Useful Correlations for Lockhart Martinelli Method

Lockhart Martinelli’s parameter (X) is used to calculate pressure drop for two phase flow in pipes. The Lockhart Martinelli’s (LM) parameter is calculated as a square root of the ratio of pressure drop when only liquid flows to the pressure drop when only gas (or vapor) flows. This definition was seen earlier. Using LM parameter (X), we can read two corresponding multiplying factors $Y_L$ and $Y_G$ from the given plot as seen earlier. The problem with the plot is that it is a log-log plot and accurate reading is difficult. One would prefer some correlation which can be used in getting $Y_L$ and $Y_G$ from the value of X. The chart contained six plots based on the flow conditions. Three plots were for reading $Y_L$ value and three are for reading $Y_G$ value. The top curves were for the case where liquid and gas were both in turbulent flow (that is Reynolds numbers were higher than 2000). The middle curves were for the case where liquid was turbulent and gas was in laminar flow or vice versa. That is one of the two fluids is in laminar and other in turbulent flow. No distinction is thus made between the case where liquid is in turbulent and gas in laminar flow and the case where liquid is in laminar and the gas is in turbulent flow. In the correlations given below, such a distinction is indeed made. The lower curves were for the case when both liquid and gas were in laminar flow. As we know, the turbulent-turbulent case is the most likely in industrial practices. Useful fitted correlations corresponding to these plots are as given below. These correlations can be considered as least squares fit to the corresponding curves. The correlations are useful to get $Y_L$ and $Y_G$ for any value of X.

Case I: Liquid and Gas both in Laminar flow

$$Y_L = \exp \sum_{i=1}^{6} 2a_i (\ln X)^{i-1}$$

The fitted constants are as follows.

$$a_1 = 0.97995 \quad a_2 = -0.42951 \quad a_3 = 0.09563$$
$$a_4 = -0.00547 \quad a_5 = 0.00142 \quad a_6 = 0.00011$$
\[ Y_G = \left[ \sum_{i=1}^{4} a_i X^{i-1} \right]^2 \]

The fitted constants are as follows:
\[ a_1 = 1.10310 \quad a_2 = 1.49456 \quad a_3 = -0.01132 \quad a_4 = 0.00011 \]

Case II: Liquid in Turbulent and Gas in Laminar flow
\[ Y_L = \exp \sum_{i=1}^{6} 2a_i (\ln X)^{i-1} \]
\[ a_1 = 1.24907 \quad a_2 = -0.44314 \quad a_3 = 0.06680 \quad a_4 = -0.00521 \quad a_5 = -0.00057 \quad a_6 = 0.00012 \]

\[ Y_G = \exp \sum_{i=1}^{6} 2a_i (\ln X)^{i-1} \]
\[ a_1 = 1.24906 \quad a_2 = 0.55672 \quad a_3 = 0.06678 \quad a_4 = -0.00518 \quad a_5 = -0.00057 \quad a_6 = 0.00012 \]

Case III: Liquid in Laminar and Gas in Turbulent flow
\[ Y_L = \exp \sum_{i=1}^{6} 2a_i (\ln X)^{i-1} \]
\[ a_1 = 1.23807 \quad a_2 = -0.46844 \quad a_3 = 0.07189 \quad a_4 = -0.00444 \quad a_5 = -0.00070 \quad a_6 = 0.00012 \]

\[ Y_G = \exp \sum_{i=1}^{6} 2a_i (\ln X)^{i-1} \]
\[ a_1 = 1.23850 \quad a_2 = 0.53139 \quad a_3 = 0.07181 \quad a_4 = -0.00442 \quad a_5 = -0.00069 \quad a_6 = 0.00012 \]
Case IV : Liquid and Gas both in Turbulent flow

\[ Y_L = \exp \sum_{i=1}^{7} 2a_i (\ln X)^{i-1} \]

\[ a_1 = 1.44065 \quad a_2 = -0.50445 \quad a_3 = 0.06212 \]

\[ a_4 = -0.00106 \quad a_5 = -0.00101 \quad a_6 = 0.00003 \quad a_7 = 0.00002 \]

\[ Y_G = \exp \sum_{i=1}^{7} 2a_i (\ln X)^{i-1} \]

\[ a_1 = 1.44105 \quad a_2 = 0.49541 \quad a_3 = 0.06153 \]

\[ a_4 = -0.00113 \quad a_5 = -0.00095 \quad a_6 = 0.00003 \quad a_7 = 0.00002 \]

Let us take an example in which LM parameter is 2 and liquid and gas both are in turbulent flow. From the curve, value of \( Y_L \) and \( Y_G \) are around 10 and 40 respectively. Now let us calculate them using these correlations. Case IV suits for the case where both the fluids are in turbulent flow. Using the fitted correlation and the given values of constants \( (a_i) \), we get values of \( Y_L \) and \( Y_G \) as 9.39 and 37.59 respectively. This can be considered to be equivalent to the plot reading, because reading a log-log plot itself has some error.

Let us take another example in which liquid is in laminar flow and gas is in turbulent flow. LM parameter (X) is 10. Lockhart Martinelli’s plot shows the value of \( Y_L \) and \( Y_G \) as 2.8 and 260 respectively. Case III is applicable in this flow condition. Using the given correlations, we get values of \( Y_L \) and \( Y_G \) as 2.58 and 258.37 respectively. These match reasonably with the visual reading from the plots.