ENVIRONMENTAL & SAFETY OF MINES SUBJECT

Airflow through Mine Openings and Ducts

College of Petroleum & Mining Eng.

Mining Engineering Dept.

4th Class

Lecture No.1 – Chapter 5-Part-I

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Overview-**PART-I**

- State of air flow in mine opening
- Effect of State of Flow on Velocity Distribution
- Calculations of Head Losses
- Determination of Airway Friction factor

State of air flow in mine opening

The dimensionless criterion used in establishing boundaries for each state is called the *Reynolds number* N_{Re}. Laminar flow exists up to $N_{Re} = 2000$ and turbulent flow above $N_{Re} = 4000$. These boundaries are only approximate, and the region between is known as the *intermediate range*. The Reynolds number in fluid flow is a function of the fluid properties and can be determined as follows:

$$N_{Re} = \frac{\rho D V}{\mu} = \frac{DV}{\nu} \qquad (5.9)$$

- Or directly use,

$$N_{Re} = 6250DV \qquad (5.10)$$

State of air flow in mine opening

The fluid velocity corresponding to N_{Re} = 4000, the lower boundary of turbulent flow for a conduit of given size, is called the *critical velocity* V_c. If the fluid velocity exceeds V_c, then the state of flow is always turbulent. The critical velocity can be found easily from the last relation above, solving for V_c in fpm (m/s) and setting N_{Re} = 4000:

$$V_c \approx \frac{40}{D} \tag{5.11}$$

Effect of State of Flow on Velocity Distribution, Page 149

- One way that the state of flow affects the dynamic characteristics of a fluid is in the velocity distribution over the cross section of the conduit.
- Different velocity distributions in a circular conduit for the same average velocity of airflow over varying Reynolds numbers are shown in Fig. 5.9.

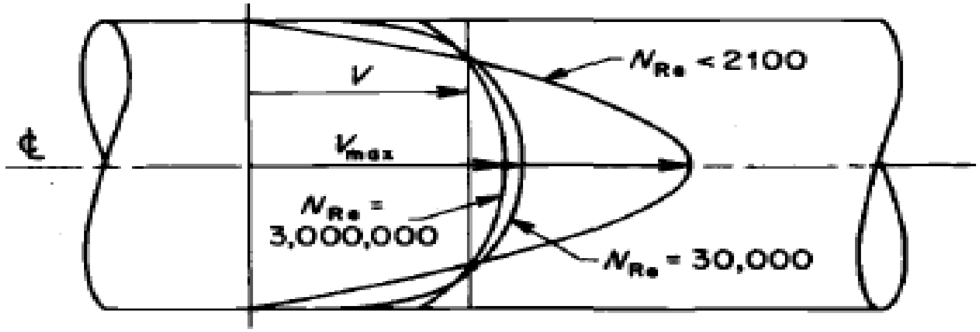

FIGURE 5.9 Velocity distributions in circular conduits, average velocity constant. (After Rouse, 1937. Reprinted from *Trans. Amer. Soc. Civil Engl.*, Vol. 102, p. 163 with permission of the ASCE.)

- The maximum velocity *Vmax* occurs at the center of the conduit, but it varies in magnitude with the Reynolds number. The usual aim in ventilation is the measurement of average velocity V, not maximum velocity

- The variation of *V* with Vmax is determinable as a function of the Reynolds number, however, as shown in Fig. 5.10. This graph enables one to estimate the average velocity when only one measurement along the centerline has been made. Discretion should be exercised in its use in mine ventilation, however, since

- Mine openings are rarely circular and the many irregularities of the walls tend to produce a nonsymmetrical flow pattern. Because the Re. no. in mine ventilation generally exceeds 10,000.
- it is customary to assume for approximate work that in the equation,

$$V \simeq 0.8\ V_{max} \tag{5.12}$$

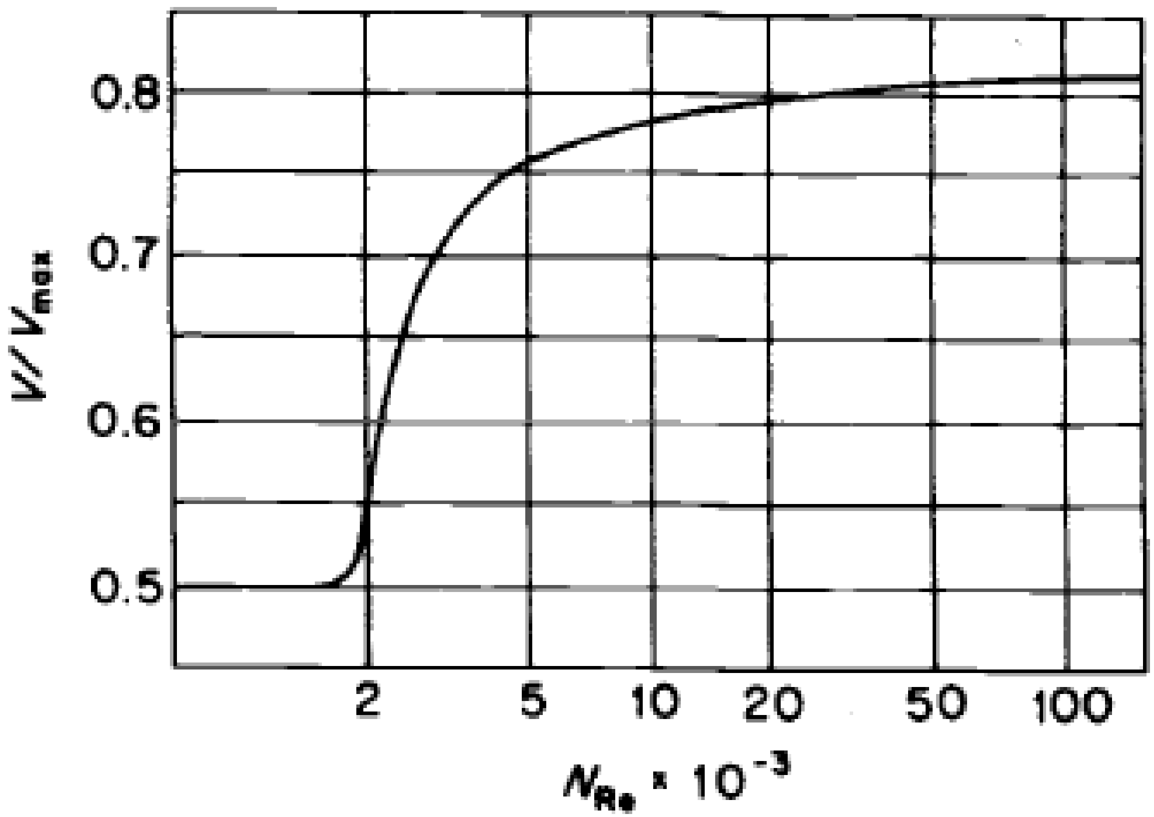

FIGURE 5.10 Relation of velocity ratio V/V_{max} and Reynolds number.

Calculations of Head Losses- Page 151

1. Velocity Head Calculation
2. Friction Loss Calculation

1. Velocity Head Calculation

Use the following eq. to find velocity head

$$H_v = \left(\frac{V}{4009}\right)^2 \qquad (5.14)$$

- These equations may also be used to calculate the velocity when the head is known. To facilitate conversions of velocity and velocity head, the **Nomograph in Appendix Fig. A. 1** may be employed for estimation purposes.

Calculations of Head Losses- Page 152

- **2. Friction Loss Calculations**
- The friction losses in airflow through mine openings constitute 70-90% of the sum of the head losses in a mine ventilation system.
- They are therefore of greater practical importance than shock losses and deserving of more care and precision in calculation.

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Calculations of Head Losses- Page 152

- ***Atkinson Equation for Friction Loss H_f***

$$= \frac{KOLV^2}{5.2A} \qquad (5.18)$$

- H_f: friction loss
- K: empirical friction factor
- O: Perimeter
- L: length of conduit
- V: Velocity
- A: Area

Calculations of Head Losses- Page 153

- ***Atkinson Equation for Friction Loss***
- *This equation used ,If Q is known*

$$H_f = \frac{KOLQ^2}{5.2A^3} \qquad (5.20)$$

- H_f: friction loss
- K: empirical friction factor
- O: Perimeter
- L: length of conduit
- Q: Flowrate
- A: Area

$$K = (800)(10)^{-10} f \qquad (5.21)$$

Calculations of Head Losses- Page 153

- *K* is not a constant but varies directly with air specific weight; values of *K* are commonly expressed in tables at standard air specific weight. From Appendix-B or Below equation.

$$K = (800)(10)^{-10} f \qquad (5.21)$$

- f : friction factor can be found by next slides

Determination of Airway Friction factor- Page 154

- Friction factor K may be obtained from :
- Table 5.1 Page 155 (for non coal mine)
- In order to find K we need,

1. type of airway, (rock type)
2. Air way straight or curved
3. Is there obstruction? Which type?
4. Surface area alignment

Notes:

1. Obtained (K) value has to be multiplied by $10^{\wedge -10}$
2. The same procedure for table 5.2 page 156 but for coal mines

END OF PART-I