

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

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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 the pipeline, whereas, in the present work we consider a more general case in which the turbulent jet injects fluid at an angle θ_0 (45° , 90° , 135°). Further we find out the experimental results for water-water mixing and 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 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 struck 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.

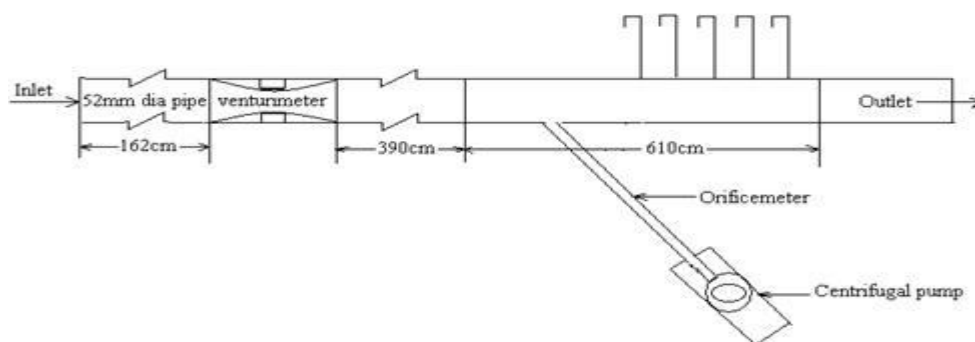


Fig.1. Mixing at 135° branch angle

III MATHEMATICAL FORMULATION

Calculation for Water with salt solution

$$M_{\text{salt}} = 10\text{kg}$$

$$\underline{m_s} = \underline{m_w} + \underline{\overset{m}{\text{salt}}} \quad \rho = \underline{\rho_s V_w} + \underline{10}$$

$$v_s = v_s = v_s \quad v_s = v_s$$

$$v_w = 1.2 \times 1.2 \times 1m^3 \quad v_s = v_w = 1.44m^3$$

$$\rho_w = 1000 \text{ kg / m}^3 \quad \rho_s = 1006.94 \text{ kg / m}^3$$

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

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

For orifice, X= 63.5 cm

$$h = X \left(\frac{S}{1} \right)^{-2}$$

$$H = 793.8 \text{ cm} \quad Q = 1084.3 \text{ cm}^3/\text{s}$$

$$Q = A \cdot u = a_1 u \quad U = 189.56 \text{ cm/s}$$

$$\alpha = 0.11 \quad \beta = 0.6$$

Table No 1 Mixing length for water-wate

Serial No.	Velocity Ratio (R)	$\theta=90^0$	$\theta=45^0$	$\theta=135^0$
		Mixing Length (L)	Mixing Length (L)	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

Table No. 2 Mixing length for water with salt solution

Serial No.	Velocity Ratio (R)	$\theta=90^0$	$\theta=45^0$	$\theta=135^0$
		Mixing Length (L)	Mixing Length (L)	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

$u= 189.56\text{cm/sv}= 75.73\text{cm/sQj}= 1084.3\text{cm}^3/\text{sQ}= 1507.14\text{cm}^3/\text{s}$

$D= 5.2\text{cm}$

$d= 2.7 \text{ cm}$

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).

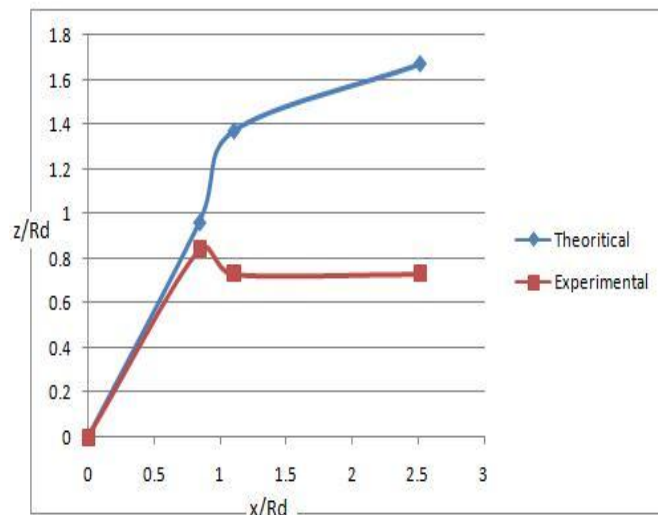
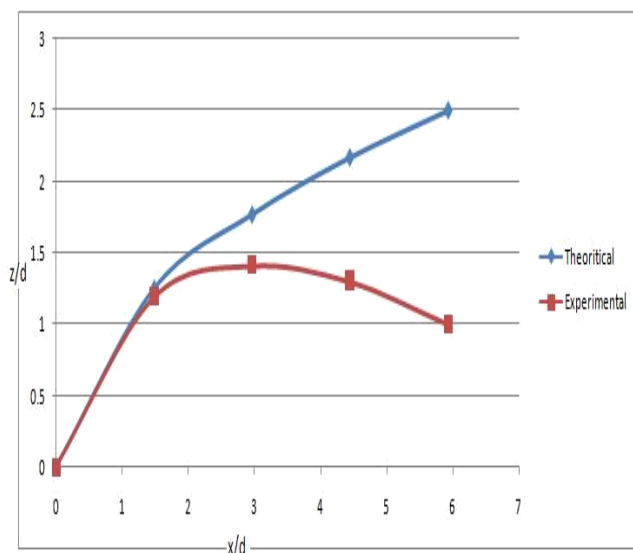


Fig.1 Jet trajectory at 45° for water-water, R=1.1

Fig.2 Normalized coordinates of jet trajectory

at 90° for water-water, R=1.12

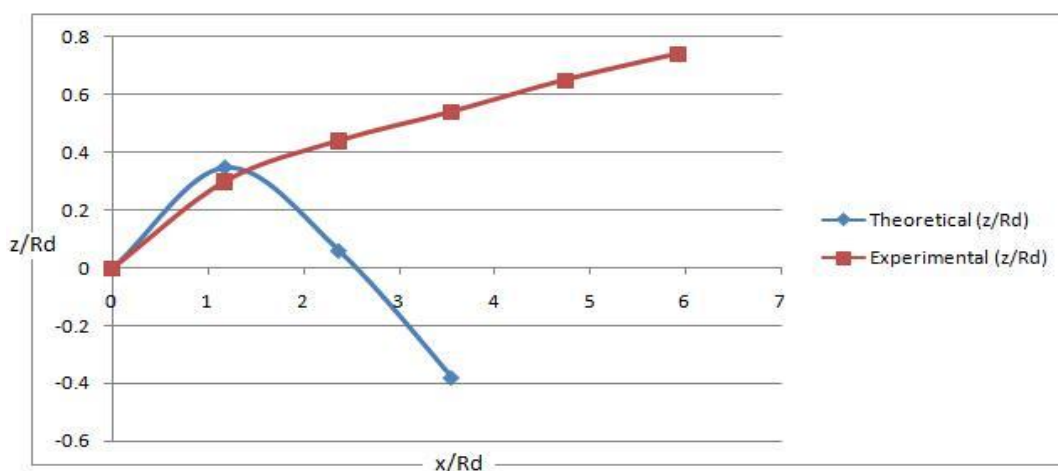


Fig.3 Normalized coordinates of jet trajectory at 135° for water with salt solution and water-water, R=1.44

Since three angles have been used with the help of joint 2" pipe and 1" pipe at 45°, 90°, and 135°. 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 hibern in the respect of water-water mixing.

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