**MIDDLE EAST TECHNICAL UNIVERSITY**

**CIVIL ENGINEERING DEPARTMENT**

**CE 372 - HYDROMECHANICS**

**Experiment I- Head Losses in Pipes**

Year: 3

Section: 4

04/11/2015

**1) Introduction**

The purpose of this experiment is to search the head losses in pipes that have different types of characteristics (such as pipe diameter , roughness height etc.). Also, friction and minor losses can be calculated by datas which we obtained during the experiment for different types of pipes.

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**2) Calculations**

(υ=1\*10^ -6 m2/s , g=9.81m/s2)

**a) For A:**

This is a type-I problem.

hfA =( fA \*L\*V²)/(D\*2\*g) Swamee-Jain formula;

hfA=(8\* fA \*L\*Q²)/(g\*pi²\*D^5) fA =1.325/(In(ε/3.7\*D +5.74/ Re ^0.9))²

Re =V\*D/ υ =4\*Q/pi\*D\* υ = 4\*0.00041/(3.14\*0.02\*1\*10^-6)

Re= 26114.65 (Turbulent)

fA = 1.325/(In(0.0015\*10^-3/(3.7\*0.02) + 5.74/26114.65^0.9))²

fA=0.0244

hfA = 8\*0.0244\*4.59\*0.00041²/9.81\*3.14²\*0.02^5

hfA =0.487 m

The measured value of hfA is 1.115-0.497=0.618 m. So, my calculated result is smaller than the measured value.

**b) For B:**

This is a type-II problem.

1) ε /D=0.0450\*10^-3/0.02=2.25\*10^-3

2) f ͥ =f ͦ

Assume it is completely rough flow and 5.74/Re^0.9 =0

f ͦ = 1.325/(In(ε/3.7\*D))² = 1.325/((In2.25\*10^-3)/3.7))² =0.0242

Full form of Swamee-Jain formula:

f ͥ =1.325/(In(2.25\*10^-3)/3.7+5.74/ Re ^0.9))²

3) V=(2\*g\*hf\*D/f\*L)½ L=9\*0.51=4.59 m

4) Re =V\*D/ υ hf =0.485-0.36=0.125 m

5) f(Re, ε /D) → f ͥ =1.325/(In(2.25\*10^-3)/3.7+5.74/ Re ^0.9))²

6) f calculated = f ͥ

|  |  |  |  |
| --- | --- | --- | --- |
| f assumed | V(m/s) | Re | fcalculated |
| 0,0242 | 0,665 | 13300 | 0,0327 |
| 0,0327 | 0,572 | 11440 | 0,0337 |
| 0,0337 | 0,563 | 11260 | 0,0337 |

I repeat these processes for three times and I stop to iteration because I found correct f value.

V=0.563 m/s

Q=V\*A=0.563\*pi\*0.02²/4=0.00018 m³/s

The measured value of Qis 0.00029 m³/s. So, my calculated result is greater than the measured value.

**c) For C:**

This is a type-III problem.

L=4.59 m

hfc =0.230-0.227=0.003 m Q=0.00012 m³/s

1) Assume f ͦ =0.02

2) Dc = =(8\* fc \*L\*Q²)/(g\*pi²\* hfc) ^5

3) V=4\*Q/pi\*D²

4) Re =V\*D/ υ

5) f(Re, ε /D) → f=1.325/(In(0.0045\*10^-3/(3.7\*0.02)+5.74/ Re ^0.9))²

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| f assumed | D(m) | V(m/s) | Re | fcalculated |
| 0,02 | 0,0325 | 0,145 | 4712,5 | 0,0402 |
| 0,0402 | 0,0374 | 0,109 | 4076,6 | 0,0417 |
| 0,0417 | 0,0377 | 0,108 | 4071,6 | 0,0417 |

I repeat these processes for three times and I stop to iteration. So, D=0.0377 m

The actual value of D is 0.05 m. So, my calculated result is smaller than the actual value.

**d)For D:**

*Q000m³/s*

For expansion (D1-D2);

hL = H2 - H1 =0.578-0.575 =0.003 m

hm =Km\*V²/2\*g (hf ‘s are neglected for pipe D)

hL = hm + hf = hm

V1 = 4\*0.0003/(pi\*0.02²) , V2 = 4\*0.0003/(pi\*0.05²)

V1 = 0.955 m/s, V2 = 0.153 m/s ; V1 >V2

For minor losses, I get the higher velocity at the expansion and contraction points.

hm =0.578-0.575=Km\*((0.955^2)/2\*9.81)

0.003= Km\*(0.04648)

Km= 0.645 m Re= 0.955\*0.02/1\*10^-6=19100

For contraction (D3-D4);

hL = H3 – H4 =0.574-0.502 =0.072 m

hm =Km\*V²/2\*g (hf ‘s are neglected for pipe D)

hL = hm + hf = hm

V4 = 4\*0.0003/(pi\*0.02²) , V3 = 4\*0.0003/(pi\*0.05²)

V4 = 0.955 m/s, V3 = 0.153 m/s ; V4 >V3

For minor losses, I get the higher velocity at the expansion and contraction points.

hm =0.574-0.502=Km\*((0.955^2)/2\*9.81)

0.077= Km\*(0.04648)

Km= 1.5489 m Re= 0.955\*0.02/1\*10^-6=19100

*Q=0.00026 m³/s*

For expansion (D1-D2);

hL = H2 - H1 =0.422-0.420 =0.002 m

hm =Km\*V²/2\*g (hf ‘s are neglected for pipe D)

hL = hm + hf = hm

V1 = 4\*0.00026/(pi\*0.02²) , V2 = 4\*0.00026/(pi\*0.05²)

V1 = 0.828 m/s, V2 = 0.132 m/s ; V1 >V2

For minor losses, I get the higher velocity at the expansion and contraction points.

hm =0.422-0.420=Km\*((0.828^2)/2\*9.81)

0.002= Km\*(0.0349)

Km= 0.0572 m , Re= 0.828\*0.02/1\*10^-6=16560

For contraction (D3-D4);

hL = H3 – H4 =0.421-0.363 =0.058 m

hm =Km\*V²/2\*g (hf ‘s are neglected for pipe D)

hL = hm + hf = hm

V4 = 4\*0.00026/(pi\*0.02²) , V3 = 4\*0.00026/(pi\*0.05²)

V4 = 0.828 m/s, V3 = 0.132 m/s ; V4 >V3

For minor losses, I get the higher velocity at the expansion and contraction points.

hm =0.421-0.363=Km\*((0.828^2)/2\*9.81)

0.058= Km\*(0.0349)

Km= 1.6598 m , Re= 0.828\*0.02/1\*10^-6=16560

*Q=0.00031 m³/s*

For expansion (D1-D2);

hL = H2 - H1 =0.646-0.643 =0.003 m

hm =Km\*V²/2\*g (hf ‘s are neglected for pipe D)

hL = hm + hf = hm

V1 = 4\*0.00031/(pi\*0.02²) , V2 = 4\*0.00031/(pi\*0.05²)

V1 = 0.987 m/s, V2 = 0.158 m/s ; V1 >V2

For minor losses, I get the higher velocity at the expansion and contraction points.

hm =0.646-0.643=Km\*((0.987^2)/2\*9.81)

0.003= Km\*(0.04965)

Km= 0.0604 m , Re= 0.987\*0.02/1\*10^-6=19740

For contraction (D3-D4);

hL = H3 – H4 =0.642-0.565 =0.077 m

hm =Km\*V²/2\*g (hf ‘s are neglected for pipe D)

hL = hm + hf = hm

V4 = 4\*0.00031/(pi\*0.02²) , V3 = 4\*0.00031/(pi\*0.05²)

V4 = 0.987 m/s, V3 = 0.158 m/s ; V4 >V3

For minor losses, I get the higher velocity at the expansion and contraction points.

hm =0.642-0.565=Km\*((0.987^2)/2\*9.81)

0.077= Km\*(0.04965)

Km= 1.5508 m , Re= 0.987\*0.02/1\*10^-6=19740

*Q=0.00029 m³/s*

For expansion (D1-D2);

hL = H2 - H1 =0.540-0.538 =0.002 m

hm =Km\*V²/2\*g (hf ‘s are neglected for pipe D)

hL = hm + hf = hm

V1 = 4\*0.00029/(pi\*0.02²) , V2 = 4\*0.00029/(pi\*0.05²)

V1 = 0.924 m/s, V2 = 0.148 m/s ; V1 >V2

For minor losses, I get the higher velocity at the expansion and contraction points.

hm =0.540-0.538=Km\*((0.924^2)/2\*9.81)

0.003= Km\*(0.04352)

Km= 0.0460 m , Re= 0.924\*0.02/1\*10^-6=18480

For contraction (D3-D4);

hL = H3 – H4 =0.539-0.468 =0.071 m

hm =Km\*V²/2\*g (hf ‘s are neglected for pipe D)

hL = hm + hf = hm

V4 = 4\*0.00029/(pi\*0.02²) , V3 = 4\*0.00029/(pi\*0.05²)

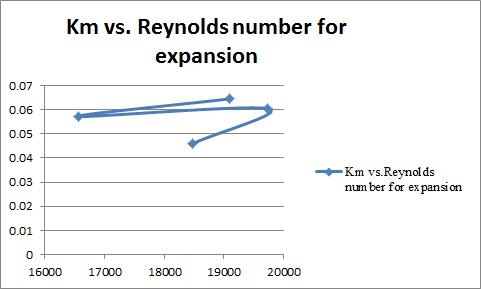
V4 = 0.924 m/s, V3 = 0.148 m/s ; V4 >V3

For minor losses, I get the higher velocity at the expansion and contraction points.

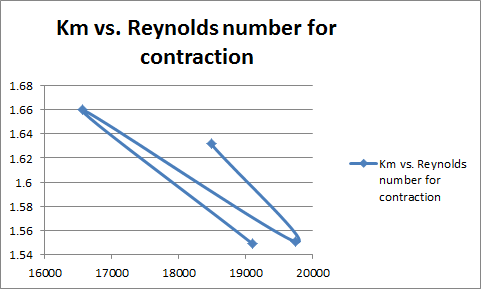
hm =0.539-0.468=Km\*((0.924^2)/2\*9.81)

0.071= Km\*(0.04352)

Km= 1.6316 m , Re= 0.924\*0.02/1\*10^-6=18480



**Graph.1-** Km versus Reynolds number curve for expansion



**Graph.2-** Km versus Reynolds number curve for contraction

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Pipe | Q(m³/s) | hu | hd | hf | E | D | ε /D |
| A | 0,00041 | 1,115 | 0,497 | 0,618 | 1,50E-06 | 0,02 | 7,5\*E-05 |
| B | 0,00029 | 0,485 | 0,360 | 0,125 | 4,50E-05 | 0,02 | 2,25\*E-03 |
| C | 0,00012 | 0,230 | 0,227 | 0,003 | 4,50E-05 | 0,05 | 9\*E-04 |

**Table.1**- Measured/actual values recorded during the experiment for pipes A,B and C

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Pipe | Q(m³/s) | h1 | h2 | h3 | h4 | hf1-2 | hf3-4 | E | D |
| D | 0,0003 | 0,575 | 0,578 | 0,574 | 0,502 | 0,003 | 0,072 | 1,50E-06 | 0,02/0,05 |
|  | 0,00026 | 0,420 | 0,422 | 0,421 | 0,363 | 0,002 | 0,058 | 1,50E-06 | 0,02/0,05 |
|  | 0,00031 | 0,643 | 0,646 | 0,642 | 0,565 | 0,003 | 0,077 | 1,50E-06 | 0,02/0,05 |
|  | 0,00029 | 0,538 | 0,540 | 0,539 | 0,468 | 0,002 | 0,071 | 1,50E-06 | 0,02/0,05 |

**Table.2**- Measured/actual values recorded during the experiment for pipe D

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Pipe | Q(m³/s) | f | D(m) | V(m/s) | Re | hf | ε /D |
| A | 0,00041 | 0,0244 | 0,02 | 1,306 | 26114,65 | 0,487 | 7,5\*E-05 |
| B | 0,00018 | 0,0337 | 0,02 | 0,563 | 11260 | 0,125 | 2,25\*E-03 |
| C | 0,00012 | 0,0417 | 0,0377 | 0,108 | 4071,2 | 0,003 | 3,23E-04 |

**Table.3**- Calculated values for pipes A,B and C

|  |  |  |  |
| --- | --- | --- | --- |
| Pipe | Km exp | Km cont | Re |
| D | 0,0645 | 15,489 | 19100 |
|  | 0,0572 | 16,598 | 16560 |
|  | 0,0604 | 15,508 | 19740 |
|  | 0,046 | 16,316 | 18480 |

**Table.4**- Calculated values for pipe D

**3) Discussion of results**

We find the calculated friction loss for pipe A, the calculated discharge for pipe B, the calculated diameter for pipe c and finally the minor losses and minor loss coefficients at expansion and contraction. When we compared these values with measured/actual values, we can see some differences between all of them. There might be some reasons about this situation. First, our pipes can be mossed or be dirty and this affects our experiment negatively. Secondly, there can be air bubble in pipes and also this causes some errors. Thirdly, we might make mistake when we take datas during experiment (human errors).And lastly, any vibration in pipes doesn’t provide to taking correct datas from system even if it is a fixed system.