The optimum condition for rapid mixing of two fluid streams in turbulent pipe flow were investigated for different velocity ratio and different angles (45^0,$90^0$and 135^0) jet injection

Rishikesh Kumar Singh

Department Mechanical Engineering GLB-ITM, Greater Noida

ABSTRACT

The optimum condition for rapid mixing of two fluid streams in turbulent pipe flow were investigated for different velocity ratio and different angles (45°, 90°, and 135°) jet injection. The optimum velocity ratio and optimum injection angle were determined by comparing the mixing characteristics for one phase flow (water-water) and two phase flow (water with salt solution).

The mixing characteristics and optimum condition compare between experimental results and asymptotic solution (theoretical results) for water-water. The mixing characteristics and optimum conditions compare between water-water and water with salt solution. Static pitot tubes measure the velocity at different sections after mixing for different velocity ratio and different discharge.

Keywords: turbulent, velocity ratio, discharge, asymptotic solution.

I INTRODUCTION

The extreme uses of Jet mixing of two fluid streams in a pipeline are in the chemical industry in pipeline transport process and in tubular apparatus for the purpose of dilution, heat transfer and reaction (combustion). Rapid mixing in the shortest distance downstream from the injection point is usually required. Effective use of turbulence increase reactant contacts and decreases reaction times, which can significantly reduce the cost of producing many chemicals. Efficient mixing is necessary to obtain profitable yields or to eliminate excessive corrosion in reactor or combustion chamber. An effective, simple method to mix two fluids with in a pipeline is to introduce feed jets such that jet contact with pipeline walls in minimized and mixing occurs rapidly with in the turbulent core of the pipeline. However, most of the research has been conducted for a configuration in which the jet is normal to thepipeline, whereas, in the present work we consider a more general case in which the turbulent jet injects fluid at an angle θ_0 (45^0, 90^0, 135^0). Further we find out the experimental results for water-water mixingand compare it to the asymptotic solution for jet trajectory. Also the water-water mixing is compared to water with salt solution for jet trajectory and

International Journal of Advance Research in Science and Engineering
Volume No.06, Special Issue No.(02), December 2017
www.ijarse.com

IJARSE
ISSN: 2319-8354

tracer concentration profiles in the region of the jet injected point.

When the turbulent mixing at a T-junction of two pipes, it is controlled by the mixing of the inclined turbulent jet as it intersects the main flow. It is easy to see that, if the jet velocity is too low there will be insufficient penetration into the main flow, if the jet velocity is too high there will be too much penetration as a general rule, a balance should be stunk in such a way that mixing between the jet and the main flow takes place over a wide range of conditions and within the shortest possible distance.

II PROBLEM FORMULATION

The main aim of our present work is to obtain a better and appropriate mixing of two fluids with the respective arrangement of the apparatus. The apparatus consists of a venturimeter, orifice plate, static pitot tube, manometer, filter box and some valves which guide the flow of fluid. As the fluid enters the pipeline it is made to pass through a venturimeter which increases the velocity of flow and further after passing through it the velocity becomes constant. The secondary fluid to be mixed with the base fluid is supplied using a centrifugal pump. The centrifugal pump is so arranged that the orientation of the supply of secondary fluid can be changed for better results. The systematic arrangement as shown below is used for further inspection to fulfill the objective. The effect of orientation on mixing is discussed in mathematical formulation.
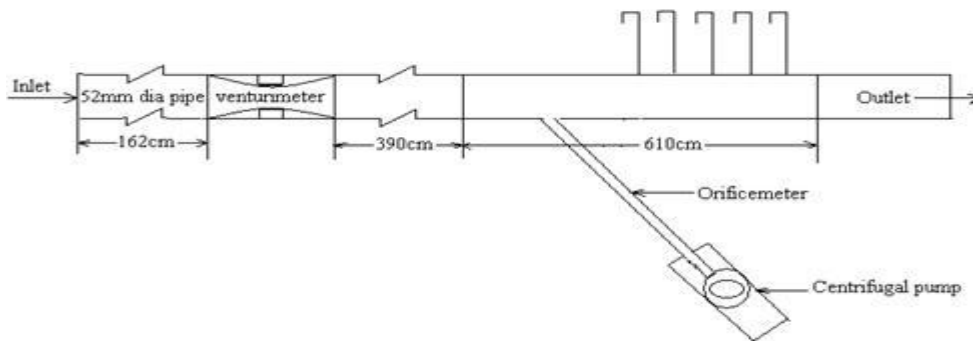

Fig.1. Mixing at 135° branch angle

III MATHEMATICAL FORMULATION

Calculation for Water with salt solution
M_{salt}= 10kg

$$\frac{m_s}{v_s} = \frac{m_w}{v_s} + \frac{m_{salt}}{v_s} \qquad \rho = \frac{\rho_s v_w}{v_s} + \frac{10}{v_s}$$

$$\nu_w = 1.2 \times 1.2 \times 1 m^3 \qquad\qquad \nu_s = \nu_w = 1.44 m^3$$

$$\rho_w = 1000 \, kg/m^3 \qquad\qquad \rho_s = 1006.94 kg/m^3$$

Specific gravity (S) = density of salt solution/density of water

$$S = \frac{\rho_s}{\rho_w} \qquad\qquad S = 1.007$$

For orifice,   X= 63.5 cm

$$h = X\left(\frac{S_2}{S_1} - 1 \right)$$

H= 793.8cm   Q= 1084.3cm^3/s

Q= A.u=a$_1$u   U=189.56cm/s

                     $\beta = 0.6$

$\alpha = 0.11$

Table No 1 Mixing length for water-wate

Serial No.	Velocity Ratio (R)	$\theta=90^0$ Mixing Length (L)	$\theta=45^0$ Mixing Length (L)	$\theta=135^0$ Mixing Length (L)
1	1.12	20	16	12
2	1.25	16	20	12
3	1.44	16	20	8
4	1.77	12	20	16
5	2.5	16	24	16

International Journal of Advance Research in Science and Engineering
Volume No.06, Special Issue No.(02), December 2017
www.ijarse.com

IJARSE

ISSN: 2319-8354

Table No. 2 Mixing length for water with salt solution

Serial No.	Velocity Ratio (R)	$\theta=90^0$ Mixing Length (L)	$\theta=45^0$ Mixing Length (L)	$\theta=135^0$ Mixing Length (L)
1	1.12	16	12	8
2	1.25	12	16	8
3	1.44	12	16	4
4	1.77	8	16	12
5	2.5	12	20	12

u= 189.56cm/sv= 75.73cm/sQj= 1084.3cm^3/sQ= 1507.14cm^3/s

D= 5.2cm

d= 2.7 cm

Table No3 Combined table for water with salt solution and water-water with $\theta=135^0$ and R= 2.5

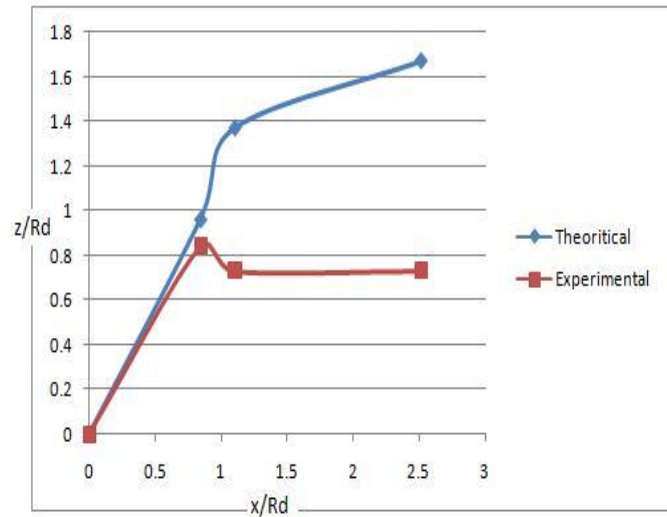| Serial No	Water with salt solution						Water-water		
	X	x/d	z	z/d	x/Rd	z/Rd	z	z/d	z/Rd
1	0	0	0	0	0	0	0	0	0
2	-4	-1.48	3.5	1.3	-0.59	0.52	4	1.48	0.59
3	4	1.48	3	1.11	0.59	0.44	3.5	1.3	0.52
4	8	2.96	2.8	1.04	1.18	0.41	3.2	1.19	0.47
5	12	4.44	2.6	0.96	1.78	0.39	3	1.11	0.44
6	16	5.93			2.4		2.7	1	0.4

IV RESULT

The following results have been Plotted-
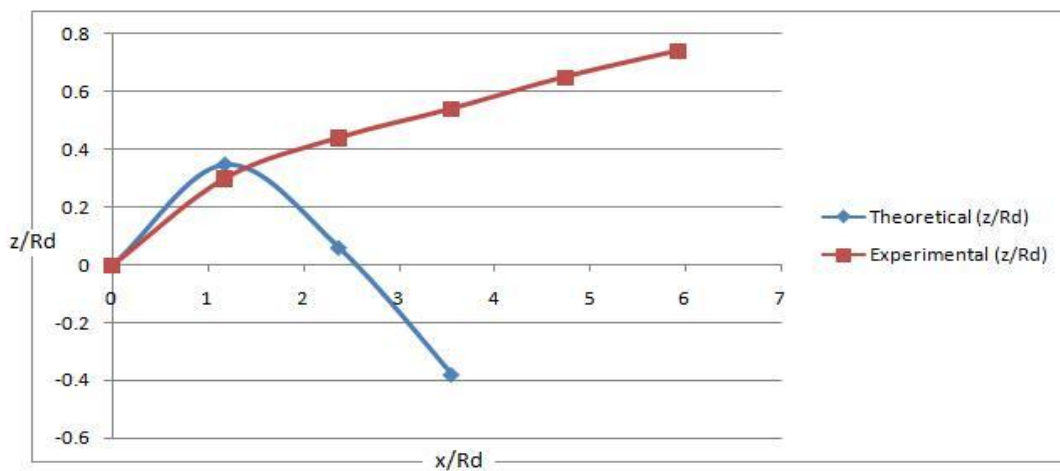
(1)   Jet trajectories (x/d, z/d).

(2)   Normal coordinates of jet trajectories (x/Rd, z/Rd).

(3)   Mixing length (L) Vs velocity ratio (R).
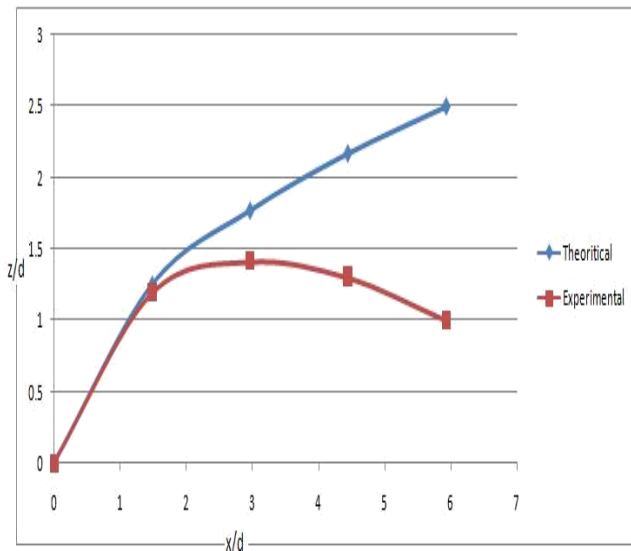
Fig.1 Jet trajectory at 45^0 for water-water, R=1.1   **Fig.2 Normalized coordinates of jet trajectory at 90^0 for water-water, R=1.12**

Fig.3 Normalized coordinates of jet trajectory at 135^0 for water with salt solution and water-water,R=1.44

Since three angles have been used with the help of joint 2" pipe and 1" pipe at 45^0, 90^0, and 135^0. The result have been plotted for water-water mixing and water with salt solution in terms of jet trajectories and normalized coordinate of jet trajectories in the graphs from fig 5.50 the difference between theoreticaand experimental results in graphs come because the theoretical results have parabolic equation and the losses (friction loss, bend loss, etc) are from fig. 5.51 to 5.58.

During the measurements it was observed that in most of the cases the mixing length is less when we used water with salt solution in the respect of water-water mixing.

REFERENCES

[1]T. Maruyama, T. Mizushina, F. Watanabe (April 1982), Turbulent mixing of two fluid streams at an oblique branch", journal of international chemical engineering, vol. 22, no.2Page 287-294.

[2] ZhigangFeng, Xiodong Wang, Larry J. Forney (December 1999) ,Single jet mixing at arbitrary angle in turbulent tube flow", Journal of fluid engineering, vol. 121, page 762-

[3] Sundarraj, S.,Selladurai, V., Numerical abd Experimental Study on , jet Trajectories and Mixing Behaviour of Venturi-Jet Mixer", Journal of fluids Engineering, 132 (2010), 10,pp. 101104(1-9).

[4] Y. Kawashima, M. Nakagawa, S. Luchi (Oct 1983), The two dimensional pattern of flow at a right- angled, T-shaped confluence". Journal of international chemical engineering, Vol. 23, no. 4. Page 287-294.

[5] J.W.Hiby (April 1981) "Defination and measurement of the degree of mixing in Liquid mixture", journal of international chemical engineering, vol.22, no. 2. Page 287-294.

[6] Brain K. Johnson and Robert K. Prudhomme(September 2003) , Chemical processing and Micromixing in confined impinging Jets", AIChE Journal, vol. 49, Issue 9, pages2264-2282.

[7] Benjamin J. Mccoy and Giridhar Madras (October 2002) " Trace mixing Dynamics during agrigation and fragmentation", AIChEJournal,Vol. 48, Issue 10. Pages 2167-2178.

[8] Gang Pan and HuiMeng (December 2001) "Experimental study of Turbulent Mixing in a Tee Mixer Using PIV and PLIF", AIChE Journal, Volume 47, Issue 12, Pages 2653-2665.

[9] Patrice Nadeau DimitriosBerk and Richard J. Munj (March 2001) "Mixing in a Cross-flow- Impinging Jet Reactor", AIChE Journal, Vol. 47, Issue 3, Pages 536- 544.

[10] Ricardo Macias-Salians and James R. Fair (January 2000) " Axial Mixing inModern Packings, Gas and Liquid Phases: II. Two-phase Flow", AIChE Journal, Vol. 46, Issue 1, Pages 79-91.

[11] DavidR.Unger and Fernando J.Muzzio(Dec 1999) "Laser-induced Fluorescence technic for the Quantification in Impinging Jets", AIChE journal, Vol 45, issue 12 pages2264-2282.

[12] P.O. Hedman, D.R. Leavitt, J.L. Sharp (July 1985) "Cold flow mixing rates in confined, recirculating coaxial jets with angular secondary injection", AIChE Journal, Volume 31, Issue 7, Pages 1105-1112.

[13] L. M. Sroka, L. J. Forney (March 1989) "Fluid mixing with a pipeline tee: Theory and experiment", AIChE Journal, Volume 35, Issue 3, Pages 406-414.

[14] L. J. Forney, L. A. Oakes (January 1984) "Slow second-order reactions in a deflected buoyant jet". AIChE Journal, Volume 30, Issue 1, Pages 30-37.

[15] Amighi, A., Eslamian, M., Ashgriz, N., "Traqjectory of a liquid jet in high pressure and high temperature subsonic air cross flow", Pro