Annular Flow Instability

As a second example consider vertical annular flow that becomes unstable when the Bernoulli force overcomes the stabilizing surface tension force. From equation (Njo1), this implies that disturbances with wavelengths greater than a critical value, λ_c, will be unstable and that

$$\lambda_c = 2\pi S(\rho_1 + \rho_2)/\rho_1\rho_2(\Delta u)^2 \tag{Njq1}$$

For a liquid stream and a gas stream (as is normally the case in annular flow) and with $\rho_L \ll \rho_G$ this becomes

$$\lambda_c = 2\pi S/\rho_G(\Delta u)^2 \tag{Njq2}$$

Now consider the application of this criterion to the flow regime maps for vertical pipe flow included in figure 1, section (Njd), and figure 3, section (Njd). We examine the stability of a well-developed annular flow at high gas volume fraction where $\Delta u \approx j_G$. Then for a water/air mixture equation (Njq2) predicts critical wavelengths of $0.4cm$ and $40cm$ for $j_G = 10m/s$ and $j_G = 1m/s$ respectively. In other words, at low values of j_G only larger wavelengths are unstable and this seems to be in accord with the break-up of the flow into large slugs. On the other hand at higher j_G flow rates, even quite small wavelengths are unstable and the liquid gets torn apart into the small droplets carried in the core gas flow.