MET330 Test 3: Problem 1

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Input Data		
Specific Weight=	9.81	kN/m^3
Kinematic Viscosity=	1.15E-06	m^2/s
Pressure 1=	400	kPa
Z_2=	0.3	m
Pipe length = L_{IIB}=	8.3	m
Pipe length = L_{IIA}=	0.3	m
Pipe length = L_I=	6.5	m
D_{IIB}=	0.0266	m
D_{IIA}=	0.0266	m
D_I=	0.0409	m
Wall Roughness=	4.60E-05	m
K valve=	150	fT
K elbow=	30	fT
K sprinkler=	50	
K contraction=	0.044	fT
Le/D tee 1, 2=	60	20
D_{IIB}/e=	578.26	
D_{IIA}/e=	578.26	
D_I/e=	889.13	
g=	9.81	m/s^2

ITERATION 1

f_{IIB}= 0.01
f_{IIA}= 0.01
f_I= 0.01

Sub-Iteration	Q_I (m3/s)	Q_{IIB} (m3/s)	Q_{IIA} (m3/s)	(NEW) Q_I (m3/s)	%diff Q_I
1	0.010000	0.001937432	0.001963844	0.003901276	-60.99%
2	0.003901	0.002095667	0.002157482	0.004253149	9.02%
3	0.004253	0.002090507	0.002151213	0.004241721	-0.27%
4	0.004242	0.002090682	0.002151426	0.004242108	0.01%
5	0.004242	0.002090676	0.002151419	0.004242095	0.00%

V_{IIB} (m/s)	V_{IIA} (m/s)	V_I (m/s)	Re_{IIB}	Re_{IIA}	Re_I
3.76213	3.87143	3.22882	8.70E+04	8.95E+04	1.15E+05

NEW f_{IIB}	NEW f_{IIA}	NEW f_I	%diff f_{IIB}	%diff f_{IIA}	%diff f_I
0.02485	0.02480	0.02250	-148.48%	-147.95%	-125.01%

ITERATION 2

f_{IIB}= 0.02485
f_{IIA}= 0.02480
f_I= 0.02250

Sub-Iteration	Q_I (m3/s)	Q_{IIB} (m3/s)	Q_{IIA} (m3/s)	(NEW) Q_I (m3/s)	%diff Q_I
1	0.01000	0.001482114	0.001495017	0.002977132	-70.23%
2	0.00298	0.001987742	0.002134621	0.004122363	38.47%
3	0.00412	0.001947973	0.002085545	0.004033518	-2.16%
4	0.00403	0.00195155	0.002089965	0.004041515	0.20%
5	0.00404	0.001951231	0.002089572	0.004040803	-0.02%
6	0.00404	0.00195126	0.002089607	0.004040867	0.00%

V_{IIB} (m/s)	V_{IIA} (m/s)	V_I (m/s)	Re_{IIB}	Re_{IIA}	Re_I
3.51125	3.76020	3.07561	8.12E+04	8.70E+04	1.09E+05

NEW f_{IIB}	NEW f_{IIA}	NEW f_I	%diff f_{IIB}	%diff f_{IIA}	%diff f_I
0.02498	0.02485	0.02259	-0.53%	-0.22%	-0.40%

ITERATION 3

f_{IIB}= 0.02498
f_{IIA}= 0.02485
f_I= 0.02259

Sub-Iteration	Q_I (m3/s)	Q_{IIB} (m3/s)	Q_{IIA} (m3/s)	(NEW) Q_I (m3/s)	%diff Q_I
1	0.01000	0.001478541	0.001491125	0.002969666	-70.30%
2	0.00297	0.001987003	0.002134634	0.004121636	38.79%
3	0.00412	0.001946872	0.002085097	0.004031969	-2.18%

4	0.00403	0.001950498	0.002089578	0.004040076	0.20%
5	0.00404	0.001950173	0.002089177	0.004039351	-0.02%
6	0.00404	0.001950202	0.002089213	0.004039416	0.00%

V_{IIB} (m/s)	V_{IIA} (m/s)	V_I (m/s)	Re_{IIB}	Re_{IIA}	Re_I
3.50935	3.75950	3.07455	8.12E+04	8.70E+04	1.09E+05

NEW f_{IIB}	NEW f_{IIA}	NEW f_I	%diff f_{IIB}	%diff f_{IIA}	%diff f_I
0.02498	0.02485	0.02259	0.00%	0.00%	0.00%

In Upstream Piping:	Q_I = 64.0247 gpm	f_I = 0.02259	V_I = 3.07455 m/s
At 1st Sprinkler Head:	Q_{IIA} = 33.114 gpm	f_{IIA} = 0.02485	V_{IIA} = 3.75950 m/s
At 2nd Sprinkler Head:	Q_{IIB} = 30.9107 gpm	f_{IIB} = 0.02498	V_{IIB} = 3.50935 m/s

Therefore, the volume flow rate delivered to the first sprinkler head is Q_{IIA} = 33.114 gpm and the volume flow rate delivered to the second sprinkler head is Q_{IIB} = 30.9107 gpm. The volume flow rate in the upstream piping is Q_I = 64.0247 gpm.

When looking at the flow rates at each sprinkler, it is worth noting that they are not the equal. To make the flow rates the same, I would recommend either increasing the energy losses in pipe IIA or reducing the energy losses in pipe IIB. Reducing energy losses in pipe IIB could be achieved by increasing the pipe diameter. However; we would have to choose from commercially available pipe sizes so there is a low probablility that we would be able to make the flow rate of IIA and IIB exactly the same using this method. The solution with a better chance of producing the desired result would be to increase energy losses for pipe IIA by adding a mechanical component, such as a valve, that could restrict the flow and adjust energy loss to equal the energy loss in IIB. (See hand calculations for determining K value of proposed valve in branch IIA)

When comparing the fluid velocities for each pipe to critical velocity (3 m/s), all three of the fluid velocities for this system are above critical velocity with pipe I velocity being the closest. To prevent fluid velocities from being higher than critical velocity, I would recommend increasing the pipe sizes. However; it is worth noting that if this is done and the pressure at P1 remains constant at 400kPa, then the flow rates will increase for each piping section due to less frictional energy losses.