As shown in fig. 9 (b). it is shown that the combination of Wallis and the liquid property does not fully correlate the data. The data scatter widely, especially for an extremely change of inner diameter as shown in Ousaka et al and Pantzali et al data. A new parameter is needed to be found to provide a general flooding correlation.

4. Conclusion

The onset of flooding in nearly horizontal pipe was investigated experimentally. The tube diameter and tube length were 50 mm an 1.1 m, respectively. The experiments were carried out using water, two different concentrations of butanol aqua solution and glycerin aqua solution as test liquids. The results are summarized as follows :

1. The flooding is characterized by the inversely proportional relation of the flooding velocities i.e. the flooding gas velocities decrease with an increase in the liquid flow rate.
2. The effect of inclination angle is significantly observed to affect the flooding phenomena. A decrease of the flooding velocities is observed with the decrease of inclination angle.
3. The liquid viscosity influence in the flooding phenomena is relatively stronger than the surface tension effect. It is proven by the plotted data above.
4. The viscous dumping effect is found as the minor effect of the liquid viscosity. This effect become stronger in a little change of the liquid viscosity, but the destabilizing effect of liquid viscosity is to be dominant in the decrease of inclination angle.

Reference

Barnea, D., Ben Yoseph, N., Taitel, Y., 1986. Flooding in inclined pipe: effect of entrance section. Can. J. Chem. Eng. 64 (2),177–184.

Tien, C.L., Liu, C.P., 1979. Survey on vertical two phase counter-current flooding. EPRINP-984(1979)

Chung, K. S., Liu, C. P. & Tien, C. L. 1980 Flooding in two-phase countercurrent flows--II: Experimental investigation. *PhysicoChem. Hydrodynam.* 1, 209-220.

Clift, R., Pritchard, C. & Nedderman, R. M. 1966 The effect of viscosity on the flooding conditions in wetted wall columns. Chemical engineering Science 21, 87-95.

Wallis, G. B. 1969 One-dimensional Two-phase Flow, Chap. 11. pp. 336-345. McGraw Hill, NewYork.

Hewitt, G. F. 1977 Influence of end conditions, tube inclination and physical properties on flooding in gas liquid flows. Harwell Report No. HTFS-RS 222 (1977).

Kamei, S., Onishi, J. & Okane, T. 1954 Flooding in a wetted wall tower. *Chem. Eng. (Jap.)* 18, 364-368.

Suzuki, S. & Ueda, T. 1977 Behaviour of liquid films and flooding in counter-current two-phase flow--part 1. Flow in circular tubes. *Int. J. Multiphase Flow* 3, 517-532.

Nariai, T., Tomiyama, A., Vallée, C., Lucas, D., Kinoshita, I., Murase, M., 2010. Counter-current flow limitation in a scaled-down model of a PWR hot leg, in proceeding of International Topical Meeting on Nuclear Thermal-Hydraulics, Operation and Safety (NUTHOS-8) N8P0109 Shanghai, China, pp. 1-12, October 10-14, 2010.

Mouza, A.A., Paras, S.V., Karabelas, A.J., 2003. Incipient flooding in inclined tubes of small diameter, International Journal of Multiphase Flow 29 (2003) 1395–1412.

Pantzali, M.A., Mouza, A.A., Paras, S.V., 2007. Study of hydrodynamic characteristics of the liquid layer during counter-current flow in inclined small diameter tubes: the effect of liquid properties, in proceeding of 6th International Conference on Multiphase Flow, ICMF 2007, Leipzig, Germany, July 9–13, 2007

Geweke, Beckmann, H., Mewes, D., 1991 Experimental studies of countercurrent flow in inclined tubes, in proceeding of European Two Phase Flow Group Meeting, Rome, Italy 27-29 May 1991, Paper B1 pp (1991)

Ousaka, A., Deendarlianto, Kariyasaki, A., Fukano, T. 2005. Prediction of flooding gas velocity in gas–liquid counter-current two-phase flow in inclined pipes. Nuclear Engineering and Design, Volume 236, Issue 12, June 2006, Pages 1282-1292

Zapke, A., Kröger, D. G., 1996.The Influence on fluid properties and inlet geometry on flooding in vertical and inclined tubes. Int. J. Multiphase Flow Vol. 22, No. 3, pp. 461-472.

Acknowledgments

The author would like to thanks to Mr. Deendarlianto for the knowledge, assistance and patience in the performance of the experiment and the Helmholtz Zentrum Dresden Rossendorf Topflow Facility crews for their contribution in this experiment. This work is also partly supported by Alexander Van Humboldt Foundation in Germany.