LECTURE – 1

THE CONTENTS OF THIS LECTURE ARE AS FOLLOWS:

1.0 NATURAL VENTILATION

Air will always flow from a region of high pressure to a region of low pressure. The difference in pressure may be either by natural means or by artificial means using fan. The ventilation in a mine due to the former is referred to as natural ventilation and that due to the latter is called mechanical ventilation. It is important to understand here that, in case of mechanical ventilation, natural ventilation also exists. In some situations, natural ventilation will aid the mechanical ventilation whereas in some case, it may oppose mechanical ventilation.

2.0 PRODUCTION OF NATURAL VENTILATION

For natural ventilation to take place, there must be difference in density between the air of the two shafts. As shown in Fig. 1, there are two shafts from level ground surface of same diameter (D) and same depth (H). There won't be flow of air in the level if the temperature and pressure of air in both the shafts are the same. In this case, the weight of air column in both the shafts are the same.

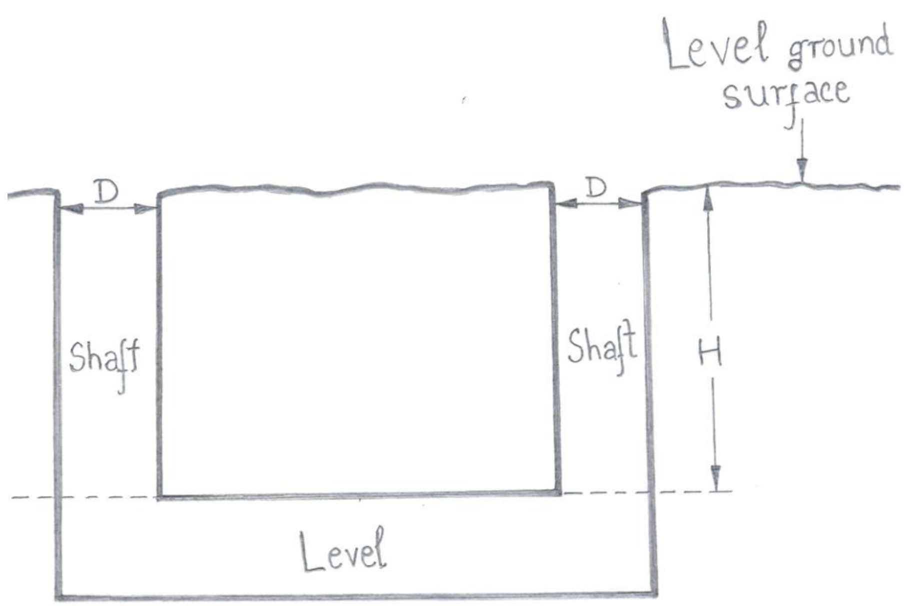

Fig. 1

In Fig. 2, there are two shafts AB and CD the tops of which are at different elevations. During winter season, the shaft AB will act like a downcast shaft due to the imaginary column of outside air starting from A to E. The reason being, A to E is cold air and denser whereas A’ to C is hot air and lighter. This makes AB as the downcast shaft and CD as the upcast shaft.

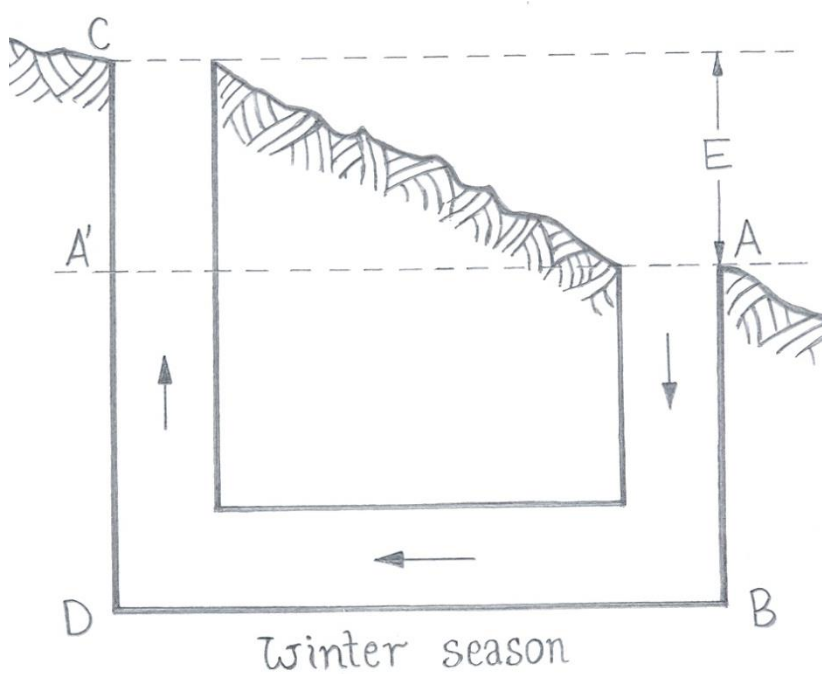

Fig. 2

Now, let us take the case of summer season. During summer, the outside air being warmer than that of the mine, the shaft CD will act as a downcast shaft and AB will be the upcast shaft.

This type of natural ventilation is very effective during extreme summer and winter seasons. However, during other seasons, the natural ventilation is ineffective.

In Fig. 3, a main mechanical ventilator (Exhaust fan) is installed at the shaft top of shaft CD. As it is evident, during winter season, the natural ventilation will aid the mechanical ventilator. The opposing effect will be observed during summer season.

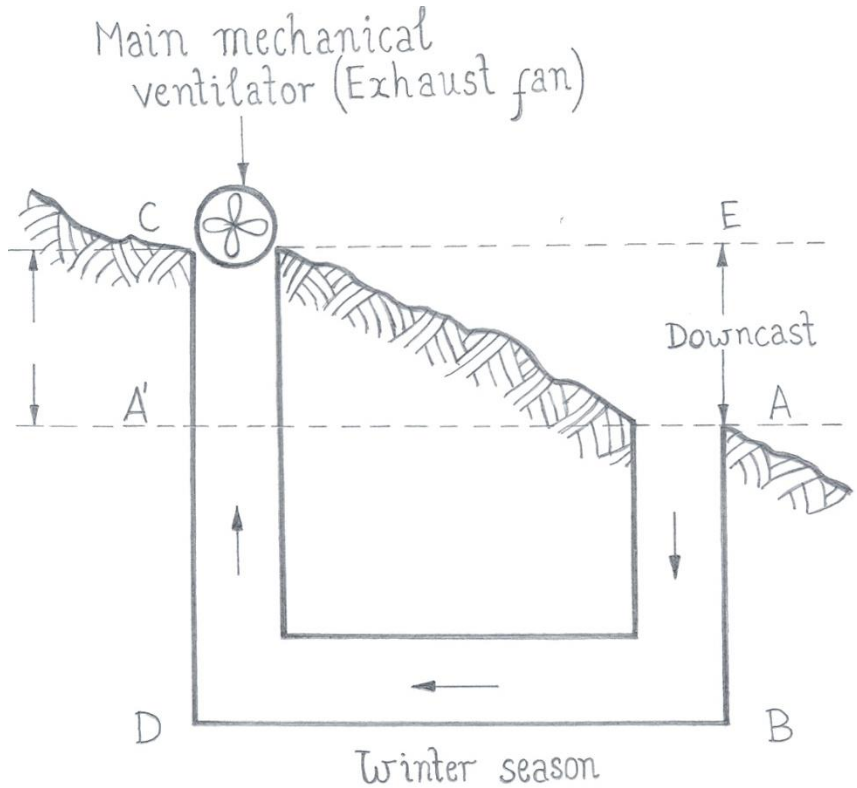

Fig. 3

3.0 DENSITY DIFFERENCE BETWEEN THE AIR OF TWO SHAFTS

The density difference between the air of the two shafts may be created by the following factors:

- Presence of firedamp in one of the shafts which makes the air lighter.
- Steam jet introduced in one of the shafts making the air lighter.
- Introducing furnaces at the bottom of the upcast shaft. The heated air coming out at the bottom of the upcast shaft gets further rarefied by the furnace and is forced upwards. The air in the mines gets heated up due to addition of heat from rocks, men, machinery, lights, spontaneous heating etc.
- Cage movement in the shaft.
- Flow of cold water down one of the shafts, which makes the air cooler and denser.

- Addition of gases like methane and carbon dioxide in the mine air changes the density of the air. While addition of methane reduces the density of return air, addition of carbon dioxide increases the density of the return air and causes the opposite effect to take place.
- In multilevel mine workings, the leakage of denser downcast air to the upcast shaft results in an increase in the density of upcast air, thereby reducing natural ventilation.
- Cool air circulation through the downcast shaft, increases the density of downcast air and thus increasing natural ventilation in the mine.

4.0 DEFINITION OF NATURAL VENTILATING PRESSURE

The pressure difference which is required to cause airflow in a mine by unequal densities of weights of air columns in mine openings and without the aid of any mechanical contrivance is called natural ventilation.

5.0 MOTIVE COLUMN

It is possible to express natural ventilation as meters of air column or motive column, which is the height of an imaginary column of air that produces a pressure equal to the difference of pressure between the bottoms of downcast and upcast shafts.

$$\text{Motive column (h)} = \frac{NVP}{g.\rho_d} \quad \text{(m)}$$

NVP is in Pascal

ρ_d is the density of air in the downcast shaft (kg/m^3)

g is acceleration due to gravity (m/s^2)

6.0 COMPUTATION OF NVP FROM AIR DENSITY

The NVP in a mine is the difference in pressures of air columns in the downcast and upcast shafts.

Therefore, NVP = P_d - P_u

P_d = Pressure of air column in downcast shaft

P_u = pressure of air column in upcast shaft

Let the mean density of downcast air = ρ_d kg/m^3

And mean density of upcast air = ρ_u kg/m^3

Let the depths of both the shafts be equal and let us denote it by 'D' in meters

Then, NVP = $\rho_d Dg - \rho_u Dg$

$= Dg(\rho_d - \rho_u)$ Pa

Now,

$$\rho_d = \frac{(B_d - 0.378e_d)\,10^3}{287.1\,T_d} \text{ kg m}^{-3}$$

$$\rho_u = \frac{(B_u - 0.378e_u)\,10^3}{287.1\,T_u} \text{ kg m}^{-3}$$

Where,

B_d and B_u = Mean barometric readings in KPa in the downcast and upcast shaft respectively

e_d and e_u = Average vapour pressures of moisture in KPa in the downcast and upcast shaft respectively

T_d and T_u = Mean temperatures of the downcast and upcast air columns respectively in Kelvin

Let us assume that $B_d = B_u = B$

Also, let us neglect the effect of moisture

$$\text{Therefore NVP} = Dg\left(\frac{B}{287.1T_d} - \frac{B}{287.1T_u}\right) \times 10^3$$

$$= \frac{gDB}{287.1}\,\frac{T_u - T_d}{T_u T_d} \times 10^3 \text{ Pa}$$

7.0 PRACTICAL METHODS OF DETERMINING NVP

7.1 From Measurement of Pressure and Quantity of Air in the Fan Drift

Let,

Q_f = Quantity of air with fan running

Q_n = Quantity of air with fan stopped

P_f = Fan drift pressure (fan pressure)

P_n = NVP

When the fan running, the mine resistance, R = $\frac{P_f+P_n}{Q_f^2}$

When the fan is stopped, the mine resistance, R = $\frac{P_n}{Q_n^2}$

Therefore, $\frac{P_n}{Q_n^2} = \frac{P_f+P_n}{Q_f^2}$

Solving for P_n we get,

$P_n = P_f \frac{Q_n^2}{Q_f^2 - Q_n^2}$

7.2 From Measurement of Pressure and Quantities in the Fan-Drift at Two Different Speeds of Fan

Let the two different fan speeds be N_1 and N_2.

Let P_{f1} and Q_1 be the fan-drift pressure and fan-drift quantity at speed N_1 of the fan.

Let P_{f2} and Q_2 be the fan-drift pressure and fan-drift quantity at speed N_2 of the fan.

Then Mine resistance,

R = $\frac{P_n+P_{f1}}{Q_1^2} = \frac{P_n+P_{f2}}{Q_2^2}$

$$P_n = \frac{P_{f1} - P_{f2}}{Q_1^2 - Q_2^2}\ Q_1^2\ - P_{f1}$$

Or

$$P_n = \frac{P_{f1} - P_{f2}}{Q_1^2 - Q_2^2}\ Q_2^2\ - P_{f2}$$

7.3 From Measurement of Air Pressure at Pit-Bottom with Fan Running and Fan Stopped

Let,

p_n = Pit bottom pressure with fan stopped

p_f = Pit bottom pressure with fan running

R = Mine resistance

R_s = Shaft resistance

Therefore, $p_n = P_n - R_s Q_n^2$

Now, $P_n = RQ_n^2$

$$Q_n^2 = \frac{P_n}{R}$$

Therefore,

$$p_n = P_n - R_s \frac{P_n}{R} = P_n\left(1 - \frac{R_S}{R}\right) \text{ ----------------------------(1)}$$

In a similar way, p_f can be computed which will give

$$p_f = (P_n + P_f)\left(1 - \frac{R_S}{R}\right) \text{ ----------------------------------(2)}$$

From Equations (1) and (2) above, we get,

$$\frac{p_f}{p_n} = \frac{P_n + P_f}{P_n}$$

$$P_n = P_f\ \frac{p_n}{p_f - p_n}$$

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