International Journal for Modern Trends in Science and Technology
Volume: 03, Issue No: 08, August 2017
ISSN: 2455-3778
http://www.ijmtst.com

Mixing Enhancement By Using Airtabs in Convergent Nozzle

K.Vidyasri[1] | M.Kedarnath[2] | Dr.P.Lovaraju[3]

[1]M.Tech. student, Department of Mechanical Engineering, Godavari Institute of Engineering & Technology
[2]Associate Professor, Department of Mechanical Engineering, Godavari Institute of Engineering & Technology
[3]Professor & Head of Department, Department of Aerospace Engineering, Lakireddy Balireddy College of Engineering

To Cite this Article
K.Vidyasri, M.Kedarnath and Dr.P.Lovaraju, "Mixing Enhancement By Using Airtabs In Convergent Nozzle", *International Journal for Modern Trends in Science and Technology*, Vol. 03, Issue 08, August2017. pp.: 41-43.

ABSTRACT

Mixing enhancement has wide applications in aerodynamics, welding, automobiles, food industry, pharmaceutical industry etc. Therefore, various techniques have been invented to improve it. Co-flow jets are used for promoting mixing characteristics. In this case outer jet interact with inner jet and reduces the length of potential core which results in mixing enhancement. Even change in size and shape of nozzle act as parameters which varies the mixing characteristics. Airtabs are used as main variable in this study to increase the mixing enhancement. Two airtabs and four airtabs were used at the exit of the convergent nozzle. Primary jet forms from nozzle whereas secondary jet forms from air tabs. In this condition experiments were carried out at two airtabs open and four airtabs open. These results were compared to the case of without airtabs. The readings obtained from the manometers were tabulated in excel and obtained results were plotted by using the Techplot software. The graphs were plotted between X/D and M/Me. Both are dimensionless numbers. After observing all the plots it is concluded that mixing enhancement increases with increase in mach number of secondary jet. If the difference between primary jet mach number and secondary jet mach number is more then the length of the potential core is very small.

Keywords: *Jet, Nozzle, Mixing enhancement, Airtabs*

I. INTRODUCTION

Gas ejected from a narrow opening such as nozzle, orifice etc and disperses into the environment is defined as jet. Types of the nozzle, the geometry of the nozzle, inlet diameter, outlet diameter, lip thickness of the nozzle, vortex generator, pressure of gas, mach number are few parameters which effect the characteristics of a jet. Distribution of flow of gas in the environment is referred as jet flow field. At the point when the jet is constrained to flow from a narrow opening it experiences significant changes in its flow velocity. Up to certain axial distance the flow velocity will not be affected. This particular region is known as potential core. After this region continuous decrease in flow velocity takes place. This is known as characteristic decay. Subsequently irrelevant changes in velocity take place which is known as developed zone and region after that is known as fully developed zone.

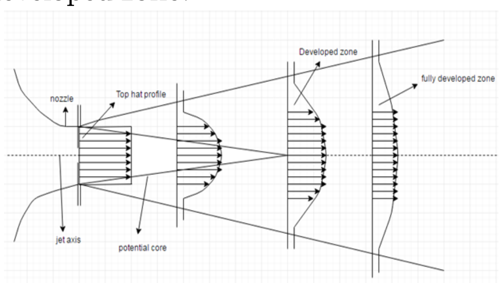

Figure 1: Jet flow field

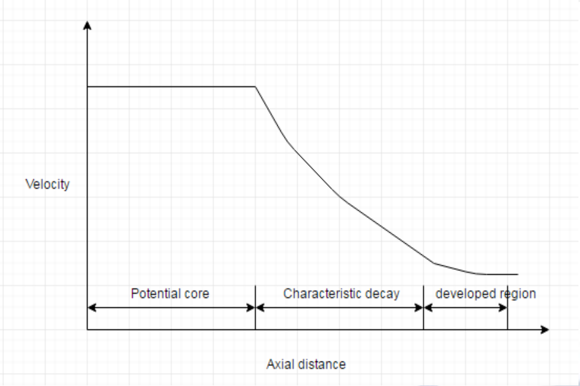

Figure 2: Centerline decay

II. EXPERIMENTAL MODEL

The experimental model used in this study was a symmetrical, convergent nozzle of 50mm length. The outer diameter of the nozzle is 27mm and inner diameter is 12mm at the exit of the nozzle. The cross sectional area will be varying through out the nozzle. At the exit of the nozzle four tubes were located which will be straight and makes 90 degrees angle with adjacent tubes. Brass was used for preparing this nozzle.

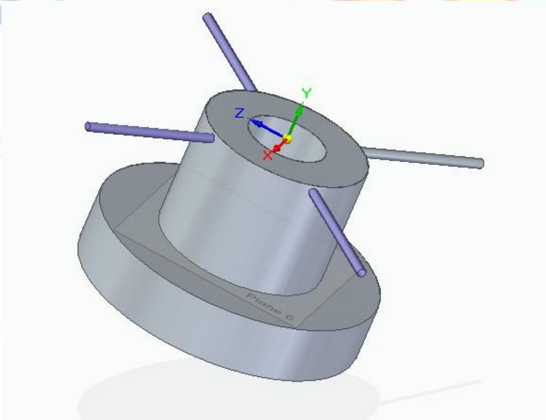
Figure 3: Isometric view of model

Compressed air flows through main nozzle and forms primary jet whereas, air flows through tubes at the exit of the nozzle and forms secondary jet. This secondary jet acts like air tabs and changes primary jet characteristics.

III. METHODOLOGY

The major parameters considered for analyzing a jet are the centerline pressure or centerline velocity decay. These measurements were carried out using pitot probe. Compressed air is send to the settling chamber, where the flow reaches a settled equilibrium. The required stagnation pressure in the chamber can be maintained with the help of a pressure regulating valve. The stagnant air from the chamber is expanded through the convergent nozzle. The pressure in the chamber is controlled to achieve the desired velocity at the nozzle exit. The pitot probe is placed at the exit of the nozzle by coinciding their centers. There should not be any contact between pitot probe and nozzle. The Pitot tube mounted on a traverse mechanism is aligned at the centre of the inner nozzle exit and moved downstream. The Pitot probe is connected to a U-tube manometer for pressure measurement. The traverse mechanism is used for the movement of Pitot probe in all three directions viz. X, Y and Z. The traverse is moved manually using a lever.
The experiments were done by considering with airtabs and without airtabs and readings were tabulated. In this study primary jet was maintained at mach number 0.2 and secondary jet was maintained at mach number 0.5. In the case of airtabs, experiments were done at two airtabs open and four airtabs open.

IV. RESULT AND DISCUSSION

Centerline velocity decay or centerline mach number decay is used to measure the potential core length, velocity decay, mixing inhibition, mixing enhancement etc of the free jet. Potential core length describes upto what extent the exit velocity will be unaffected. It also explains whether mixing inhibition takes place or mixing enhancement takes place. Therefore centerline velocity decay can be shown clearly by the potential core. It can also be defined as the distance from the nozzle exit where characteristics decay starts.

4.1 Centerline decay without airtabs:

Centerline reading were taken here without using any airtabs at mach number 0.2. For mach number 0.2 potential core was stable upto 4.33 X/D, after that centerline decay starts.

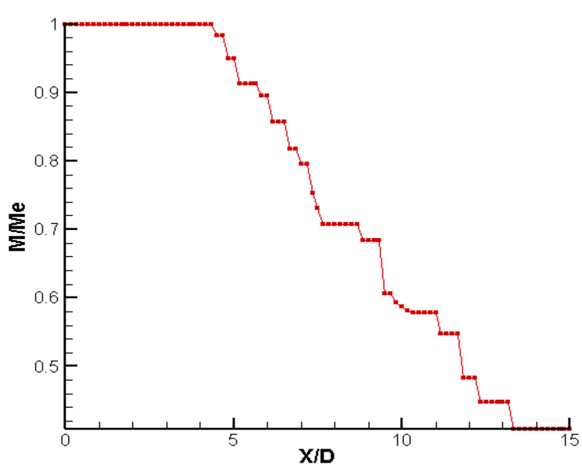

Figure 4: Centerline decay without airtabs

4.2 Centerline decay with 2 airtabs:

Centerline reading were taken here with two air tabs open with primary jet mach number 0.2 and secondary jet mach number 0.5. At this case potential core was stable upto 2.33 X/D, after that centerline decay starts.

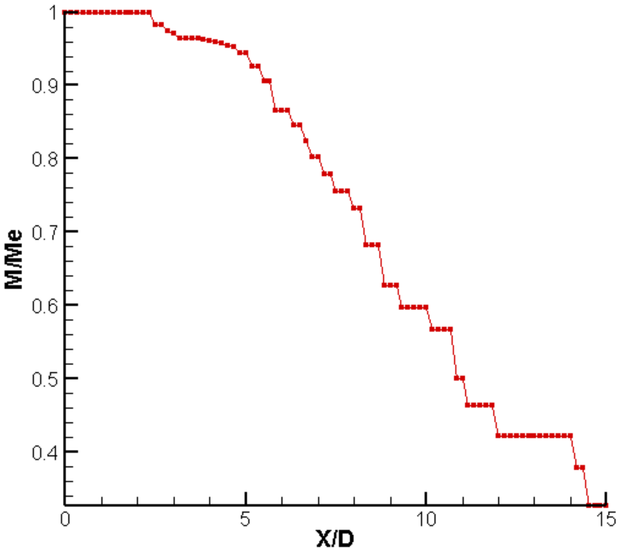

Figure 5: Centerline decay with 2 airtabs open

4.3 Centerline decay with 4 airtabs:

Centerline reading were taken here with four air tabs open with primary jet mach number 0.2 and secondary jet mach number 0.5. At this case potential core was stable upto 0.16 X/D, after that centerline decay starts.

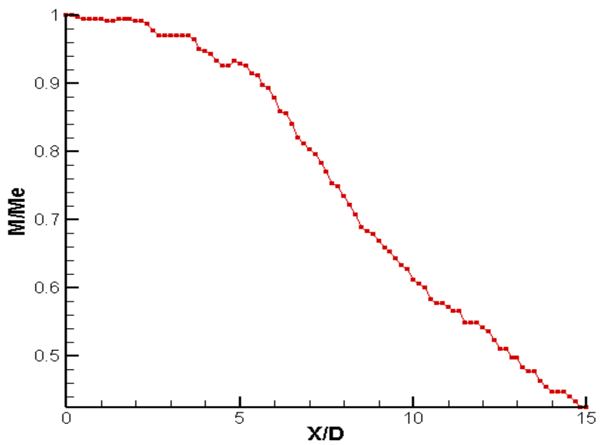

Figure 6: Centerline decay with 4 airtabs open

4.4 Crossplot:

For above three cases crossplot was done to compare the result. The plot is shown in figure.

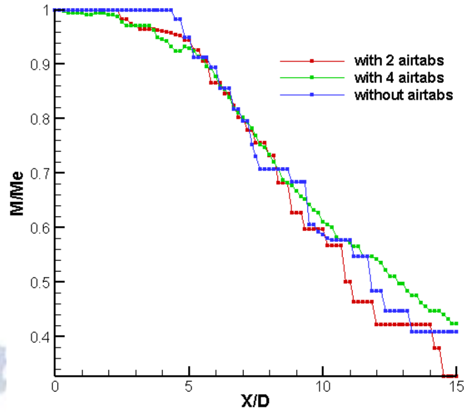

Figure 7: Crossplot for above 3 cases

V. Conclusion

This study aimed to identify the mixing characteristics of jet. Therefore, without airtabs, with two airtabs and with four airtabs cases were done and obtained values were plotted by using the software Techplot. After analyzing the plots the following points were concluded:

- Increase in number of airtabs decreases potential core.
- Mixing enhancement improves with increase in secondary jet mach number.
- Always secondary jet pressure need to be higher than primary jet pressure.

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