LECTURE – 6

THE CONTENTS OF THIS LECTURE ARE AS FOLLOWS:

1.0 SELECTION PROCESS OF MINE FANS

1.1 Fan Selection

Either to install an existing fan or in case we want to order a new fan we need to keep the below mentioned points in mind:

- The fan should be effective i.e. it should be able to deliver the required quantity at the required pressure

- Its operation should be efficient. In other words, it should have a higher efficiency so that the power consumption is low which will reduce the cost of operation.

The selection of a mine fan depends on the following factors:

- Pressure and quantity requirements throughout the mine life
- Nature of air to be handled-density, humidity, temperature etc.
- Unidirectional or bidirectional flow required
- Type and capacity of driving shaft or power available
- Cost requirements and budget
- Space requirements and availability

1.2 Fans in Series

When two fans are installed one behind the other in such a way that they handle the same air, they are said to be in series. When two fans are in series, the same volume o air passes through each and each adds a certain amount of pressure to it in the process.

1.3 Fans in Parallel

When two fans are installed side by side in such a way that they draw air from the same source and deliver it to the same destination, they are said to be in parallel.

When two fans are connected in parallel, they may not handle the same quantity of air. However, they produce the same pressure as they are drawing air from a common point and also delivering it to a common point.

2.0 SERIES CONNECTION

2.1 Case – I

Let us assume Fan A and Fan B are blowing air into a duct that is closed at the other end (Fig. 1).

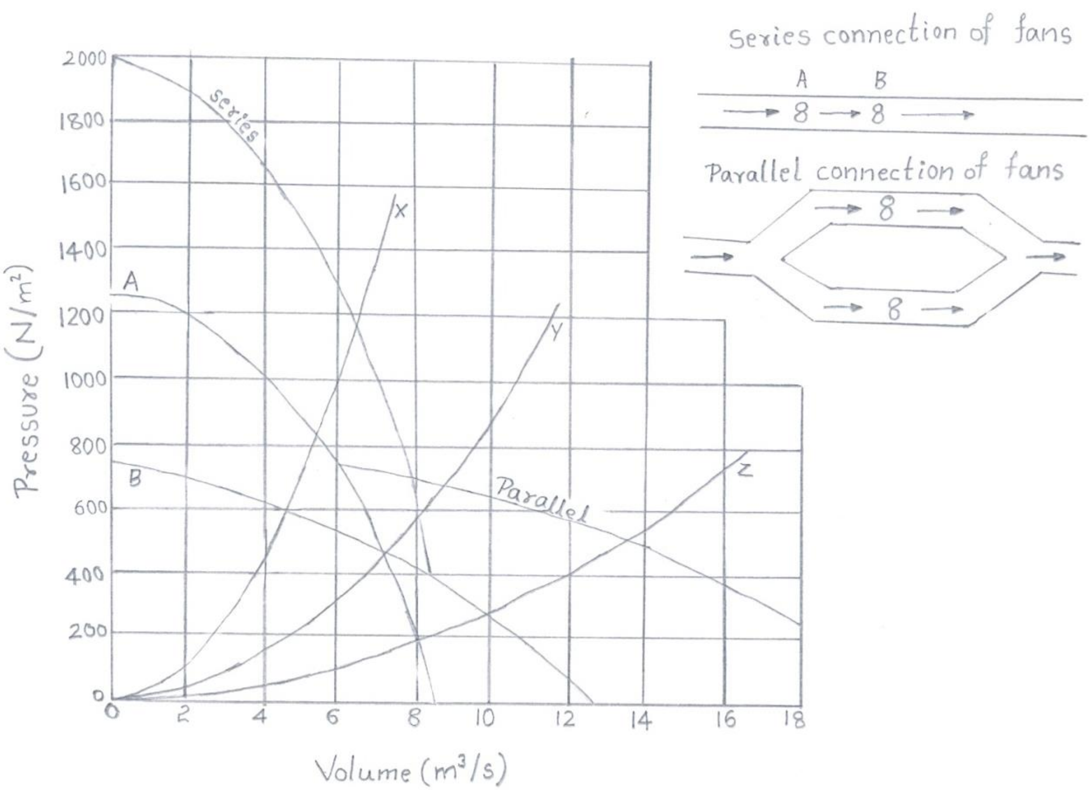

Fig. 1 (after Le Roux, 1972)

In this case none of the fans i.e. Fan A and Fan B will be handling any volume of air.

Therefore, Volume flow = 0 m^3/s

But,

Fan A will raise the pressure by an amount = 1250 Pa

And

Fan B will raise the pressure by an amount = 750 Pa

Therefore, Final pressure = 1250 + 750 = 2000 Pa

2.2 Case – II

Now, let us assume that, we allow them to handle 5 m^3/s quantity of air. This can be done by opening the closed end of the duct and using a regulator so that only 5 m^3/s quantity of air flows through the duct.

In this case, Fan A will raise the pressure by 900 Pa and Fan B by another 590 Pa.

Therefore the total pressure raised by Fan A and Fan B = 900 + 590 = 1490 Pa

2.3 Case – III

When 8.3 m^3/s is required to be handled (again by controlling this quantity through a regulator),

Pressure put up by Fan A into the air = 0 Pa

Pressure put up by Fan B into the air = 400 Pa

When Fan B is handling more than 8.3 m^3/s, Fan A will not be of any assistance and will actually form a slight resistance in the circuit.

Now let us make a table consisting of quantity delivered in m^3/s with that of pressure developed as given in Table 1.

Table 1 Quantity versus pressure developed by Fans A and B when they are connected in series

Quantity (m^3/s)	0	5	8.3
Pressure (Pa)	2000	1490	400

By plotting the values of quantity and pressure of Table 1, we get the curve for Fan A and Fan B when they are connected in series.

3.0 PARALLEL CONNECTION

Let us now assume that Fan A and Fan B are connected in parallel as shown in Fig. 1.

3.1 Case – I

At a pressure of 750 Pa,

Quantity handled by Fan A = 5.9 m^3/s

Quantity handled by Fan B = 0 m^3/s

Thus, total quantity handled by Fan A and Fan B together = 5.9 m^3/s

3.2 Case – II

At a pressure of 200 Pa,

Quantity handled by Fan A = 7.9 m^3/s

Quantity handled by Fan B = 10.7 m^3/s

Thus total quantity handled by Fan A and Fan B = 18.6 m^3/s

Now let us make a table consisting of quantity handled in m^3/s with that of pressure developed as given in Table 2.

Table 2 Quantity versus pressure developed by Fans A and B when they are connected in parallel

Quantity (m^3/s)	5.9	18.6	---------------
Pressure (Pa)	750	200	---------------

By plotting the values of quantity and pressure of Table 2, we get the curve for Fan A and Fan B when they are connected in parallel.

If the pressure required is more than 750 Pa, Fan B will not be able to provide this pressure and will not only be of no assistance but will actually be a hindrance because Fan A will force some of its air back through Fan B.

4.0 FAN SELECTION

Now, to use either Fan A alone or Fan B alone or Fan A and Fan B in series or Fan A and Fan B in parallel will actually depend on the resistance of the duct system (in case of mine, resistance of the mine). In Fig. 1, three system characteristics are shown namely, X, Y and Z. As can be seen,

X = High resistance system

Y = Medium resistance system

Z = Low resistance system

It would have been better to show the input power curves for the two fans, A and B. However, it will make Fig. 1 congested. In the absence of that, let us make the assumption that:

Fan A always consumes 7.5 KW

Fan B always consumes 6.0 KW

Now, using Fig. 1, we can construct Table 3 to indicate quantity, pressure, input power and efficiency for Fan A alone, Fan B alone, Fan A and Fan B in series, Fan A and Fan B in parallel.

In Table 3, efficiency is calculated using the relation,

Efficiency = $\frac{Air\ power}{Motor\ power}$ X 100 = $\frac{PQ}{Motor\ power}$ X 100

As for instance, for system Z, and for Fan A alone,

Efficiency = $\frac{PQ}{Motor\ power}$ X 100 = $\frac{8\ X\ 180}{7.5\ X\ 1000}$ X 100 = 19.2 %

Now, using Table 3, it is possible to decide, in the case of each system, which would be the most suitable installation.

Table 3 Quantity, pressure, input power and efficiency for different fan combinations

System	Parameters	Units	Fan A alone	Fan B alone	Fan A and Fan B in series	Fan A and Fan B in parallel
X	Volume	m^3/s	5.4	4.6	6.3	---
	Pressure	Pa	840	610	1180	---
	Input power	KW	7.5	6.0	13.5	13.5
	Efficiency	%	61	47	55	---
Y	Volume	m^3/s	7.2	7.3	8.0	8.7
	Pressure	Pa	470	480	580	680
	Input power	KW	7.5	6.0	13.5	13.5
	Efficiency	%	45	58	34	44
Z	Volume	m^3/s	8.0	9.8	---	13.3
	Pressure	Pa	180	280	---	520
	Input power	KW	7.5	6.0	13.5	13.5
	Efficiency	%	19.2	46	---	51

Let us consider system Y of Fig. 1. When the two fans i.e. Fan A and Fan B are running in parallel and handling 8.7 m^3/s of air at a pressure of 680 Pa, each of these fans should be producing 680 Pa. If we move horizontally along this pressure line, we will notice that Fan A will handle 6.3 m^3/s and Fan B only 2.4 m^3/s.

If Fan A and Fan B are running in series, they both will handle 8 m^3/s of air. If we move vertically along this quantity line, we will notice that Fan A is producing only 960 Pa whereas Fan B is producing 420 Pa.

The calculation shown above can also be applied when more than two fans are installed either in series or in parallel.

Let us now derive the general expression of quantity produced by two fans when they are connected in series and in parallel

5.0 GENERAL EXPRESSION FOR SERIES AND PARALLEL CONNECTIONS

5.1 Series Connection

Let,

P = Pressure produced by each of the two fans

q = Quantity produced by each of the two fans

Q = Quantity produced by the two fans in series

R_m = Mine resistance

R_f = Resistance of each fan

Therefore, with one fan

$P = (R_m + R_f)\, q^2$

$q = \frac{\sqrt{P}}{\sqrt{(R_m + R_f)}}$

Now, when the two fans are connected in series,

$2P = (R_m + 2R_f)\, Q^2$

$Q = \frac{\sqrt{2}\,\sqrt{P}}{\sqrt{(R_m + 2R_f)}}$

Therefore,

$$\frac{Q}{q} = \frac{\sqrt{2}\sqrt{(R_m + R_f)}}{\sqrt{(R_m + 2R_f)}}$$

If R_f is very small compared to R_m,

$$\frac{Q}{q} = \sqrt{2}$$

$Q = q\sqrt{2} = 1.414\ q$

This shows that quantity is increased by about 40 %

5.2 Parallel Connection

With one fan,

$P = (R_m + R_f)\ q^2$

Now, Resistance of two fans in parallel = $\frac{R_f}{4}$

Therefore,

$P = (R_m + \frac{R_f}{4})\ Q^2$

Therefore,

$$\frac{Q}{q} = \frac{\sqrt{(R_m + R_f)}}{\sqrt{(R_m + \frac{R_f}{4})}}$$

If R_f is very small compared to R_m,

$\frac{Q}{q} = 1$

$Q = q$

Hence there is no increase in the volume.

Though there is no change in quantity, still we connect many times fans in parallel because their efficiency may be higher and therefore power consumption less (Refer data of Table 3).

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