Int. J. Multiphase Flow, Vol. 5, pp. 225-228
Pergamon/Elsevier, 1979. Printed in Great Britain

BRIEF COMMUNICATION

THE THEORY OF THE GAS-LIFT PUMP: A REJOINDER

S. A. K. JEELANI, K. V. KASIPATI RAO and G. R. BALASUBRAMANIAN
Reactor Research Centre, Kalpakkam 603102, India

(*Received* 6 *December* 1978; *in revised form* 22 *February* 1979)

1. INTRODUCTION

Air or gas lift pumps are widely used in radiochemical, chemical and petroleum industries. Design data are available (De Witte 1961, Govier 1957, Hussain 1976), for these pumps of riser diameters of the order of 8 mm and above. The present investigations show that the design data of higher diameter airlifts cannot be used for lower diameter air lifts of the order 8 mm and less. Low liquid capacity air lifts are being used for metering liquids in radiochemical pilot plants (Balasubramanian 1978). The present work tests the validity of the theoretical model proposed by Hussain (Hussain 1976) for smaller diameter air lifts.

2. RESULTS AND DISCUSSION

Hussain predicted the liquid mass flow rate to be:

$$W_l = \frac{K_2 A^{2.75} h^{0.25} \rho_{g0}^{1.5}}{W_g^{1.5}(e^x - 1)}$$

where $x = K_1 A \cdot \rho_{g0}/\rho_l R_s W_g$. A = cross-sectional area of the air lift (cm^2); h = height of the air lift (cm); $R_s = h_s/h$, submergence ratio; h_s = level of liquid above the level of air entry nozzle (cm); W_g = mass rate of flow of air (g/hr); W_l = mass rate of flow of liquid (g/hr); ρ_{g0} = density of air at the entry point (g/cm^3); ρ_l = density of liquid (g/cm^3); K_1 = constant (g/(hr)(cm^2)); K_2 = constant ((g/hr cm^2) (cm/hr^2)$^{0.75}$).

Experimental data on smaller diameter air lifts (table 1) have been fitted to the above model. Figure 1 compares the liquid output with the predictions, indicating that the data fit the model reasonably well at air flows greater than 20 g/hr. The liquid capacity curves for air lifts of riser diameters less than 3.5 mm are of similar pattern as for riser diameters greater than 8 mm. The maximum water capacity is sharp for smaller diameter risers, whereas it flattens for larger diameter risers. The constants K_1 and K_2 are listed for each submergence (table 2).

Table 1. Air lift configurations used

Air lift type	Riser diameter mm	Air nozzle diameter mm	Angle of nozzle (facing upwards) with riser	Height of riser cm
1	3.5	3.5	115°	126.5
2	3.5	3.5	117.5°	129.8
3	3.5	1.0	117.5°	129.8
4	2.5	2.5	107.5°	121.5
5	2.0	2.0	111°	124.0
6	3.5	1.5	90°	129.8

Table 2. K_1 and K_2 values for various air-lift configurations

Airlift type	R_s	K_1	K_2
5	0.8	3.049×10^5	3.3200×10^{13}
	0.7	2.928×10^5	2.9730×10^{13}
	0.6	3.339×10^5	4.0480×10^{13}
1	0.9	1.989×10^5	1.2175×10^{13}
	0.7	1.758×10^5	1.2175×10^{13}
	0.62	1.392×10^5	0.9392×10^{13}
	0.5	1.468×10^5	1.0910×10^{13}
6	0.9	1.985×10^5	1.6286×10^{13}
	0.7	1.604×10^5	1.2839×10^{13}
	0.62	1.277×10^5	0.9928×10^{13}
4	0.6	1.840×10^5	1.7551×10^{13}
	0.5	1.947×10^5	2.3053×10^{13}
	0.4	1.517×10^5	1.6760×10^{13}

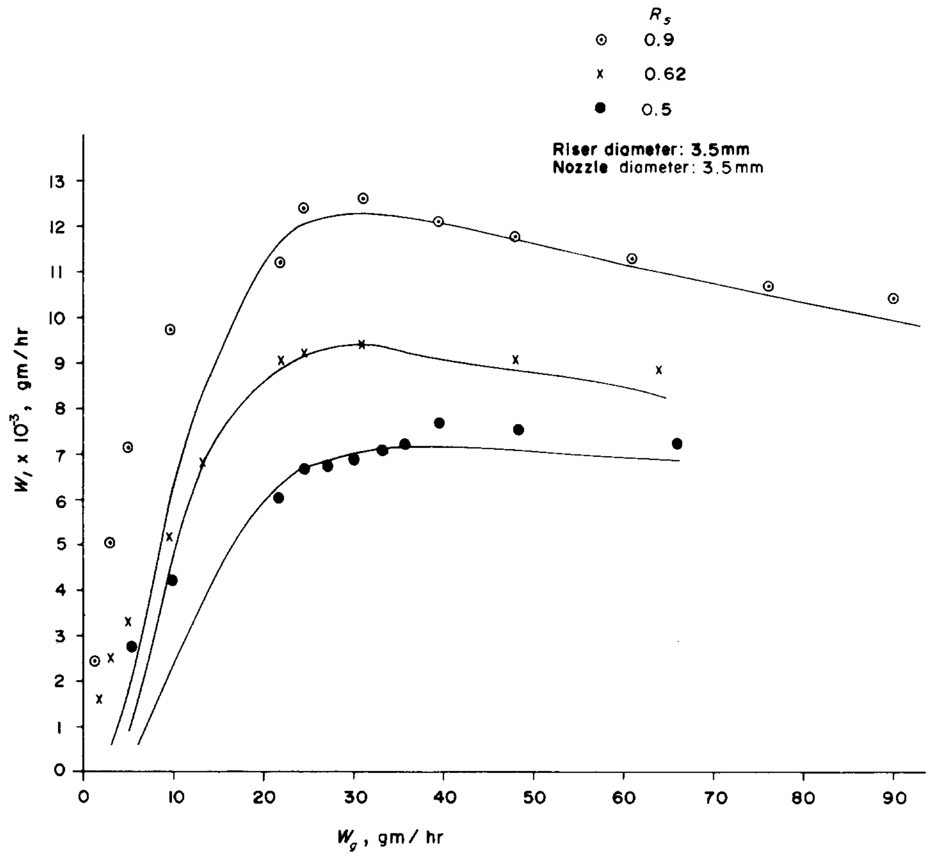

Figure 1. Comparison of 3.5 mm diameter air lift data (points) with Hussain's model (solid line).

K_1 and K_2 are said to be constant by Hussain independent of riser geometry and submergence. The variation in K_1, even for 26 mm diameter air lifts was attributed by Hussain to the difficulty in locating the maximum liquid output at low submergences. It is apparent that K_1 and K_2 vary with submergence and riser diameter for smaller riser diameter as shown in

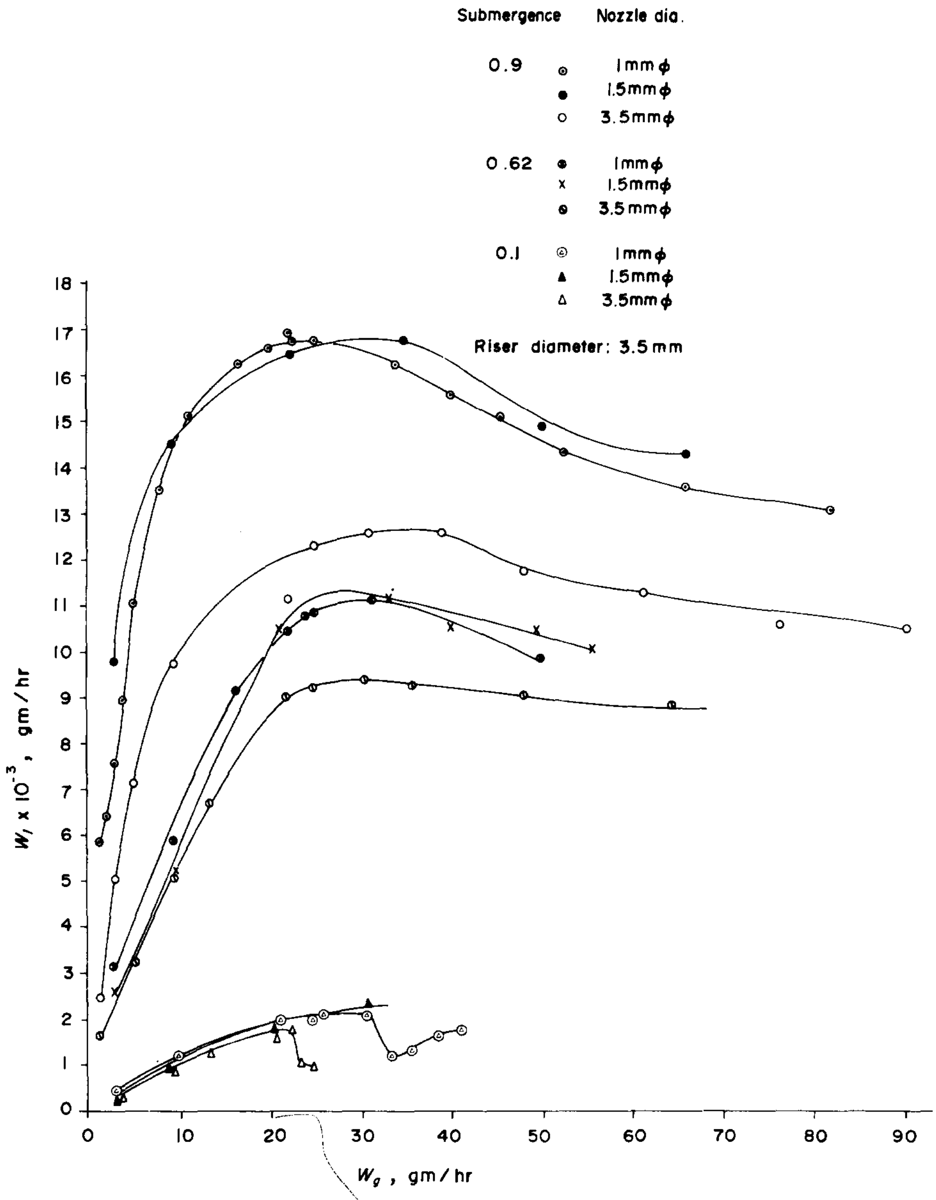

Figure 2. Effect of air entry nozzle diameter on the liquid capacity.

table 2. The discrepancy could be due to the fact that Hussain's model is valid for viscid liquids whereas for air lift diameters less than 3.5 mm, interfacial and viscous effects will be considerable. There is a marked effect of the air entry nozzle diameter on the liquid capacity for 3.5 mm diameter air lifts (figure 2) unlike the air lifts of riser diameters greater than 8 mm wherein the air entry nozzle diameter has no effect. The angle of the nozzle with the riser has no pronounced effect on the liquid capacity for air lift riser diameters less than 3.5 mm. When the riser height is doubled for air lift type No. 6 (table 1), the maximum increase in liquid capacity is found to be about 20%.

The order of W_l/W_g is found to be high for riser diameters less than 3.5 mm compared to 26 mm diameter air lifts at a given submergence. This is expected since the slip is less for smaller diameter risers than for larger diameter risers. However, W_l/W_g decreases with air flow rate in both the cases.

W_l/W_g is seen to be less sensitive to submergence in the case of smaller diameter risers (less than 3.5 mm), which resulted in the decrease of the isothermal efficiency even with increase in submergence. But the isothermal efficiency of 26 mm diameter air lifts was reported by Hussain to increase with submergence to an optimum value. This is because W_l/W_g is more sensitive to submergence for 26 mm diameter risers.

3. CONCLUSIONS

Hussain's model is valid for low diameter air lifts (less than 3.5 mm) only at high air flows to a limited extent in the sense that the constants K_1 and K_2 vary with submergence and riser diameter. The low slip and hence the high efficiency of smaller diameter air lifts make them useful in special applications.

Acknowledgements—The authors wish to thank Mr. R. Sudarshanam and Mr. R. Sivasubramanian for their assistance in conducting the experiments.

REFERENCES

Balasubramanian, G. R., Kasipati Rao, K. V. & Jeelani, S. A. K. 1978 Development of air-lift pump for low flow metering. Symp. on Transport Phenomena, Varanasi, India.

De Witte, R. 1961 Automatically-controlled Air-lift Dosimeter pumps. ETR Rep. 126.

Goviar, G. W., Radford, B. A. & Dunn J. S. G. 1957 Upward vertical flow of air-water mixtures. *Can. J. Chem. Engng* **35**, 58–70.

Hussain, L. A. & Spedding, P. L. 1976 The theory of the gas-lift pump. *Int. J. Multiphase Flow* **3**, 83–87.