Experimental study of 7^0 Divergen Angle of Diffuser on Liquid Jet Gas Ejector

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Abstract

Aim of this research is founded the effect of gas-liquid ratio on diffuser performance. Diffuser attached on end of throat of ejectors. Ejector employed water as a motive fluid and air as the entrained fluid. downward flow is direction of flow in the ejector . Ejector generated bubble flow from entrainment and mixing process in the throat section. Performance of diffuser was measured from pressure recovery value. Pressure recovery is differential pressure of upstream and down stream of diffuser divide by kinetic energy on the upstream diffuser. The result of the experimental is increasing of void fraction up to value 0.2, its became pressure recovery increase. Value of void fraction above 0.2, its became pressure recovery decrease.

Keywords: ejector, diffuser, pressure recovery, co-current flow, downward flow, two-phase flow

1. Introduction

Ejectors are co-current flow systems, where simultaneous aspiration and dispersion of the entrained fluid takes place (Brahim et.al, 1984). This causes continuous formation of fresh interface and generation of large interfacial area because of the entrained fluid between the phases. The ejector essentially consists of an assembly comprising of nozzle, converging section, mixing tube/throat and diffuser (Figure 1). According to the Bernoulli's principle, when a motive fluid is pumped through the nozzle, its created high velocity, a low pressure region is created just outside the nozzle. A suction fluid gets entrained into the ejector through this low pressure region (Kandakure, et.al.,2005). The dispersion of the entrained fluid in the throat of the ejector with the motive fluid jet emerging from the nozzle leads to intimate mixing of the two phases. The gas and liquid phases get mixed due to the shear forces between the phases and a fine dispersion of bubbles/drops is created in the throat. The diffuser at the exit of the ejector throat helps in the efficient recovery of pressure.

Neve.et.al.(1991) reported the experiment the diffuser fitted to the downstream end of the jet pump's mixing tube. It has a major influence on the operating efficiency, accounting for at least half the static pressure recovery in a typical device operating against useful back pressures and thus contributing at least half of the efficiency figure.

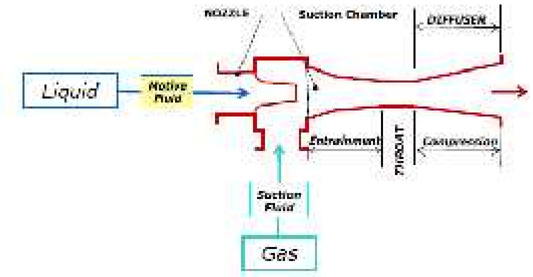

Figure 1. liquid jet gas ejector

Conversion kinetic pressure to static pressure is never achieved without loss of total (stagnation) pressure and the most realistic way of defining efficiency involves that loss. Unfortunately, such an estimation would require an extensive velocity and pressure traverse at the inlet and outlet and this has resulted in diffuser performance normally being assessed in terms of a pressure recovery coefficient *Cp*. This is a measure of the wall static pressure recovery, normalized by division by the inlet dynamic pressure.

$$C_p = \frac{\Delta p}{0{,}5\,{\circ}_m V^2} \qquad (1)$$

$${\circ}_m = {\circ}_g \pounds + (1 - \pounds)\,{\circ}_l \qquad (2)$$

$$\pounds = \frac{Q_g}{Q_g + Q_l} \qquad (3)$$

Neve, et.al (1991) reported effect of area ratio and throat length on diffuser pressure recovery. Pressure recovery of diffuser was influent of flow condition in upstream of diffuser.

Shimizu, et.al (1982) reported the effect of type of approaching flow on performance of straight conical diffuser. This research was investigated relations of boundary layer thickness, swirling component and performance of diffuser.

2. Method

The schematic diagram of the experimental facility is shown in Fig. 2. The rig was of the closed circuit type with water as the primary fluid and air as the secondary. The ejector is fabricated from transparent acrylic to enable visual observation of the process. Water as the motive fluid is pumped into the system through the nozzle from the reservoir by a centrifugal pump. Water flow rate to the ejector is controlled by adjusting the ball valves in the ejector inlet and bypass line. The flow rate, temperature and pressure of the liquid and gas are measured by a rotameter meter, a J-type thermocouple, and a pressure transducer, respectively. Static pressure measured at upstream and down stream of diffuser. MPX 0505 pressure transducer with an accuracy of 0.01% of full scale used to sensing the static pressure. Data acquisition system is used to captured and stored pressure measurement at differential and pressure on upstream in diffuser. The mixing tube diameter and length was constant at 19 mm and 350 mm. Dimension of section test in this experiment shown in Table 1.

Water flow was metered by a rotameter. Air was metered flow by a rotameter, prior to entering the vacuum chamber. Air volumetric flow rate at the diffuser inlet was calculated from the metered value, assuming it to be inversely proportional to the local static pressure. The homogeneous void fraction was based on that value. This is effectively an assumption of isothermal conditions and is in line with that made by Thang & Davis (1981).

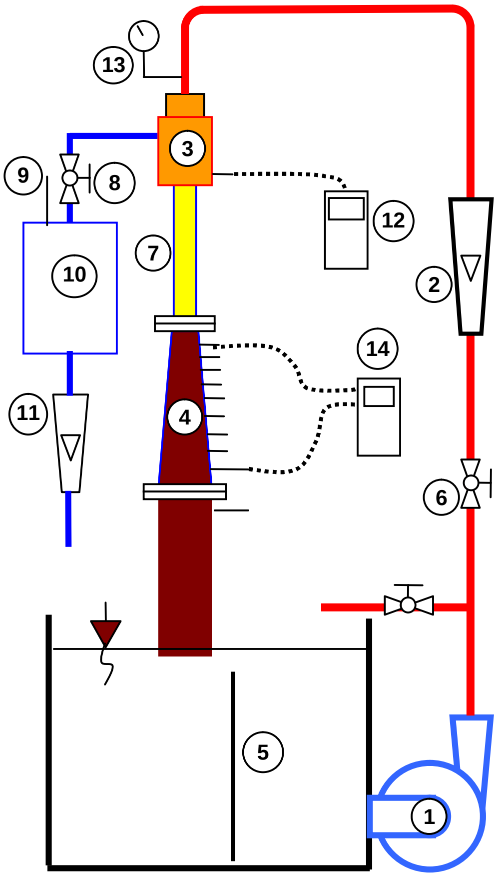

Figure 2. Experiment rig test

Legend			
.	Pump	8.	Valve
.	Flow meter	9.	Thermometer
.	Suction chamber	10.	Air reservoir
.	Diffuser	11.	Air rotameter
.	Reservoir	12.	Vacuum gauge
.	Valve	13.	Pressure gauge
.	Throat	14.	Pressure gauge

Table 1. Dimension of *Liquid gas ejector*

Component	**Design**
Nozzle	Conical, diameter 13 mm
Suction Chamber	Projection ratio = 5.d_t Konvergen angle = 10^0, D_s/d_n = 6,6
Throat	d_t =19 mm, area ratio $(d_n/d_t)^2$ = 0,4
Diffuser	Divergen angle = 7^0 ; (A_t/A_d) = 1:9

3. Discussion of Results

Figure 3. shows correlation of pressure recovery on different liquid Reynolds number. Reynolds number is based as usual for two-phase flows on the homogeneous mixture density, the sum of the superficial velocities for each phase, the inlet diameter and the liquid viscosity Homogeneous void fraction measured on upstream of diffuser. The experiment was carried out Reynolds number in range 8,4.10^4 to 1,4 10^5.

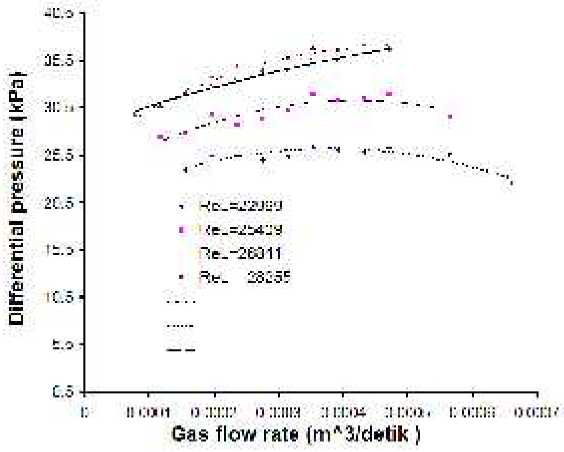

Figure 3. Differensial static pressure on variation of gas flow rate.

Pressure recovery not only depend on void fraction but also liquid Reynolds number. Increasing of void fraction on all of the liquid Reynolds number was decreasing of pressure recovery. Maximum of pressure recovery attained on homogeneous void faction about 0,1 and liquid Reynolds number 2,68.10^4.

Neve (1990) reported pressure recovery on diffuser with horizontal flow orientation. Peak of pressure recovery on homogenous void fraction about 0.4.(Figure 4.) That is higher than peak pressure recovery in this experiment. Pressure recovery is lower than Neve (1991) experiment because of bubble on the vertical diffuser decelerated and bubble merged to the bigger size

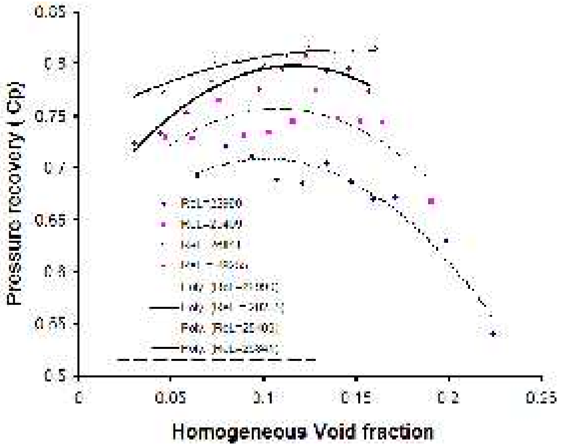

Figure 3. Pressure recovery on variation of homogeneous void fraction

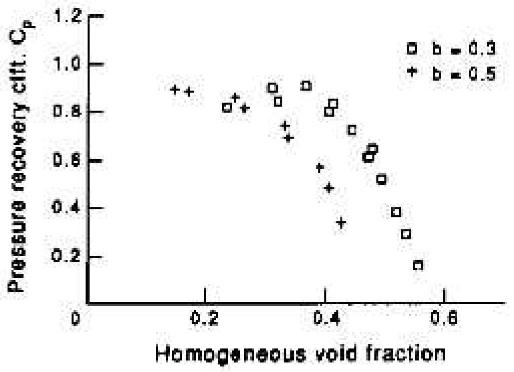

Figure 4. Pressure recovery on variation of homogeneous void fraction (Neve,1991).

Increasing of void fraction became increase of amount of gas phase in diffuser. Gas phase was decelerated velocity of downward flow in diffuser. decrease in pressure recovery can be explained by the fact that an increase of Gas flow rate (*Qg*) causes higher population of gas bubbles.

Higher pressure recovery are observed at higher liquid flow rate for same gas flow rate. The reason for this can be elucidated by considering the increasing drag experienced by the bubbles. At higher liquid flow rate, comparatively bigger bubbles are formed due to coalescence which causes a decrease in the true liquid velocity because of increase in liquid flow area. Moreover, due to bigger bubble size, some of the liquid get entrapped in the wake of bubble and as a result the bulk liquid velocity reduces which causes decreasing two-phase pressure drop at increasing liquid flow rate (Majumder et.al. 2006)

The gas flow rate increases, void fraction increases which enhance intimate contact between liquid and bubbles inside the diffuser. This increases the interfacial drag force between the phases. Also, bubble number density increases with the increase in void fraction. As the bubble number density increases, interfacial drag force increases due to increase in interfacial area. This results in increase in pressure drop due to form drag with increase in gas flow rate (Figure. 3).

4. Conclusion

Void fraction on downward flow in diffuser lower than horizontal flow orientation. Also pressure recovery lower than horizontal orientation at Neve (1991) experiment. Bubble coalescence and decelerate were influenced of losses in diffuser. On the constant gas flow rate and increasing of liquid flow rate, liquid entrapped in the wake of bubble and as a result the bulk liquid velocity reduces which causes decreasing two-phase pressure drop at increasing liquid flow rate.

REFERENCES

Brahim.A.B., Prevost.M., Bugarel.L., 1984, Momentum Transfer in Verical Down flow Liquid Jet Ejector : Case of Self Gas Aspiration and Emultion Flow, *Int. J. Multiphase Flow* Vol. 10, No. I, 79-94,

Kandakure, M.T., Gaikar, V.G., Patwardhan,A.W., 2005, Hydrodynamic aspects of ejectors, Chemical Engineering Science, 60, 6391 – 6402,

Kundu. G., Mukherjee.D., Mitra.A.K.,1995,

Experimental tudies on a o-current Gas-Liquid Dowflow Bubble Column., *Int. J. Multiphase Flow*, Vol. 21, No. 5, 893-906.

Majumder.S.K., Kundu.G., Mukherjee.D., 2006, Prediction of pressure drop in a modified gas–liquid downflowbubble column, Chemical Engineering Science 61, 4060 – 4070

Neve, R. S., 1991, Diffuser Performance in Two-Phase Jet Pumps. *International Journal of Multiphase Flow*, 17**,** 267-272.

Shimizu, Y., Nagafusa, M., Khuzuhara, S., 1982, Effect of Approching Flow Type on the Performance of Straight Conical Diffuser, Bullein JSME, 25(208), 1506-1512.

Thang, N.T., Davis,M.R, 1981, Pressure Distribution in Bubble Flow Through Venturis, *International Journal of Multiphase Flow*, 7**,** 191-210.