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Comparison of the effects of vanes and diffuser on combustion chamber swirler

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***Abstract*— Swirler is the vital component in the combustion chamber swirler to control the swirling flows and stabilize the flame. Swirling flow plays an important role in flame stabilization by generating rotating flows, turbulence jets and free jet wakes at the downstream of swirler in the combustion chamber swirler. By performing the experiment using vanes on swirler and incorporating diffuser between swirler and chamber, results compared for the recirculation zone at the downstream of the swirler. By examining the details at the different axial locations recirculation length and width are found which strongly depends on the turbulence.**

***Keywords*—Swirler, flame stabilization, recirculation zone**

I. INTRODUCTION

The mixing of primary air and fuel represent most important process in the combustion chamber which influence the efficiency of the whole combustion process. Swirling flow has its use in aerospace engineering due to it adds flame stabilization.

Swirling flows are highly complex have the characteristics of free turbulence and rotating motion which occur in reacting and non-reacting conditions. Swirler application is in gas turbine, burners, spray dryers and chemical processing plants, marine combustor, rotary kilns.

Swirling flow generates pressure gradients in the field of flow which help to reverse the flow at the downstream of the combustion chamber swirler. The strength of swirl depends on non-dimensional number called as swirl number.

The main objectives of this paper are: (i) to obtain experimental measurements of axial, radial and tangential velocity profiles downstream of the swirler in order to understand the flow field characteristics, (ii) to obtain a base line experimental data for the validation of numerical results, and (iii) to have recirculation zone created by vane swirler.

II. GEOMETRY AND PARTS

(1) The swirler with vane angle 45° is made in Perspex and transparent material as shown in Fig. 1.

(2) The inlet pipe of length 350 mm, 120 mm outer diameter and hub diameter of 40 mm. Holes of 10mm are made in axial direction in inlet pipe to measure mean velocity.

(3) The diffuser with inlet diameter of 120 mm and 250 mm outlet diameter.

(4) Expansion round chamber of 250 × 250 mm cross-section and a length of 1100 mm.

(5) A tail pipe of 120 mm diameter and length of 1300 mm is designed to prevent the atmospheric disturbances in the development of the flow.

The holes of 10 mm diameter are drilled in diffuser and chamber to measure the velocity by five hole probe. The swirler is placed in the inlet pipe.

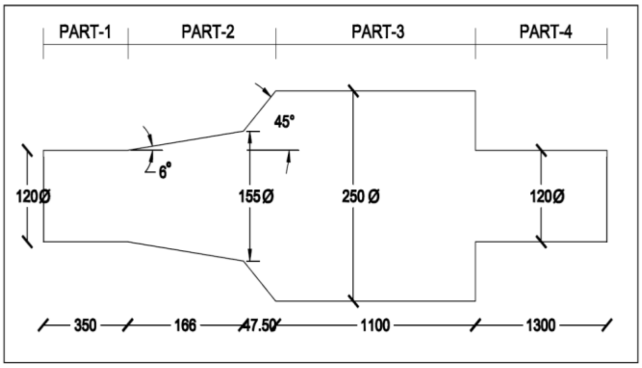

Fig. 1 geometry of combustion swirler set-up

The design of 45° vane swirler is shown in Fig. 2. There are six symmetrical vanes 2 mm in thickness. The angle given by a vane in the axial direction is 75° with overlap of 30° between vanes. The hub length is 175 mm and a hemispherical bluff body is provided in the upper part of the hub to have smooth guidance of the flow impinging on the hub.

III. EXPERIMENTAL FACILITY

To perform the experiments low speed vane blower with cascade tunnel is used. The flow of air through combustion swirler set up is provided by blower. Blower has a backward flow type of vanes. Cascade wind tunnel placed at the exit of the blower having convergent type of nozzle. The condition of the flow is of stagnation type in wind tunnel.

The tail end pipe is attached to reduce the back flow of fluid which can affect the swirl flow development in the expansion chamber. The axial velocity at the inlet of the test section is found to be 20 m/s for free jet. The position of the measuring locations in the axial length of the swirler at downstream region are provided to consider the exit of the swirler as the reference location so experimental values can be positive as shown in fig. 3.

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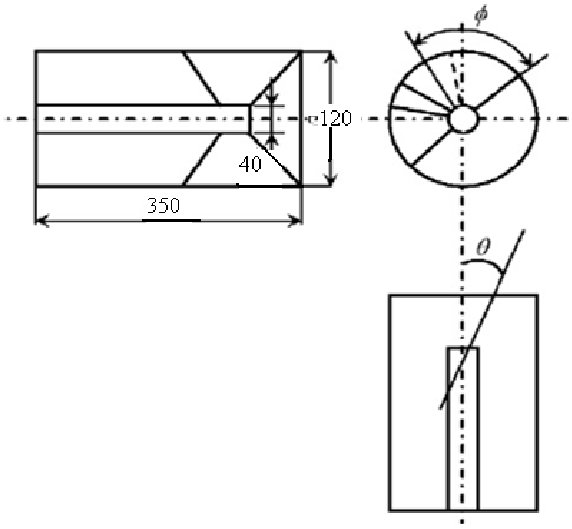

Fig. 2 swirler portion geometry

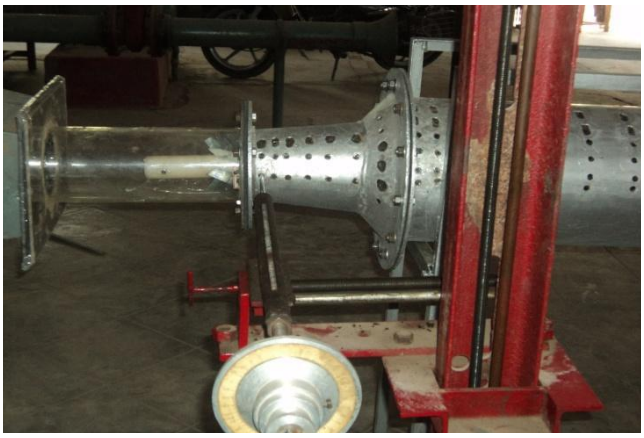

Fig.3 Experimental set up

IV. PRESSURE LOSS FACTOR

The pressure loss factor gives a measurement of the flow resistance when the air stream passes through the vane swirler. This pressure loss should be as small as possible for better fuel consumption in a combustion system. It is evident that the introduction of the vane swirlers necessarily introduces a certain amount of pressure loss in the system. The swirlers of varying vane angle are optimized when the pressure loss factor of each is known. The minimization of the total pressure drop is necessary in order to have proper recirculation zone for flame stabilization and sufficient turbulence and mixing.

V. RESULT AND DISCUSSION

At various axial locations the axial, radial and tangential velocities are measured. At each axial location the five-hole pitot sphere is moved for measuring the various velocity components. The fig.4 and fig.5 shows the axial velocity profiles from experimental values for six vanes swirler. As shown in fig.4, the negative velocity exists only at the centre point which is due to the presence of hub and the axial velocity increases gradually as we move from the centre to15 mm for six vanes swirler radially and thereafter the velocity reduces and almost reaches a constant value near the wall. The increase in the axial velocity is due to impart of kinetic energy to the moving fluid by the vane swirler.

For six vanes swirler, reverse velocity occurs from station A to K and maximum reverse velocity occurs is of 4.68 m/s at station F in the central portion. It can also be seen from the profiles that the values of axial velocities are positive from station L to P for six vanes swirler. The radial velocity is very small and negligible as compared to the axial and tangential gives in flame stabilization by generating a hot flow of recirculated combustion products and a reduced velocity region. The flame speed and flow velocity is matched in the recirculation zone.

It can be seen that the central recirculation occur for six vanes swirler up to the station K and ends at station L. For case of six vanes swirler, the maximum width of the recirculation zone is 35 mm at plane I on the either side of the central axis. The width of the liner is maximum about 0.59D and length of recirculation zone is 3.34D.

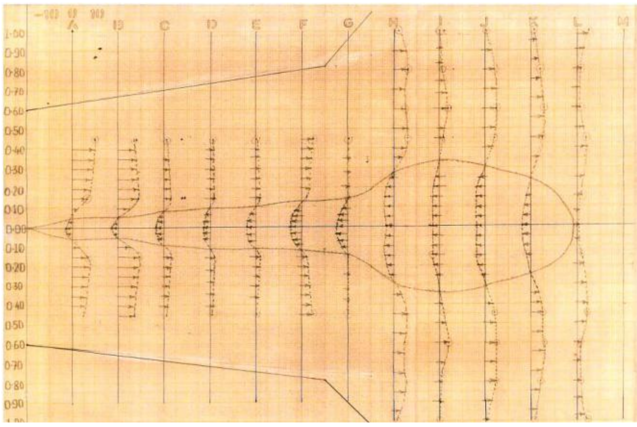

Fig.4 Recirculation zone for 45^{O} 6 vanes swirler with diffuser

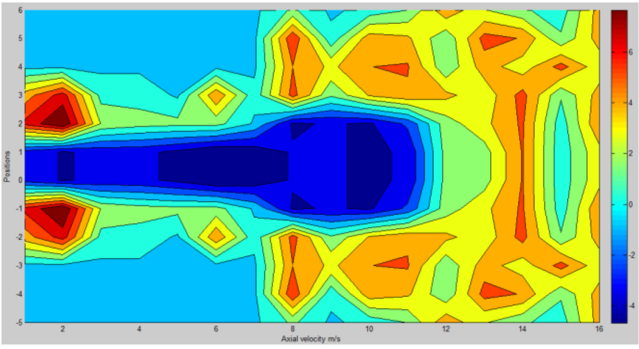

Fig.5 Recirculation zone for 45^{O} 6 vanes swirler with diffuser (MATLAB)

Similarly, as shown in fig.6 reverse velocity occurs from station A to G and maximum reverse velocity is at station A at the beginning. After that it is continuously decreasing. The recirculation zone for 6 vanes without diffuser ranges from station A to H and length of recirculation zone is less in comparison of with diffuser.

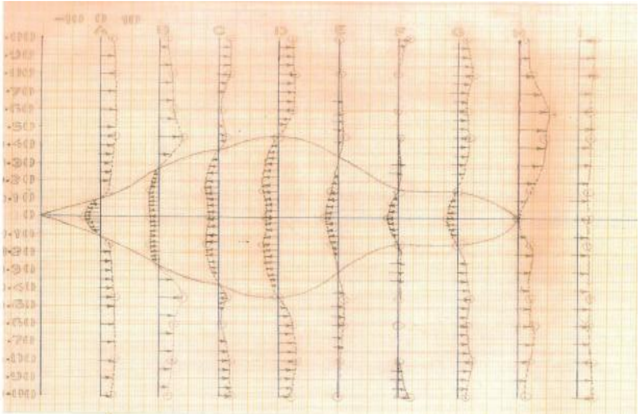

Fig.6 Recirculation zone for 45^{O} 6 vanes swirler without diffuser

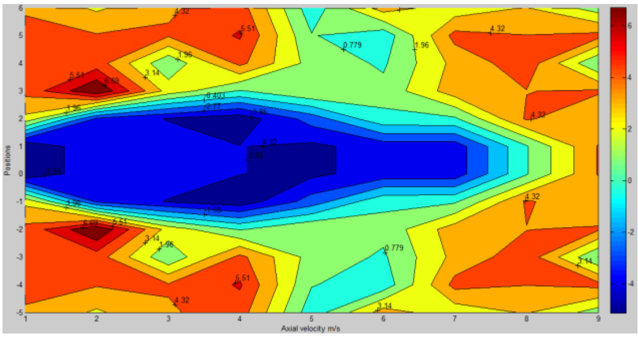

Fig.7 Recirculation zone for 45^{O} 6 vanes swirler without diffuser (MATLAB)

VI. CONCLUSION

The experimental results provide a basic bench mark data for validating the numerical results. A 45° 6 vane swirler with diffuser provides a reasonably good recirculation zone as compared to 6 vane swirler without diffuser which may help flame stabilization more efficiently. The pressure loss factor is also less for the prior case. The tailpipe provided at the downstream of the swirler will drop the pressure loss by avoiding the atmospheric disturbance. The measurement of axial, radial and tangential velocity helps to determine the mean flow field characteristics downstream of the swirler, which can be used for reacting flow studies in burners and combustors.

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