Indian J.Sci.Res. 17 (1): 292-296, 2017

ISSN: 0976-2876 (Print)
ISSN: 2250-0138 (Online)

INVESTIGATION OF MIXING TIME USING JET MIXER

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ABSTRACT

Jet mixer is one of the simplest methods to achieve mixing. Mixing can be achieved by injecting a fluid through a jet inside the tank at a higher velocity. A wide range of jet injection rates has been investigated. By varying the height as well as the angle of the jet, mixing time gets vary due to change in the flow pattern. The experimental study includes the determination of mixing time in a batch wise jet mixer and includes the effect of jet Reynolds number, effect of nozzle twisting, effect of jet angle, effect of nozzle clearance and effect of jet diameter on mixing time.

KEYWORDS: Angle of The Jet, Jet Mixing, Jet Mixer, Mixing Performance And Mixing Time.

Blending or homogenization of two or more miscible liquids is very widely encountered in a variety of physical and chemical process. The blending process may be carried out in a batch wise or in a continuous mode of operation. The important process parameters for the blending process are the blending time, which is frequently termed as the mixing time. Experimental determination of the blending time involves introduction of a tracer at some location in the vessel and measuring the tracer concentration as a function of time with the help of a conductivity meter. Van de Vusse who employed a new correlation which was independent of the Reynolds number. The flow pattern and the mixing in a jet agitated vessel were investigated by Ranade (1996) using CFD, and he found the alternating jet flowing in different direction are more efficient in the initial dispersion of tracer than the steady jet. Jayanthi (2001) recommended the use of conical bottom tank to eliminate the dead zone in the tank and reducing the mixing time. Patwardhan,A. W. and A.R. Thatte (2004) found that, mixing time decreases with an increase in the jet length. This has been confirmed with the help of CFD modeling also. They also proposed a correlation base on two dimension less parameters. The flow pattern and the mixing in a jet agitated vessel were investigated by Ranade (1996) using CFD, and he found the alternating jet flowing in different direction are more efficient in the initial dispersion of tracer than the steady jet. Jayanthi (2001) recommended the use of conical bottom tank to eliminate the dead zone in the tank and reducing the mixing time. Patwardhan,A. W. and A.R. Thatte (2004) found that, mixing time decreases with an increase in the jet length. This has been confirmed with the help of CFD modeling also. They also proposed a correlation base on two dimension less parameters.

EXPERIMENTAL PROCEDURE

In this research experimental setup consists of flat bottom circular tank having the suction pipe located at the bottom of the tank (i.e. It may achieve the complete drain of the liquid in the tank by locating the outlet at the bottom of the tank). Suction pipe was connected to pump. The outlet from the pump is once again given as inlet to the tank at certain height from base of the tank (i.e. clearance). Nozzle was located inside of the tank with various angles of inclination and height from the base. Flow rate through the nozzle was constantly maintained by adjusting the valve, which is connected in between the jet and the pump outlet. Through the outlet we can collect samples constantly to find the mixing time. In our project tap water is used as a working fluid and sodium chloride is used as a tracer, conductivity meter is used to found the mixing time of the liquid

In this paper the same procedure for doing experiment for all the models of the jet mixer. The procedure is discussed below. Fit the jet inside the tank at a particular angle of inclination and height as mentioned in the model. Set the volumetric flow rate of the jet by adjusting the valve. Fill the tank with a working fluid up to the marked level. Make up the sodium chloride solution at a particular concentration (i.e. in this experiment sodium chloride is used as a tracer). Switch on the pump and allowed to run for few minutes and then inject the tracer suddenly into the tank. Collect the sample from the outlet every 10seconds and measure the conductivity value. At a particular time, the conductivity value would constant. The time taken for attaining this is taken as the mixing time. Shown in the graph 1. Repeat the same procedure for three to four times and an average value is taken. Review Stage Repeat the same procedure with various height and angle of the jet.

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Model:1 Single jet Side Entry

In this model experiments were carried out in a flat bottom cylindrical tank of 0.365m internal diameter and 0.365m liquid height. The height of the jet is 0.007m from the base. Mixing has been achieved with the help of a 0.5HP centrifugal pump. Based on the conductivity principle we found the mixing time of this model. Patwardhan and Gaikwad (2003) have studied the effect of nozzle diameter on the mixing time. It was observed that an increase in the nozzle diameter leads to a decrease in mixing time at the same level of power consumption. They had investigated nozzle up to 38mm in diameter. The height and diameter of this model will be same with flat bottom cylindrical tank. The nozzle was located at the bottom of the tank at an angle of 30° inclination.

The experimental set up used in the present work is depicted in fig 8. The parameters of the tank are listed below the fig 8. Tracer (sodium chloride) injected just opposite to the jet and the samples are collected with the constant time in travel and monitored with conductivity meter. The time required to achieve 95% homogeneity was calculated based on the concentration profiles and this was considered as the mixing time

RESULT ANALYSIS OF MODEL 1 AND MODEL2

Single Jet Side entry

Effect of Jet Reynolds Number

The fig 1 shows the mixing time plotted against the jet Reynolds number. The jet Reynolds number increases mixing time decreases due to momentum change in the tank increases. A good agreement is shown between the experimental results of H.D.Zughbi, M.A.Rakib (2003) and the present work. When the mixing time measurement corresponds to 95% mixing over the whole tank are used, then the difference is less between the present works and H.D.Zughbi, M.A.Rakib (2003). So in this model we agree the model of H.D.Zughbi, M.A.Rakib (2003) was the best for the tank having L/D ratio equals one.

Effect of Jet Diameter

The jet diameter get increased mixing time getting decreased. This is because the flow rate of the liquid and the momentum associated with the jet increase with an increase in the nozzle diameter at the same level of the power consumption. Patwardhan and Gaikwad (2003) have studied the effect of nozzle diameter on the mixing time. It was observed that an increase in the nozzle diameter leads to a decrease in mixing time at the same level of power consumption. They had investigated nozzle up to 38mm in diameter. In this case we agree with Patwardhan and Gaikwad (2003). It was observed for three different diameters of nozzles (i.e. 4mm, 6mm, and 8mm). In that 8mm shows a minimum mixing time. The particular 8mm size nozzle diameter throughout this research.

Effect on Twisting

The mixing time plotted against the jet injected at a 30° angle with five different angle of twisting. Normally the jet is kept at 30° with 0° twisting it will be shown in the fig 1, with the angle of twisting increases, time required for mixing increases up to 60° twisting, surprisingly the mixing time get decreased at 90° twisting due to tangential. Even though at 90 ° jets length will be maximum but the mixing time reduction was small, due to the large dead zones created on the top portion of the tank. This procedure was repeated for two different Reynolds numbers. Reason for change in mixing time is due to change in the flow pattern of the fluid in the tank.

Model:2 Horizontal double jet - two side central entry in opposite direction

Effect on Jet Angle

The mixing time plotted against the jet Reynolds number. Known information that the jet Reynolds number increases mixing time decreases due to momentum change in the tank will increases. Also mixing time is a strong function of the injection angle. While the angle of the jet changed the jet length is also getting changed due to this mixing time get altered. In this research the angle of the jet is kept constant while the Reynolds number of the jet were altered due to this the mixing time get varied. The same procedure is repeated for the different jet angle this is shown in Fig.4. At 15° jet angle the mixing time found was 50sec, at 20° jet angle the mixing time found was 45sec, at 30° jet angle the mixing time found was 55sec, and the jet Reynolds number was kept constant for all the above angles as 8000. Finally, at 20° jet angle mixing time was found minimum.

Effect of Nozzle Diameter

The diameter of the jet was plotted against the mixing time. It was observed that an increase in the nozzle diameter leads to a decrease in mixing time at the same level of power consumption. This is because the flow rate of the liquid and the momentum associated with the jet increase with an increase in the nozzle diameter at the same level of the power consumption. Patwardhan and Gaikwad (2003) have studied the effect of nozzle diameter on the mixing time. They had investigated nozzle up to 38mm in diameter. In this case we agree with Patwardhan and Gaikwad (2003). We have three different diameters of nozzles (i.e. 4mm, 6mm, and 8mm). In that 8mm shows a minimum mixing time. So we use only the 8mm nozzle diameter throughout this project.

ANALYSIS

Comparison of Present work with Earlier Work

A comparison of the mixing time as a function of Reynolds number as predicted by the present work with the mixing time measured by H.D.Zughbi, M.A.Rakib (2003). In the present work both of the jets are entering at the same height in an opposite direction, one of the jets is inclined towards the upward direction and another one inclined towards the downward direction. Both the jets are entering with 20° angle of inclination. At 90° twisting flow pattern is look like a circular flow due to this the jet length is more. A good agreement had shown between the experimental results of H.D.Zughbi, M.A.Rakib (2003) with the present experimental work which we done. They tested the effect of two opposing jets inclined to the horizontal on the flow field and the blending time performance. The angle of elevation chosen for this purposes was 35°. When the mixing time measurements correspond to 95% mixing over the whole tank are used, then a difference up to 11% was observed between the H.D.Zughbi, M.A.Rakib and the present work even though the volume of the tank was increased by 1.7 times of H.D.Zughbi, M.A.Rakib.

Effect on Twisting

The mixing time plotted against the jet injected at a 20° angle with five different angle of twisting. Normally both the jets are kept at 20° with 0° twisting it will be shown in the fig 2 with the angle of twisting increases, time required for mixing increases up to 45° twisting, surprisingly the mixing time get decreased at higher angles, and at 90° twisting gave a shortest mixing time compared with the other four angle of the twisting. This procedure was repeated for three different Reynolds numbers. Reason for change in mixing time is due to change in the flow pattern of the fluid in the tank. At 90° twisting the flow pattern was looking like a circular flow due to this maximum jet length has been obtained when compared to the other twisting degrees.

ANALYSIS

A comparison of the mixing time as a function of Reynolds number as predicted by the present work with the mixing time measured by H.D.Zughbi, M.A.Rakib (2003). In the present work both of the jets are entering at the different height in an opposite direction, the jet having maximum clearance inclined towards the downward direction and another one inclined towards the upward direction. Both the jets are entering at 15° angle of inclination with 0° twisting. Even though at 90° twisting flow pattern is look like a circular flow due to this the jet length is more, but the dead zones created in the center portion of the tank. A good agreement had shown between the experimental results of H.D.Zughbi, M.A.Rakib (2003) with the present experimental work which we done. They tested the effect of two opposing jets inclined to the horizontal on the flow field and the blending time performance. The angle of elevation chosen for this purposes was 35°. When the mixing time measurements correspond to 95% mixing over the whole tank are used, then a difference observed between the H.D.Zughbi, M.A.Rakib and the present work was negligible even though the volume of the tank was increased by 1.7 times of H.D.Zughbi, M.A.Rakib.

Table:1 Effect of Jet Reynold Number

Sl. No	Nozzle Diameter in mm	Jet Reynolds no	Mixing time in s
1	8	11000	50
2	8	8000	78
3	8	6000	110

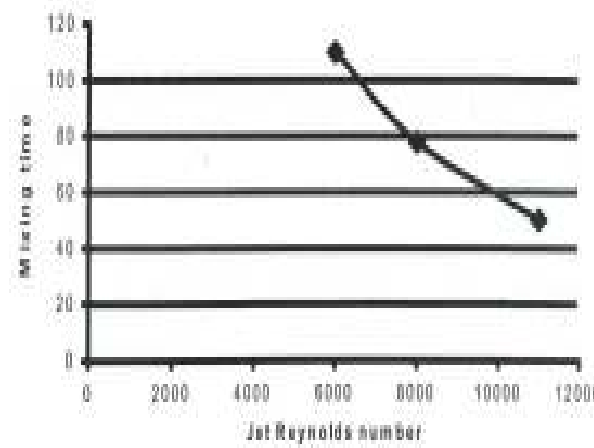

Figure 1: Jet Reynold Number Vs Mixing Time

Table 2: Effect of Jet Diameter

Sl. No	Diameter of jet in mm	Volumetric flow rate (ml/s)	Velocity (m/s)	Reynolds number	Mixing time (s)
1	4	100.53	2	8000	107
2	6	67.02	1.33	8000	93
3	8	50.26	1	8000	78

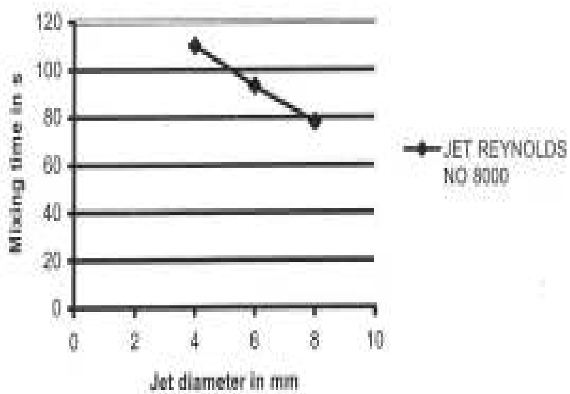

Figure 2: Jet Diameter Vs Mixing Time

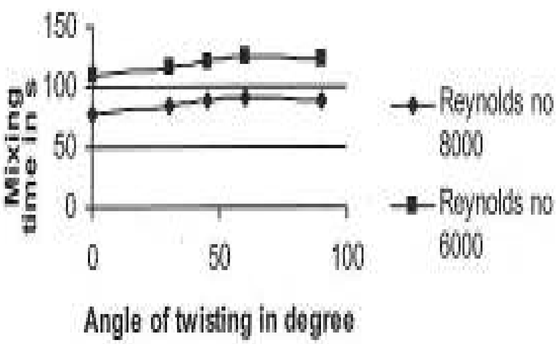

Figure 3: Angle of Twisting Vs Mixing Time

Table 3: Effect on Twisting

Sl No	Dia of jet (mm)	Reynolds number	Mixing time in s for twisted jets				
			0°	30°	45°	60°	90°
1	8	6000	110	115	120	126	122
2	8	8000	78	83	88	92	89

Table:4 Effect on Jet Angle

S1. No	Jet Dia mm	Vol. metric flow rate ml/s	Jet Reynolds number	Mixing time in s		
				15°	20°	30°
1	8	25.13	4000	95	89	103
2	8	37.69	6000	70	63	78
3	8	50.25	8000	50	45	55

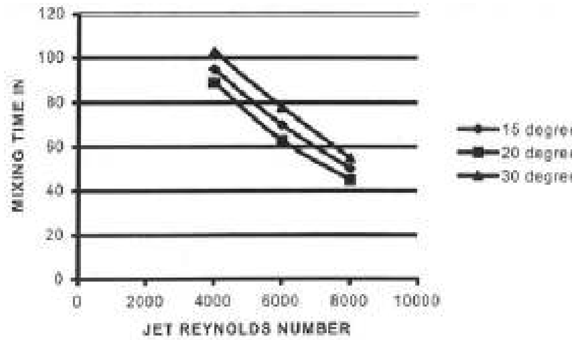

Figure 4: Jet Reynolds Number Vs Mixing Time

Table 5: Effect on Nozzle Diameter

S1 No	Diameter of jet in mm	Volumetric flow rate in ml/s	Velocity in m/s	Jet Reynolds number	Mixing time in s
1	4	100.53	2	8000	79
2	6	67.02	1.33	8000	69
3	8	50.26	1	8000	60

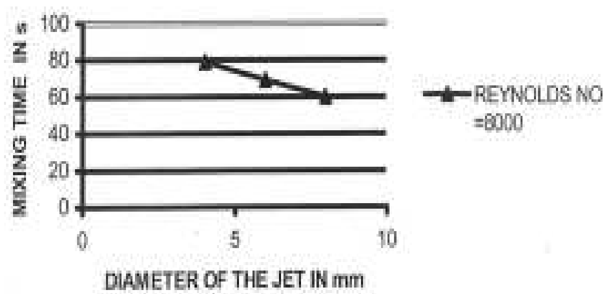

Figure 5: Jet Diameter Vs Mixing Time

Table 6: Comparison of present work with previous work

S No	Jet Reynolds number	Mixing time in s	
		Present work	Previous work
1	4000	89	100
2	6000	63	70
3	8000	45	50

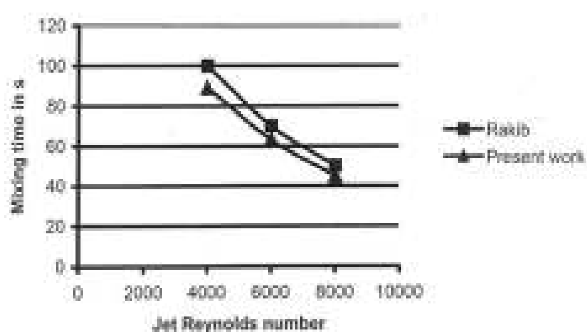

Figure 6: Comparison of present Work with Previous Work

Table 7: Effect on Twisting

Sl No	Dia. of jet mm	Reynolds number	Mixing time in s for twisted jets				
			0°	30°	45°	60°	90°
1	8	4000	95	103	112	100	89
2	8	6000	70	79	86	75	61
3	8	8000	55	63	70	60	45

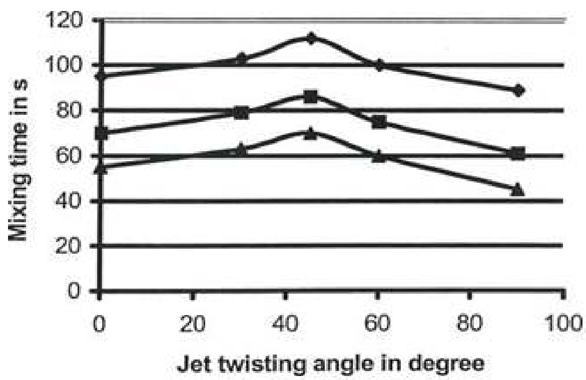

Figure 7: Jet Twisting Vs Mixing Time

CONCLUSION

In this research we have completed the four different models of. Among these models we found some valid information, they are listed below. Model 1 will give the shortest mixing time at 30° angle of inclination for the s having L/D ratio equals one. Model 2 offers minimum mixing time at 20° angle of inclination with 90° twisting for all s having L/D ratio equals one. Tangential flow offers the lower mixing time as compare to other flow pattern due to maximum jet length can be achieved only in this flow pattern. By increasing the nozzle diameter time required for mixing has been achieved quickly due to this power required for mixing reduces.

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