Calculating the Volumetric Flow Rate for each of the Channels in Alluminum Plates

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From the principle of continuity, we know that all the volumetric flow rates have to add up to 50 gpm (0.00315450982 $m^3/\sec$)

$\dot{V}_1+\dot{V}_2+\dot{V}_3+\dot{V}_4+\dot{V}_5+\dot{V}_6+\dot{V}_7+\dot{V}_8+\dot{V}_9+\dot{V}_{10}+\dot{V}_{11}+\dot{V}_{12}+\dot{V}_{13}+\dot{V}_{14}+\dot{V}_{15}+\dot{V}_{16} = 0.00315450982$

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Aditionally, all the pressure drops have to be the same (P = delta P).

$P_1 = P_2 ... = P_{16}$

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There is a way to relate volumetric flow rate with pressure drop, after going through several equations.

$\dot{V} = b * A$ (b is for velocity, V for volumetric flow rate)

$A = (3.1416 * d^2)/4$

$R_e = d * b * p/u$

$f = (-1.8(\log(6.9/R_e + ((E/d)/3.7)^{1.11})))^{-2}$

$H_L = f * (b^2/(2g)) * (L_p/d + 60n)$ ---n is the number of miter bends, 6 for plates 2 and 8, and 8 for the others.

$P = H_L * p * g$

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Constants (all values in standard SI units)

$d = 0.01905$

$p = 993.05$

$u = 695 * 10^{-6}$

$E_1 = 0.00005$ For alluminum pipe

$E_2 = 0.00007$ For channels inside the alluminum plates

$g = 9.81$

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l's in small caps are the lenghts of the channels. ~~Big~~ Capital L's are the lenghts of the pipes.

$l_1 = 4.3688$

$l_2 = 4.064$

$l_3 = 4.1402$

$l_4 = 3.8354$

$l_5 = 4.1402$

$l_6 = 3.8354$

$l_7 = 4.1402$

$l_8 = 3.8354$

$l_9 = 4.1402$

$l_{10} = 3.8354$

$l_{11} = 4.1402$

$l_{12} = 3.8354$

$l_{13} = 4.1402$

$l_{14} = 3.8354$

$l_{15} = 4.1402$

$l_{16} = 3.8354$

$L_1 = 9.9568$

$L_2 = 9.9568$

$L_3 = 9.271$

$L_4 = 9.271$

$L_5 = 8.5852$

$L_6 = 8.5852$

$L_7 = 7.8994$

$L_8 = 7.8994$

$L_9 = 7.2136$

$L_{10} = 7.2136$

$L_{11} = 6.5278$

$L_{12} = 6.5278$

$L_{13} = 5.842$

$L_{14} = 5.842$

$L_{15} = 5.1562$

$L_{16} = 5.1562$

$n_1 = 8$

$n_2 = 8$

$n_3 = 6$

$n_4 = 6$

$n_5 = 8$

$n_6 = 8$

$n_7 = 8$

$n_8 = 8$

$n_9 = 8$

$n_{10} = 8$

$n_{11} = 8$

$n_{12} = 8$

$n_{13} = 8$

$n_{14} = 8$

$n_{15} = 6$

$n_{16} = 6$

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Combining equations we get.

$$P = ((\dot{V}/(2.850236 \times 10^{-4}))^2/(2g)) * (((-1.8(\log(6.9/(d * (\dot{V}/(2.850236 \times 10^{-4})) * p/u) + ((E_1/d)/3.7)^{1.11})))^{-2})(L/d) + ((-1.8(\log(6.9/(d * (\dot{V}/(2.850236 \times 10^{-4})) * p/u) + ((E_2/d)/3.7)^{1.11})))^{-2}) * (l/d + 60n)) * p * g = \frac{\left(\frac{V}{(2.850236 \times 10^{-4})}\right)^2}{2g} * \rho g$$

$$\left(\left(\left(-1.8\left(\log\left(\frac{6.9}{d * \frac{V}{(2.850236 \times 10^{-4})} * \frac{P}{u}} + \left(\frac{\frac{E_1}{d}}{3.7}\right)^{1.11}\right)\right)\right)^{-2}\right)\frac{L}{d} + \left(\left(-1.8\left(\log\left(\frac{6.9}{d * \frac{V}{(2.850236 \times 10^{-4})} * \frac{P}{u}} + \left(\frac{\frac{E_2}{d}}{3.7}\right)^{1.}\right.\right.\right.\right.$$

$\cancel{p * g}$

Unfortunately, Maple can not solve for V in this equation. It will have to be solved with Excel.