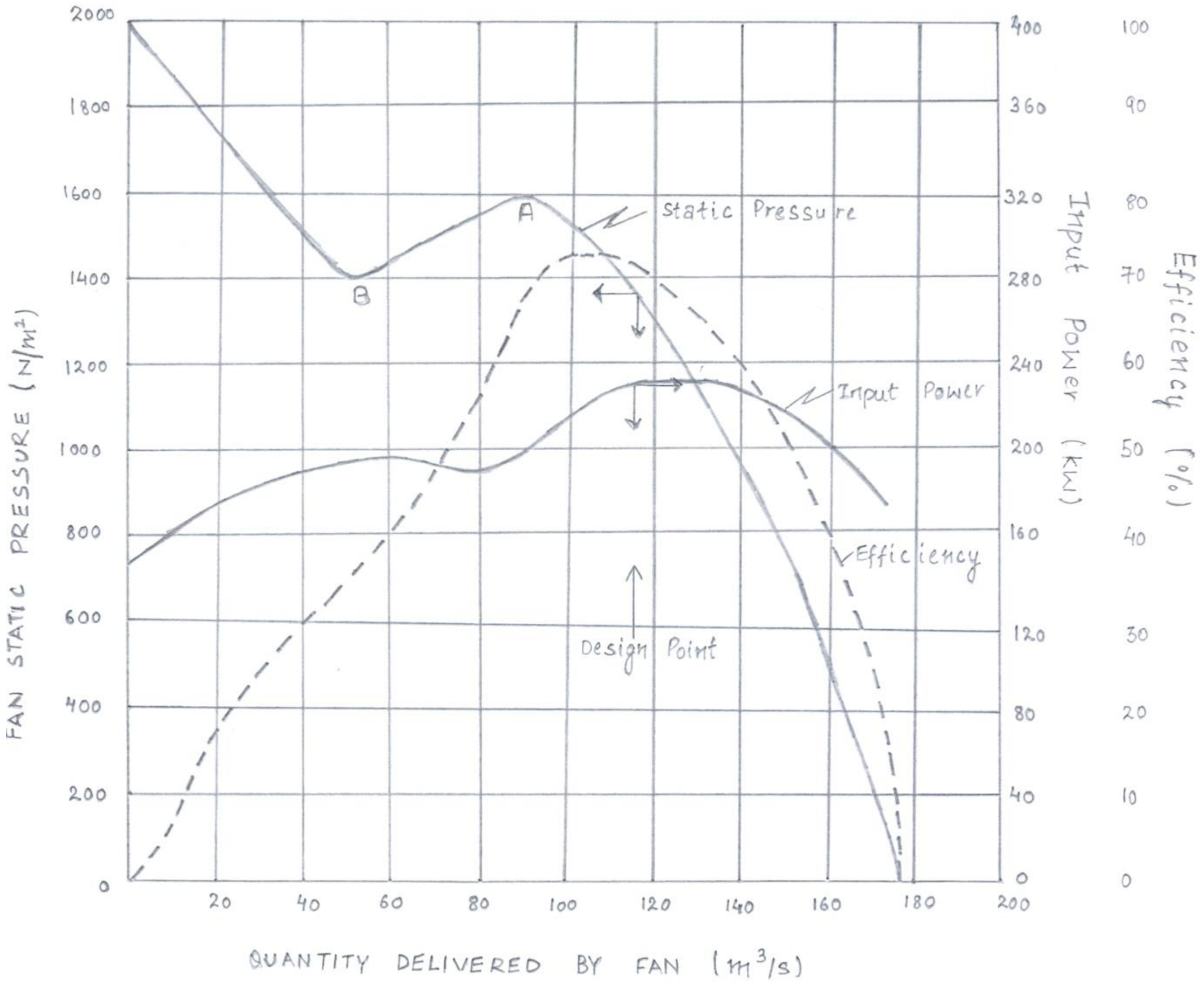

Fig. 2 Characteristic curve of a fan running at 600 RPM and handling air of density 1.2 kg/m^3 (after Le Roux, 1972)

The curve indicating static pressure, input power and efficiency of the fan are clearly indicated in Fig. 2. Now, let us look at the lower right hand portion of the PQ- curve for static pressure. It indicates that this fan will handle 175 m^3/s at zero pressure or no pressure i.e., when running in open air without attaching any ducts to it. When this fan is installed in a mine, it will handle lesser air at a higher pressure i.e. as the pressure increases, the quantity delivered will reduce.

2.1 What is Stall Zone in PQ- Curve?

As the resistance of the mine increases, the quantity of air delivered by the fan reduces. Further, greater pressure is required to be put up by the fan with increase in mine resistance till point A. At point A in Fig. 2, the fan delivers 92 m^3/s at a pressure of 1600 N/m^2. If the resistance of the mine is further increased, the fan will deliver still lesser air and at a lower pressure (AB portion of the curve in Fig. 2). This portion of the curve is called stall zone. In this zone, there is insufficient air to completely fill the space between the blade sections. The air separates from the trailing edges of the blades.

2.2 What happens if a Fan is Operated in the Stall Zone?

When a fan stalls, there is significant change in the sound level. Also, the readings of water gauge and the motor ammeter fluctuates. Because of the sound and vibrations which are set up in the blades and in the shaft, there can be a mechanical failure. Hence the fan should never be operated in the stall zone.

3.0 INPUT POWER CURVE

The input power curve of the fan in Fig. 2 gives the power required at the fan shaft with varying quantity of air delivered. If there are any losses in the drive, the motor driving the fan will have to deliver greater power than this i.e. the values indicated in the curve. Fig. 2 shows that, the input power curve starts at about 150 KW with zero quantity of air delivered. It gradually increases to 230 KW when the quantity delivered is 130 m^3/s. Beyond this, it starts decreasing and comes to 170 KW with quantity delivered at 175 m^3/s. This is a non-overloading characteristic. This means that, if a motor is able to drive the fan at the normal design duty which is about 115 m^3/s in Fig. 2, it will be able to perform any duty of the fan.

Fans which have non- overloading characteristics

All axial flow fans

Backward bladed centrifugal fans

Fans which have overloading characteristics

Radial bladed centrifugal fans

For fans which show overloading characteristics, the motor is installed which is sufficient enough for the normal design duty plus a reasonable margin of safety. If the quantity of air is allowed to increase, by the opening of the door, the motor gets overloaded and may either trip out or burn out.

4.0 EFFICIENCY CURVE

The efficiency curve of a machine or equipment is defined as the ratio of useful work output to the energy input. It is expressed in percentage. The efficiency curve is basically derived from the power input curve and the static pressure curve of Fig. 2

4.1 Air Power

The useful work done by a fan is to move the air. The output of the fan is measured by the quantity of air it moves and the pressure it puts into the air. These two terms i.e. quantity and pressure can be combined together and is called air power.

$\therefore$ Fan efficiency = $\frac{Air\ power}{Input\ power\ to\ the\ fan}$ x 100

Now, let us look back at Fig. 2. It can be seen from figure that, if the fan is not handling any air, it produces a pressure of 2000 N/m^2

$\therefore$ Air power = P x Q = 2000 x 0 = 0

$\therefore$ Efficiency = $\frac{Air\ power}{Input\ power\ to\ the\ fan}$ x 100 = $\frac{0}{150}$ x 100 = 0 %

From this we conclude that, though it requires 150 KW input power to keep the fan running at 600 rpm and to maintain a pressure of 2000 N/m^2 across the fan, but there is no movement of air and therefore, no useful work is done. Hence the fan efficiency is zero.

4.2 If No Work is Done, What happens to the Input Power Supplied to the Fan?

Since the energy created cannot be destroyed, 150 KW of input power is all converted to heat which in turn raises the temperature of the fan and the air. At free delivery also, the useful work done is zero and hence the efficiency is also zero. In this case, though the fan moves a large quantity of air, but the useful pressure is zero (Fig. 2).

Now, again, let us look at Fig. 2. We can see that, at the design point, the fan delivers 115 m^3/s at a pressure of 1370 N/m^2. At this point, it requires an input power of 225 KW.

$\therefore$ Air power = P x Q = 1370 x 115 = 157550 W = 157.55 KW$\approx$ 158 KW

$\therefore$Efficiency = $\frac{158}{225} \times 100 = 70.2$ %

Thus we can calculate the fan efficiency from different quantities. These values are plotted and the efficiency curve is drawn.

Thus we can say that the fan of Fig. 2 is efficient when it is required to handle 115 m^3/s of air quantity. However, its efficiency reduces drastically when it is required to handle lesser quantity below 90 m^3/s or higher air quantity above almost 120 m^3/s.

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