كلية الهندسة
جامعة أسوان

Water Supply Engineering

Code: CONE 323

Lecture: 6

Course Instructor:
Dr. Mohamed Fekry

HEAD LOSESS

The head loss that occurs in pipes is dependent on the flow velocity, pipe length and diameter, and a friction factor based on the roughness of the pipe and the Reynolds number of the flow. The head loss that occurs in the components of a flow path can be correlated to a piping length that would cause an equivalent head loss.

Head loss is a measure of the reduction in the total head (sum of elevation head, velocity head and pressure head) of the fluid as it moves through a fluid system. Head loss is unavoidable real fluids. It is present because of: the friction between the fluid and the walls of the pipe; the friction between adjacent fluid particles as they move relative to one another, and the turbulence caused whenever the flow is redirected or affected redirected or affected in any way by such components as:

piping entrances and exits, pumps, valves, flow reducers, and fittings. Frictional loss is that part of the total head loss that occurs as the fluid flows through straight pipes. The head loss for fluid flow is directly proportional to the length of pipe, the square of accounting for fluid friction called the fluid velocity, and a term accounting for fluid friction called the friction factor. The head loss is inversely proportional to the diameter of the pipe.

$$H_l = H_f + H_n$$

$$H_l = H_f$$

1- Main Head Loss = Frictional

* *DARCY EQUATION*

$$H_f = \frac{FLV^2}{2gd} = \frac{FLQ^2}{2gd\left(\frac{\pi^2 d^4}{16}\right)}$$

$$H_f = \frac{8FLQ^2}{\pi^2 g d^5}$$

Where:-

F : friction factor = 0.013 (if you have no data about the material of pipe)

L : pipe length.

V : velocity of flow.

جدول (٢-٢) معامل دارسى - وايزباخ للاحتكاك لأنواع المواسير المختلفة

نوع المواسير	f
الاسبستوس الأسمنتي	٠,٠١٢- ٠,٠٢٠
البلاستيك (uPVC)	٠,٠٠٨ - ٠,٠١٢
البلاستيك المسلح بألياف الزجاج (GRP)	٠,٠٠٨ - ٠,٠١٢
البولى ايثلين عالى الكثافة (HDPE)	٠,٠٠٨ - ٠,٠١٢
الخرسانة	٠,٠١٢ - ٠,٠٢٠
الحديد الزهر المرن	٠,٠١٢ - ٠,٠٢٠
الحديد الصلب	٠,٠١٢ - ٠,٠٢٠

Example : 1

Calculate the head loss in a 600 mm diameter, 1500 m long, smooth-walled concrete pipeline carrying a water flow of 0.30 $m^3/s.$, *f = 0.017*

Solution:-

$$Q = A * V$$

$$V = \frac{Q}{A} = \frac{0.30}{3.14 * 0.30 * 0.3} = 1.06 m/s$$

$$h_f = 0.017 \frac{1500(1.06)^2}{2 * 0.60 * 9.81} = 2.4 m$$

HAZEN-WILLIAMS EQUATION

The Hazen–Williams equation is an empirical formula which relates the flow of water in a pipe with the physical properties of the pipe and the pressure drop caused by friction. It is used in the design of water pipe systems such as fire sprinkler systems, water supply networks, and irrigation systems. The Hazen–Williams equation has the advantage that the coefficient *C* is not a function of the Reynolds number, but it has the disadvantage that it is only valid for water. Also, it is not able to account for the temperature or viscosity of the water.

$$H_f = \frac{10.69 * L * Q^{1.852}}{C_{H.W}^{1.852} * d_n^{4.87}}$$

C_{HW} : Factor depended upon type of pipe.

Hazen-Williams coefficients are used in the Hazen-Williams equation for friction loss calculation in ducts and pipes. Coefficients for some common materials used in ducts and pipes can be found in the next tables.

The general form of the equation relates the mean velocity of water in a pipe with the geometric properties of the pipe and slope of the energy line.

$$V = 0.355 * C_{H.W} * d^{0.63} * S^{0.54}$$

<u>*where:-*</u>

S : hydraulic slope = $\frac{h_f}{L}$

جدول (٢-١) معامل هازن وليامز للاحتكاك لأنواع المواسير المختلفة

نوع المواسير	C
الاسبستوس الأسمنتي	١٢٠ – ١٤٠
البلاستيك (uPVC)	١٤٠ – ١٥٠
البلاستيك المسلح بألياف الزجاج (GRP)	١٤٠ – ١٥٠
البولي إيثيلين عالى الكثافة (HDPE)	١٤٠ – ١٥٠
الخرسانة	١٢٠ – ١٤٠
الحديد الزهر المرن	١٢٠ – ١٤٠
الحديد الصلب	١٢٠ – ١٤٠

2- Secondary (Minor) Head loss.

In pipe line system there will be a large number of pipe fittings such as bends, elbows, joint, valves and transitions. These fitting case localized energy losses due to their shape and these losses are classified as minor losses.

Equivalent length of minor losses is that length of the pipe which will have the same head losses for the same discharge. Thus if the head losses in the pipe fittings is expressed as:

$$H_n = k_m * \frac{V^2}{2g}$$

<u>Where:-</u>

H_n: head loss.

V: velocity.

k_m: loss coefficient.

* k_m *depended upon kind of valve.*

Table shows values of ( ) k_m

جدول (٢–٥) قيم معامل الفواقد الثانوية

الحالة		K_M
من خزان إلى ماسورة		٠,٥
من ماسورة إلى خزان		١,٠
مسلوب		٠,٠٥ – ٠,١٠
أكواع	١١,٢٥ °	٠,٠٣ – ٠,٠٥
	٢٢,٥ °	٠,٠٥ – ٠,١٠
	٤٥ °	٠,١٠ – ٠,٢٠
	٩٠ °	٠,٢٠ – ٠,٣٠
مشتركات	الاتجاه الرئيسي	٠,٢٠ – ٠,٤٠
	الاتجاه الفرعي	٠,٧٥ – ١,٥٠
محابس	بوابة	٠,١٠ – ٠,٣٠
	فراشة	٠,٢٠ – ٠,٤٠
	عدم رجوع	١,٠٠ – ٣,٠٠

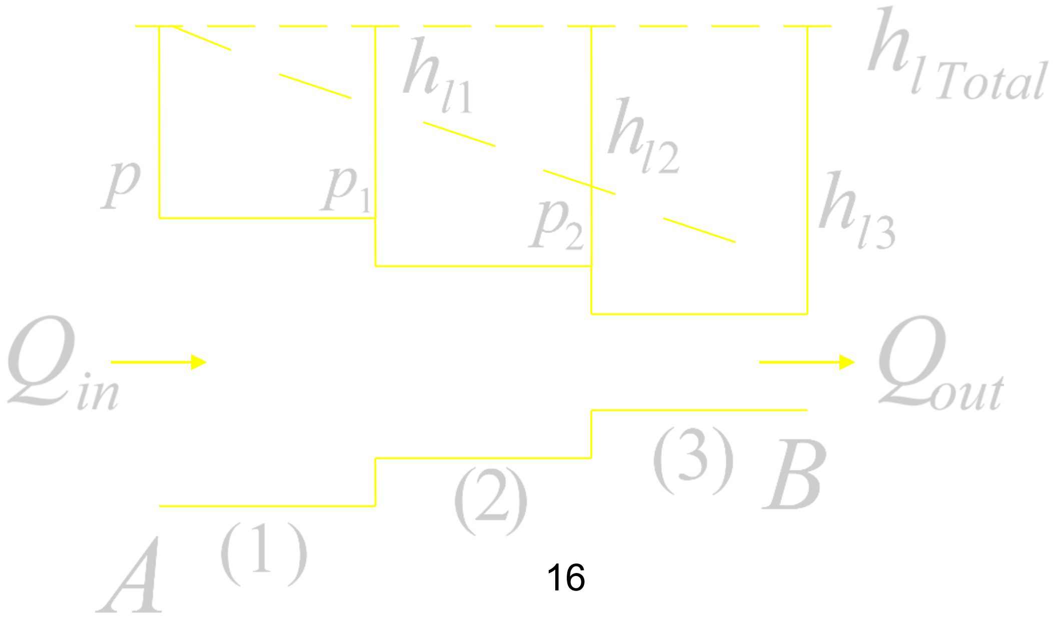
EQUIVALENT PIPE

A pipe with length l_1 , diameter D_1, and friction factor f_1 will be equivalent to another pipe of corresponding parameters l_2, D_2 and f_2 if :

$$\frac{f_1 l_1}{D_1^5} = \frac{f_2 l_2}{D_2^5}$$

there are two type of equivalent pipe:-

1- Flow in pipes in series.
When two or more pipes of different diameters or roughness are so connected that full discharge of the fluid from one flows into the other serially, the system represents a series pipeline, as depicted in figure below



$$Q_{in} = Q_1 = Q_2 = Q_3 \ldots\ldots = Q_n = Q_{out}$$

$$H_L = \sum H_L = H_1 + H_2 + H_3 + \ldots\ldots + H_n$$

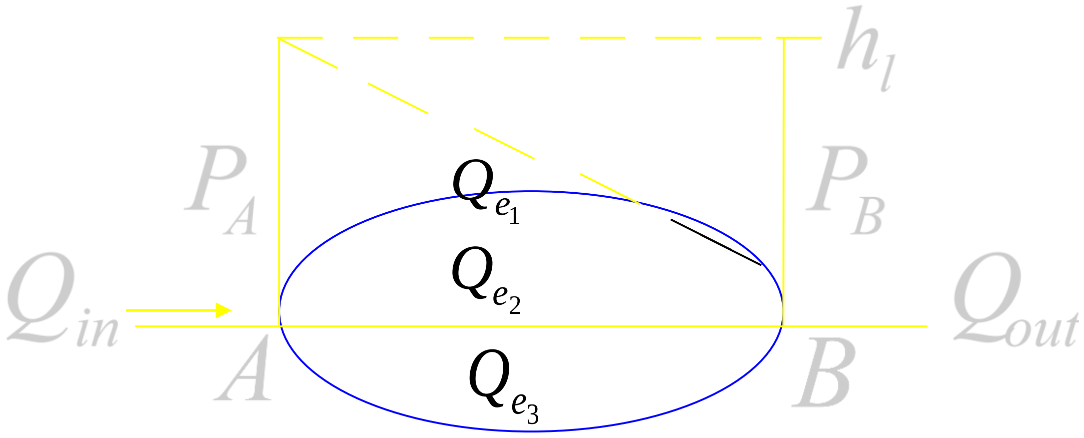
$$H_F = \frac{8FLQ^2}{g\pi^2 d^5}$$

$$\frac{L_e}{d_e^5} = \frac{L_1}{d_1^5} + \frac{L_2}{d_2^5} + \ldots\ldots + \frac{L_n}{d_n^5}$$

$$\frac{L_e}{d_e^{4.87}} = \frac{L_1}{d_1^{4.87}} + \frac{L_2}{d_2^{4.87}} + \ldots\ldots + \frac{L_n}{d_n^{4.87}}$$

2- Flow in pipes in parallel.

A combination of two or more pipes connected between two points so that discharge divided at the first junction and rejoins at the next is known as pipes in parallel, as depicted in figure .



$$Q_{in} = Q_1 + Q_2 + \ldots\ldots + Q_n$$

$$L_{e_i} = \frac{L_i * de^5}{d_i^5} ----(1)$$

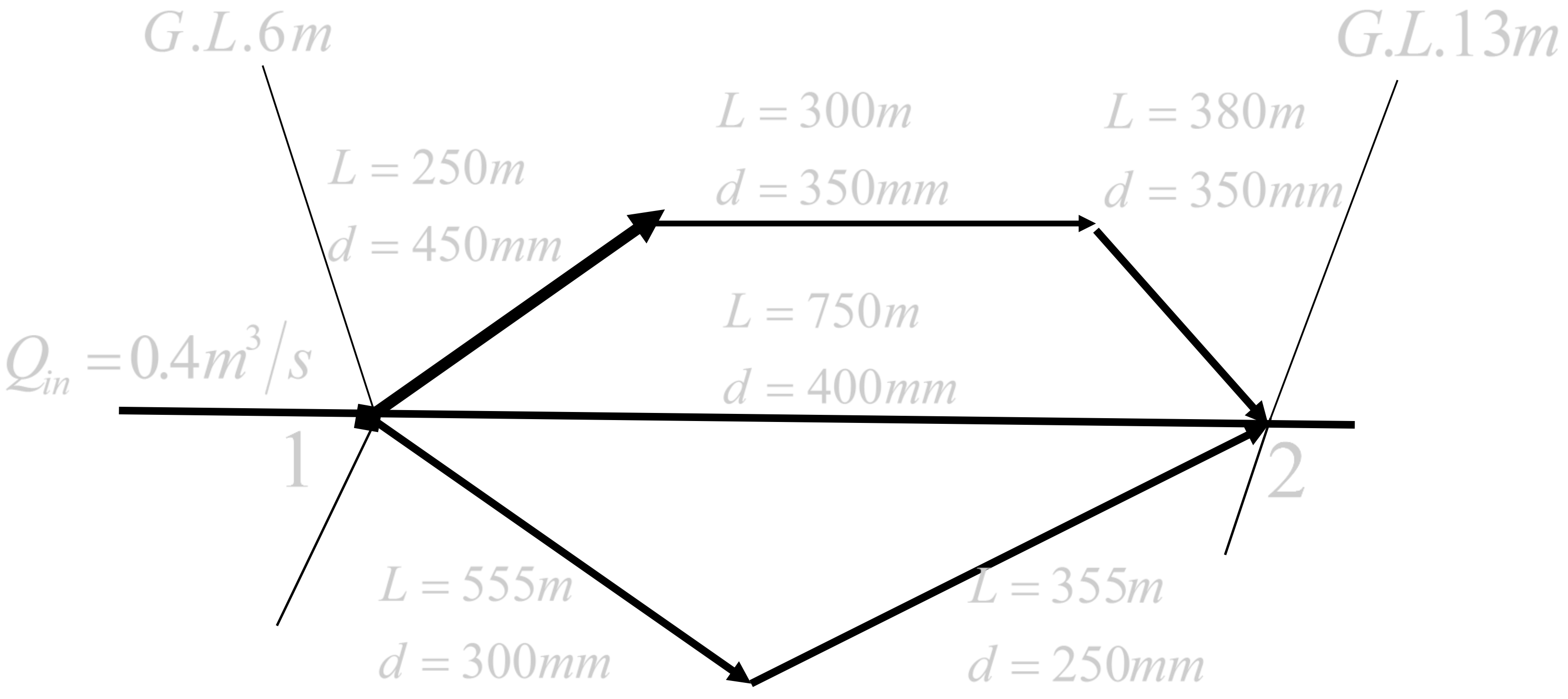
$$L_{e_i} = \frac{L_i * d_e^{4.87}}{d_i^{4.87}} ------(2)$$

$$L_{e_{(i,k)}} = \frac{L_{e_i} * L_{e_k}}{(\sqrt{L_{e_i}} + \sqrt{L_{e_k}})^2}$$

$$L_{E_{(i,k)}} = \frac{L_{e_i} * L_{e_k}}{\left[(L_{e_i})^{0.54} + (L_{e_k})^{0.54}\right]^{1.852}}$$

Example: 2

By using equivalent pipe method fined the equivalent pipe for the loop that shown in the figure, if it is diameter is 350mm. Calculate the difference of head pressure between joint 1, and 2 then find the head pressure at 1 if it is value at 2 is 35m. Calculate too the discharge in all branches, take f = 0.013



$G.L.6m$
$G.L.13m$
$L = 250m$
$d = 450mm$
$L = 300m$
$d = 350mm$
$L = 380m$
$d = 350mm$
$L = 750m$
$d = 400mm$
$Q_{in} = 0.4 m^3/s$
1
2
$L = 555m$
$d = 300mm$
$L = 355m$
$d = 250mm$

$$\frac{L_{e_a}}{d_{e_a}^5} = \frac{L_1}{d_1^5} + \frac{L_2}{d_2^5} + \frac{L_3}{d_3^5}$$

$$\frac{L_{e_a}}{0.35^5} = \frac{250}{0.45^5} + \frac{300}{0.35^5} + \frac{380}{0.35^5}$$

$$L_{e_a} = 751.16m$$

$$\frac{L_{e_b}}{0.35^5} = \frac{300}{0.30^5} + \frac{350}{0.25^5}$$

$$L_{e_b} = 3081.96m$$

$$L_{e_c} = \frac{750}{0.40^5} * (0.35)^5 = 384.68m$$

$$L_{e_{(i,k)}} = \frac{L_{e_i} * L_{e_k}}{(\sqrt{L_{e_i}} + \sqrt{L_{e_k}})^2}$$

$$L_{e_{(i,k)_1}} = \frac{751.16 * 3081.96}{(\sqrt{751.16} + \sqrt{3081.96})^2} = 336.67\,m$$

$$L_{e_{(i,k)_2}} = \frac{336.67 * 384.68}{(\sqrt{336.67} + \sqrt{384.68})^2} = 89.87\,m$$

$$h_l = \frac{8fLQ^2}{g\pi^2 d^5} = \frac{8 * 0.013 * 89.87 * 0.4^2}{9.81 * 3.14^2 * 0.35^5} = 2.941m$$

$$h_l = \frac{8fLQ^2}{g\pi^2 d^5}$$

$$Q = \sqrt{\frac{\pi^2 g d^5 h_l}{8fL}}$$

$$Q_a = 0.138 m^3/\sec$$

$$Q_b = 0.0683 m^3/\sec$$

$$Q_c = 0.193 m^3/\sec$$

$$Q = 0.3993 m^3/\sec = 0.4 m^3/\sec$$