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# Effect of Annular Jet on an Existing Jet

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## ABSTRACT

*Jets have a wide range of applications in several fields. However studying the jet characteristics by introducing a flow field of different velocity annularly to the existing jet is a classic example considered for various applications. When a jet is surrounded by a flow field of different velocity then it is termed as co-flowing jet or co-annular jets. Co-annular jets have a wide range of applications in mixing and noise reduction characteristics. A comparison is drawn between a convergent nozzle and a A co-annular convergent inner nozzle having inlet diameter 22mm, exit diameter 5mm is surrounded by an annular convergent circular nozzle with inlet diameter 42mm, exit diameter 23mm is used for studying the results. Experiments are conducted for without co-flow and with co-flow at a velocity of 50 m/s in the present investigation. It is incurred that co-flow jets have a great impact in modifying the jet and enhances better mixing.*

***KEYWORDS:*** *Co-annular jets- mixing enhancement*



**Nomenclature:**
*$P_a$ – atmospheric pressure*
*$P_o$- stagnation chamber pressure*
*$P_t$- pitot pressure*
*X- co-ordinates along axial direction*
*R- co-ordinates along radial direction*
*D- exit diameter of inner nozzle*
*U- local velocity*
*$U_e$- jet velocity*

## I. Introduction

According to the several investigational reports [1-2] co-annular jets are used for mixing enhancement as well as mixing inhibition subject to industrial applications such as removal of exhaust gases from the silencer of heavy automobile vehicles to higher altitudes, combustion chamber, dispersion of flue gases from a chimney to large heights, flame length elongation of welding torch used for metal cutting applications, water jet machining, shielding gas provided in welding etc. For better combustion efficiency and reduction of pollutants from automobiles mixing enhancement is desirable.

## II. Experimental Details

The experiments were conducted in an open jet facility at the Aerodynamics Laboratory, Lakkireddy Balireddy College of Engineering. The facility consists of a three-stage reciprocating air compressor which is capable of delivering 100ft$^3$/min of air. The air is passed through the filters and then stored in the storage tanks having a capacity of 600 psi. The compressed air is released from storage tank to the cylindrical settling chamber through a pipe. The pressure of compressed air is maintained constant throughout with the help of the control valve. A pitot probe of 0.4mm inner diameter and 0.6mm outer diameter mounted on the transverse mechanism to sense the stagnation pressure from the exit of the nozzle. Two mercury U-tube manometers and two water U-tube manometers are placed so that one at a time can be connected to stagnation chamber and the other to Pitot probe for measuring stagnation and total pressure respectively. Based on the pressure requirements either water tube manometers or mercury manometers are used.

A convergent circular nozzle with inlet diameter 22mm, exit diameter 5mm with a lip thickness of 3mm is surrounded by an annular convergent circular nozzle with inlet diameter 42mm, exit diameter 23mm with a thickness of 5mm is used. Inner nozzle and annular nozzle are mounted onthe same circular base plate with diameter 100mm which has 30 circular orifices of diameter 2mm positioned at 20mm from the center of the base plate which act as inlet for the annular jet. Experiments were carried out by placing the exit of both the inner nozzle and annular nozzle in the same plane which is termed as co-flow nozzle. The experiments were carried out by taking the primary nozzle first and then the secondary nozzle is attached to the same base plate of the primary nozzle for studying the effects of annular flow.For the convenience the cases are termed as without co-flow and with co-flow. Fig 1 & Fig 2 shows the photographs of nozzle models for carrying out the experiments.

*Fig 1 Experimental model (Primary nozzle)*

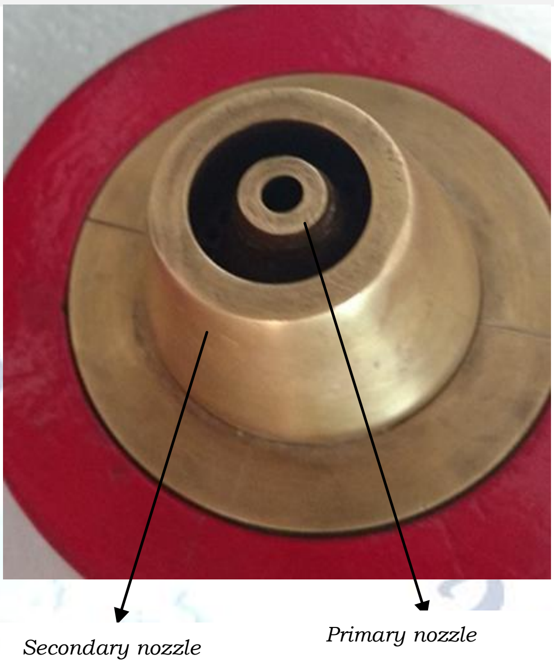


***Fig 2 Co-flow nozzle***

The pitot probe is placed at the exit of the inner nozzle by coinciding their centers. There should not be any contact between pitot probe and nozzle. The initial reading is taken at that particular position and then the pitot probe is moved axially away from the center maintaining a distance of 2mm by using transverse mechanism. Consecutive readings were taken up to x/D=15. The behavior of center line velocity is studied by interpreting the axial readings.

At axial positions of x/D= 0,1,3,5,7,10 the pitot probe is moved in radial direction maintaining a distance of 1mm until atmospheric pressure is attained.

The above experiments were conducted for nozzle without co-flow and nozzle with co-flow at two different velocities. The velocity at 50m/s is considered in the present investigation.

## III. Results and Discussion

*A. Centre line velocity decay(without co-flow)*

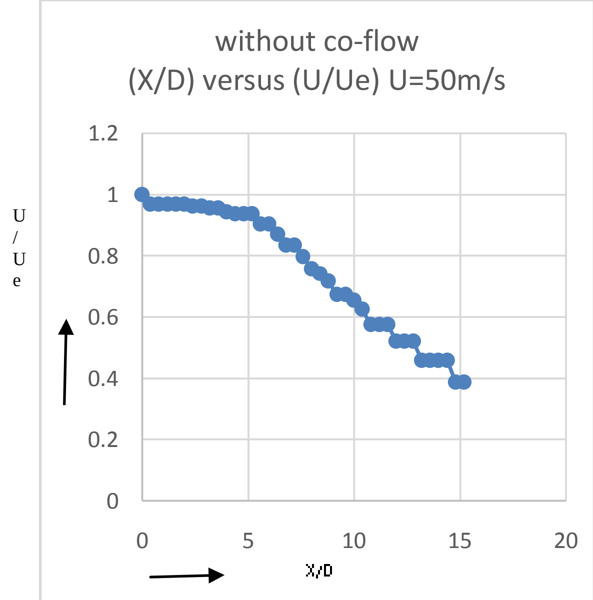


**Fig 3 Centreline velocity decay for U=50m/s (without co-flow)**

Centre line velocity decay indicates better mixing characteristics of the flow. In this case the primary nozzle is considered. The measured centerline velocity (U) is non-dimensionalizedwith the exit velocity ($U_e$) and plotted against the axial distance (X) which is also non-dimensionalized with the nozzle exit diameter (D).

The centerline velocity decay for 50m/s velocity is shown in Fig 3. In this the potential core exists up to X/D=2.8 and then the centerline velocity decay takes place.

*B. Centre line velocity decay (with co-flow)*

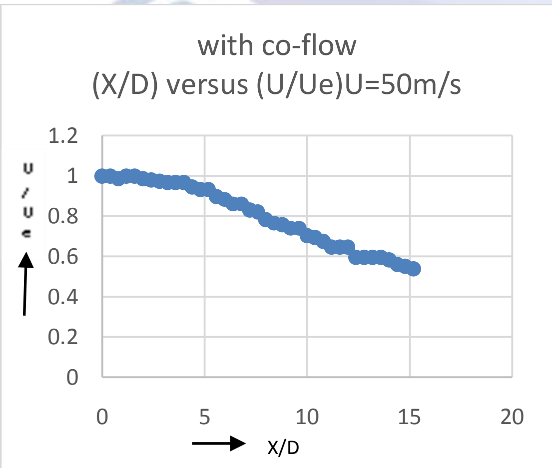


**Figure 4Centreline velocity decay for U=50m/s (with co-flow)**

The other set of experiments conducted in this experiment are by placing the secondary nozzle annularly to the primary nozzle which is termed as co-flow model. In this set the centerline velocity decay behavior is analyzed for U=50m/s.

Figure 4 shows the centerline velocity decay for the case of co-flow for the velocity of 50m/s. In this case the potential core is constant up to X/D=4.

*C. Comparison of Centre line velocity decay for without co-flow and with co-flow for U=50m/s.*

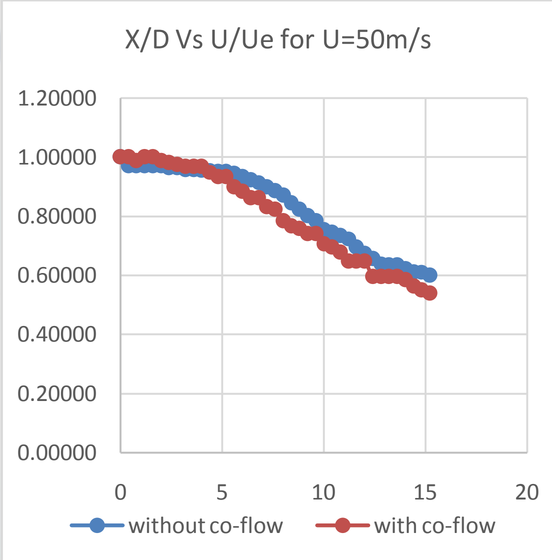


**Figure 5Comparison of Centreline velocity decay for the case without co-flow and with co-flow for U=50m/s**

In the case of without co-flow the potential core is constant upto X/D=2.8 whereas for with co-flow the potential core is constant upto X/D=4 for U=50m/s.In the case of co-flow the jet decay is faster and acts as a better promoter for mixing.Figure 5 shows the comparison of without co-flow and with co-flow.

By comparing the cases of without co-flow and with co-flow at U=50m/s velocity the centerline velocity behavior is observed in the axial direction.

*D. Velocity behavior in radial direction (for the cases of without co-flow and with co-flow for U=50m/s)*

In the above plots the behavior of center line velocity decay is witnessed but radial velocity variations are not considered. Therefore radial velocity variations are observed at particular axial positions of x/D= 0,1,3,5,7,10 in radial directions without co-flow and with co-flow.

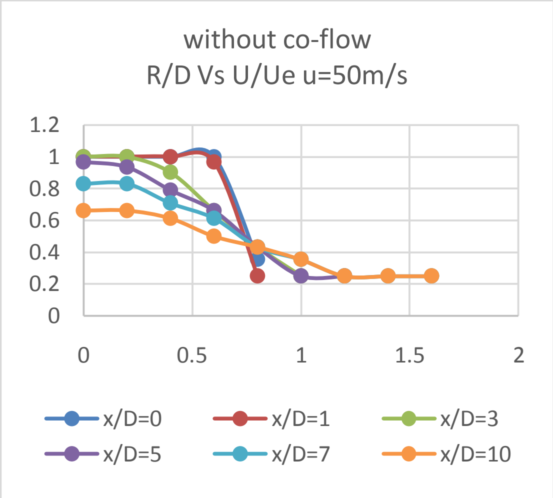


***Figure 6 Velocity profiles in radial direction for U=50 m/s for the case of without co-flow.***

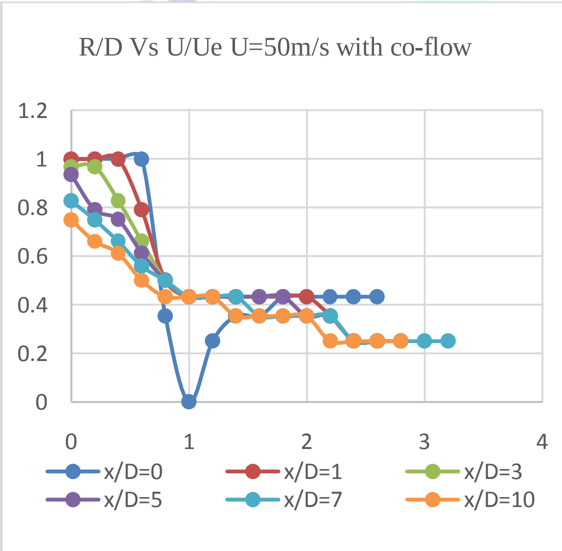


***Figure 7 Velocity profiles in radial direction for U=50 m/s for the case of with co-flow.***

Figure 6 shows the velocity profile in radial direction for the case of without co-flow at U=50 m/s. The potential core exists for X/D=0 and X/D=1 upto R/D=0.4. The jet decay starts from R/D=0.4 whereas the jet decay initiated without any potential core in the farstream for the X/D positions 3,5,7,10.

Figure 7 shows the velocity profile in radial direction for the case of with co-flow at U=50 m/s. The potential core exists for X/D=0,1,3upto R/D=0.4. The jet decay starts from R/D=0.4 whereas the jet decay initiated without any potential core in the farstream for the X/D positions 5,7,10. This shows the effects of co-flow in the far filed.

## IV. Conclusion

In this paper the effect of the annular jet to the existing jet is studied. Two cases are considered in this paper in which the first case is without co-flow and another case is with co-flow (secondary nozzle surrounded to the primary nozzle). It is investigated that the jet characteristics are altered to a great extent in the case of co-flow than without co-flow.

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