**Introduction to Fluid Mechanics**
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**Lecture – 58**
**Pipe Flow-Part-IV**

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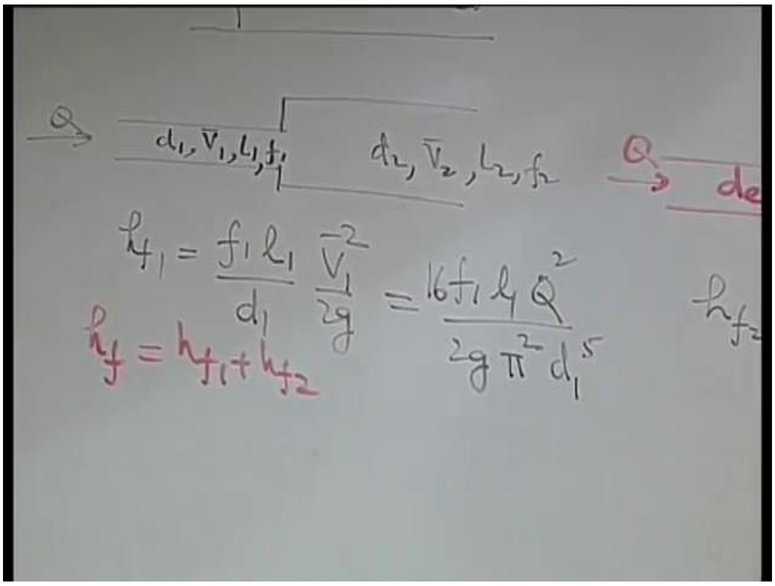


Let us say there are two pipes. The name series is obvious as they are connected one after the other. So, let us say that the diameter of the first pipe $d_1$, the average velocity $V_1$, length $l_1$, friction factor $f_1$ and for the pipe 2 corresponding things are $d_2, \bar{V}_2, L_2, f_2$ .

$$h_{f1} = \frac{f_1 L_1}{d_1}\frac{\bar{V}^2}{2g} = \frac{16 f_1 L_1 Q^2}{2g\pi^2 d_1^5}$$

So, when they are in series the common thing for them is the flow rate. The same flow rate is going through the two pipes.

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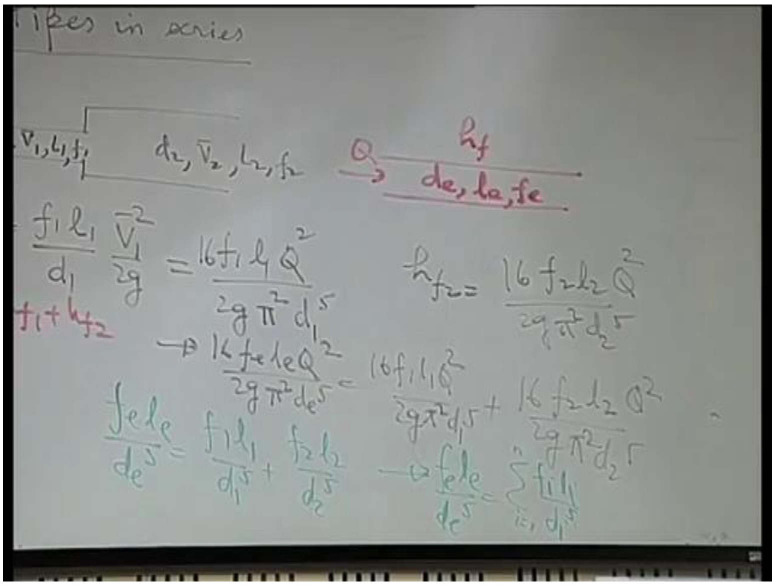

$$h_{f2} = \frac{16 f_2 L_2 Q^2}{2g\pi^2 d_2^{\,5}}$$

$$h_f = h_{f1} + h_{f2} \rightarrow \frac{16 f_e L_e Q^2}{2g\pi^2 d_e^{\,5}} = \frac{16 f_1 L_1 Q^2}{2g\pi^2 d_1^{\,5}} + \frac{16 f_2 L_2 Q^2}{2g\pi^2 d_2^{\,5}}$$

$$\frac{f_e L_e}{d_e^{\,5}} = \frac{f_1 L_1}{d_1^{\,5}} + \frac{f_2 L_2}{d_2^{\,5}}$$

If there are n number of such pipes in series $\rightarrow \frac{f_e L_e}{d_e^{\,5}} = \sum_{i=1}^{n} \frac{f_i L_i}{d_i^{\,5}}$

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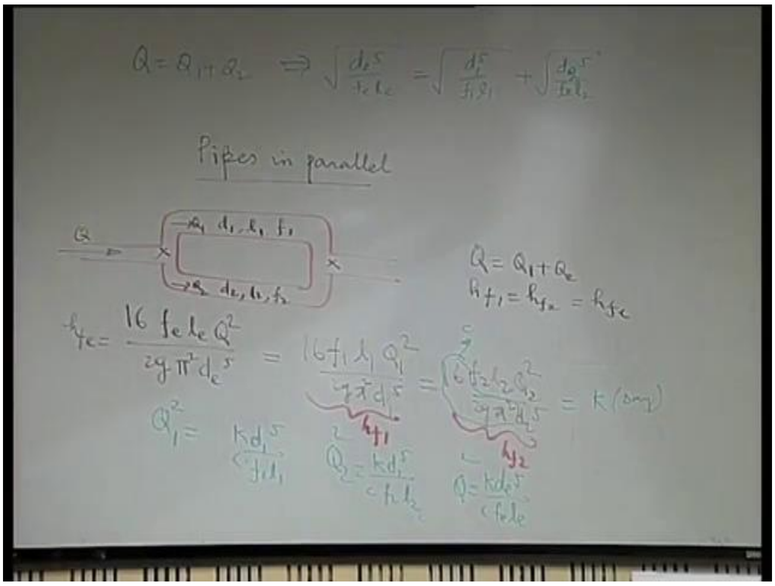


Pipes in Parallel

Let the two pipes have diameter $d_1$, length $l_1$, friction factor $f_1$ and diameter $d_2$, length $l_2$, friction factor $f_2$. Two flow rates are $Q_1$ and $Q_2$.

$$Q = Q_1 + Q_2$$
$$h_{f1} = h_{f2} = h_{fe}$$

$$h_{fe} = \frac{16 f_e l_e Q^2}{2g\pi^2 d_e^{\,5}} = \frac{16 f_1 l_1 Q^2}{2g\pi^2 d_1^{\,5}} = \frac{16 f_2 l_2 Q^2}{2g\pi^2 d_2^{\,5}} = K\left(say\right)$$

$$C = \frac{16}{2g\pi^2 d_1^{\,5}}$$

$$Q_1^{\,2} = \frac{K d_1^{\,5}}{C f_1 l_1}, Q_2^{\,2} = \frac{K d_2^{\,5}}{C f_2 l_2}, Q_e^{\,2} = \frac{K d_e^{\,5}}{C f_e l_e}$$

$$Q = Q_1 + Q_2$$
$$\Rightarrow \sqrt{\frac{d_e^{\,5}}{f_e l_e}} = \sqrt{\frac{d_1^{\,5}}{f_1 l_1}} + \sqrt{\frac{d_2^{\,5}}{f_2 l_2}}$$

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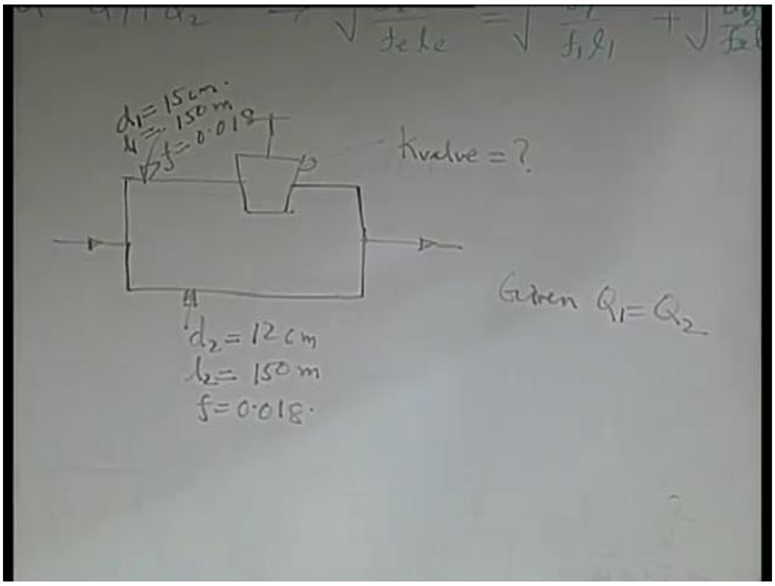


Ex

$d_1 = 15cm, l_1 = 150m, f = 0.018$
$d_2 = 15cm, l_2 = 150m, f = 0.018$

Given $Q_1 = Q_2$

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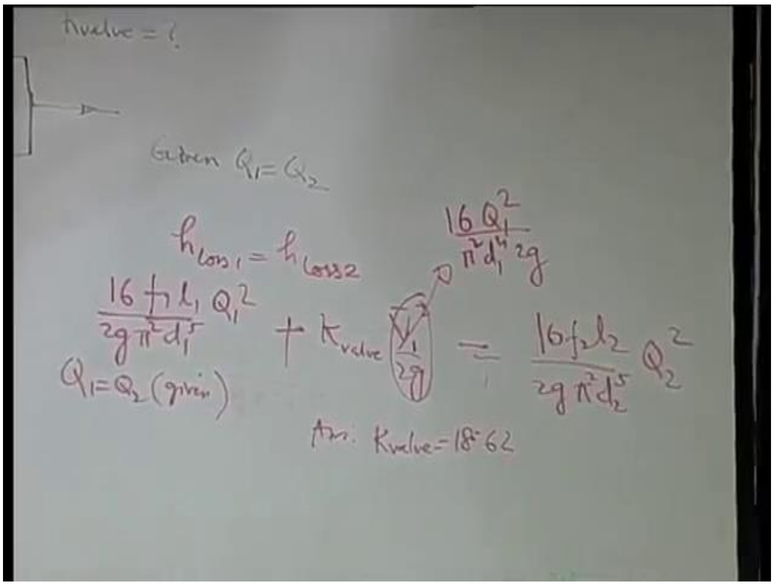


$h_{loss1} = h_{loss2}$

$$\frac{16 f_1 l_1 Q_1^2}{2g\pi^2 d_1^5} + K_{valve}\frac{\bar{V}_1^2}{2g} = \frac{16 f_2 l_2 Q_2^2}{2g\pi^2 d_2^5}$$

$$Ans : K_{valve} = 18.62$$

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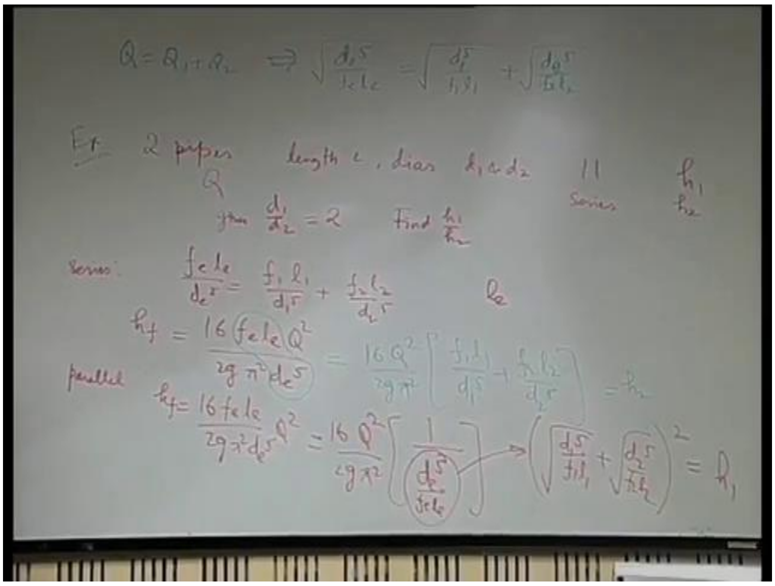


Ex

Length L, Diameters $d_1$ & $d_2$, Loss of head when in parallel is $h_1$ and when in series is $h_2$

$$Given : \frac{d_1}{d_2} = 2$$

$$Find \quad \frac{h_1}{h_2}$$

When they are in series $\frac{f_e l_e}{d_e^5} = \frac{f_1 l_1}{d_1^5} + \frac{f_2 l_2}{d_2^5}$

$$h_f = \frac{16 f_e l_e Q^2}{2g\pi^2 d^5} = \frac{16Q^2}{2g\pi^2}\left[\frac{f_1 l_1}{d_1^5} + \frac{f_2 l_2}{d_2^5}\right] = h_2$$

Parallel: $h_f = \frac{16 f_e l_e Q^2}{2g\pi^2 d_e^5} = \frac{16Q^2}{2g\pi^2}\left[\frac{1}{\frac{d_e^5}{f_e l_e}}\right]$ , $\quad \frac{d_e^5}{f_e l_e} \to \left(\sqrt{\frac{d_1^5}{f_1 l_1}} + \sqrt{\frac{d_2^5}{f_2 l_2}}\right)^2 = h_1$

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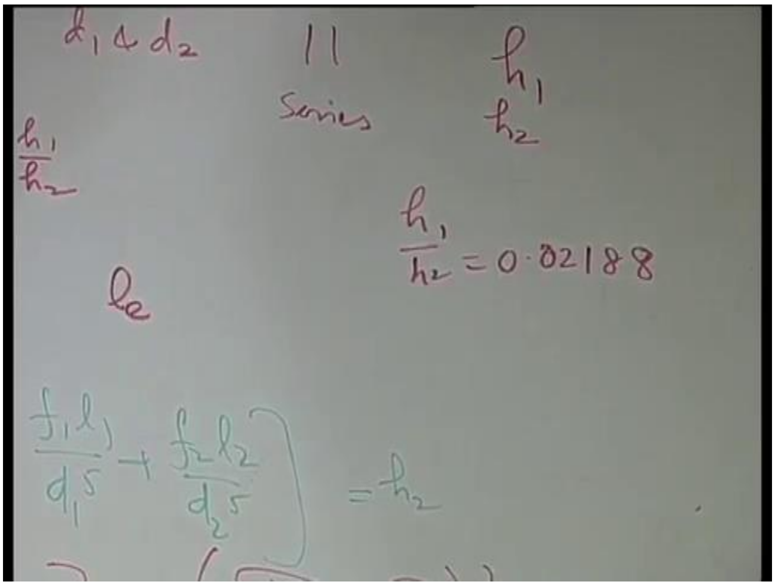


$$\frac{h_1}{h_2} = 0.02188$$

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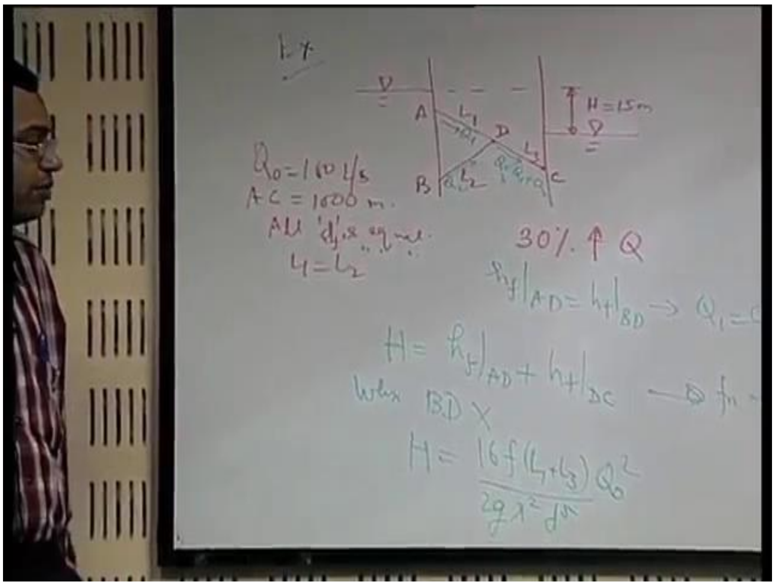


There are pipes AD, BD and DC.

$Q_0$=100L/s,  AC=1000m

All diameters are equal, same length for the two parallel pipes and same friction factor for all pipes. It is given that there is a 30 % enhancement in the flow rate.

Total Q is sum of $Q_1$ and $Q_2$.

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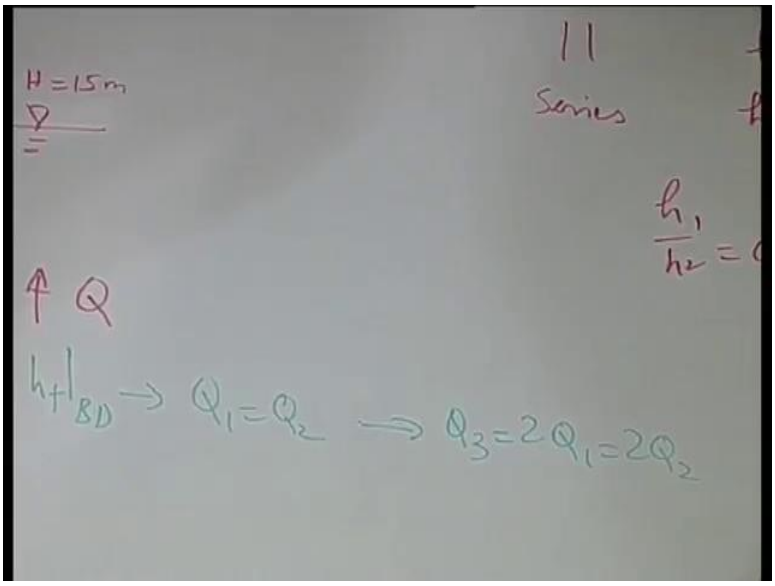


$H = h_f\big|_{AD} + h_f\big|_{DC} \rightarrow func^n.\ of\ \ Q_3$

When BD is not there $H = \dfrac{16f\left(L_1 + L_3\right)}{2g\pi^2 d^5} Q_0^{\ 2}$

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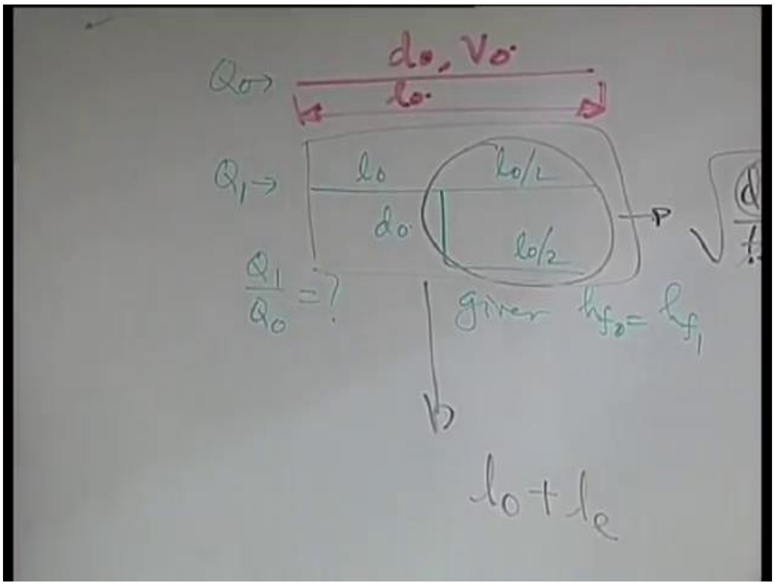


Ex

Let us say that you have two pipes or a pipeline it has a diameter say $d_0$ and the velocity $V_0$. It is having some length say $l_0$. To increase the flow rate a new arrangement is made.

Given $h_{f0} = h_{f1}$ $find$ $\frac{Q_1}{Q_0} = ?$

$$\sqrt{\frac{d_e^{\ 5}}{f_e l_e}} = \sqrt{\frac{d_1^{\ 5}}{f_1 l_1}} + \sqrt{\frac{d_2^{\ 5}}{f_2 l_2}}$$

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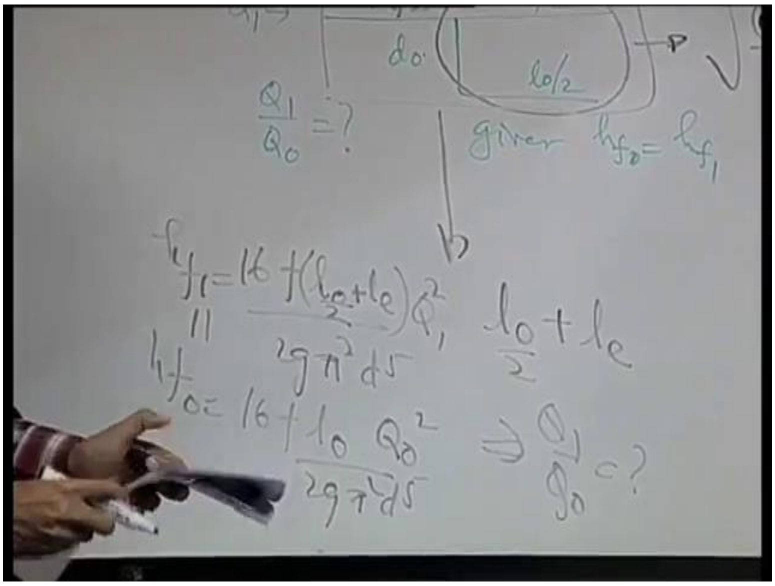

$$h_{f1} = \frac{16 f \left( \frac{l_0}{2} + l_e \right)}{2 g \pi^2 d^5}$$

$$h_{f0} = \frac{16 f l_0 Q_0^{\ 2}}{2 g \pi^2 d^5}$$

$$h_f \Big|_{AF} = h_f \Big|_{BD} \rightarrow Q_1 = Q_2 \rightarrow Q_3 = 2Q_1 = 2Q_2$$