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A NUMERICAL AND EXPERIMENTAL APPROACH TO STUDY THE EFFECTS OF PASSAGE VELOCITY, DOME VELOCITY AND HOLE DIAMETER ON JET PENETRATION HEIGHT AND JET INCIDENCE ANGLE

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ABSTRACT

In a gas turbine system, the amount of heat produced is equal to the amount of power required. The combustor of the gas turbine unit efficiently produces heat to meet the demand for power. Enough heat is produced when fuel and air are mixed in the combustion chamber for effective combustion. The parts of the combustor also need to keep their temperature constant at the outlet. That is dependent upon appropriate air distribution, since various types of air will be required for various tasks. This article presents a fundamental analysis of the air velocity from the hole in relation to the duct's jet penetration height and jet incidence angle.

Keywords: Combustors, Jet incidence angle, Numerical, Jet penetration, Gas turbine

1. INTRODUCTION

One part of a gas turbine unit that meets the need for power according to the demand is the combustion chamber. The demand for power generation is determined by how well the air is supplied to the different parts of the gas turbine combustor. Figure 1 illustrated that. To satisfy their individual needs, different combustor zones get air supply through apertures of differing sizes [1, 2].

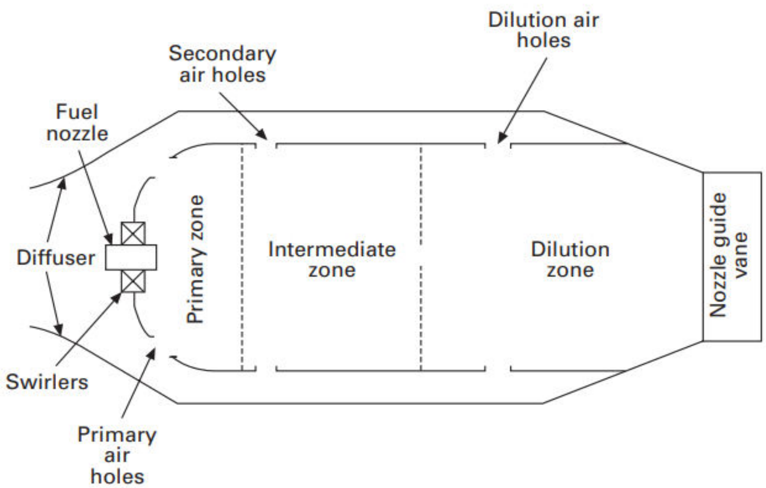

Fig. 1 Air distribution in Gas Turbine Combustor [1, 2]

Table 1 Typical dome and passage reference velocities [3]

Velocity	Nominal value	Range
Dome	9	7-12
Passage	50	35-60

2. CFD SIMULATION

Two stages of study were included in this project: first, it was numerically simulated for different air velocities from the hole to the duct side. Use the same setup for an experimental verification later on. Next, as shown in figure 2, the goal is to build a numerical analysis model with 400 × 229 ×100 mm in dimensions. The air in the test section should then be supplied through two inlets at the predetermined velocity as mentioned in reference [3], while adhering to the boundary conditions described below. From the findings, jet penetration height and incidence angle were then calculated.

Boundary conditions for numerical simulation in ANSYS as shown below:

Inlet 1: Passage velocity = Velocity input

Inlet 2: Duct velocity = Velocity unput

Turbulence Model: k – ε model

Outlet: Pressure gradient

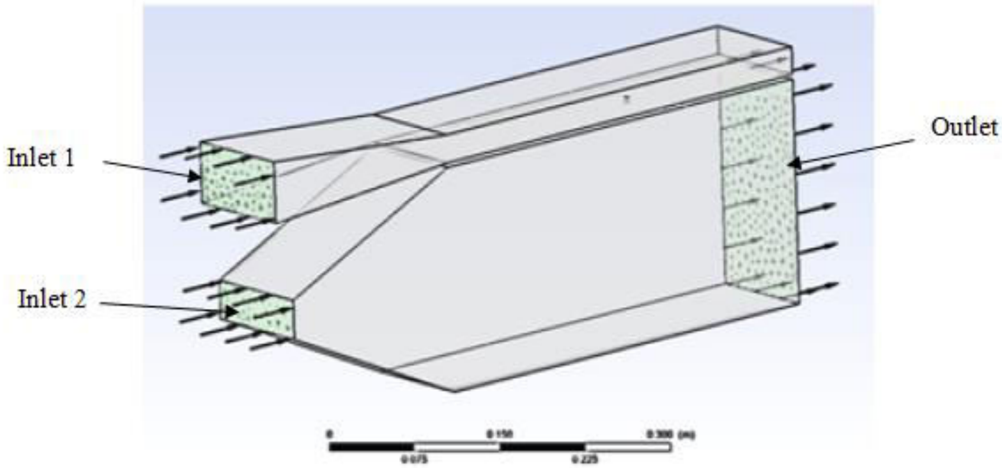

Fig. 2 Geometry model

3. EXPERIMENTATION

In accordance with the numerical simulation approach, the experiment used the blower to give air to the test portion. The blower is a component of the necessary air supply test setup. To see the flow, a test part was built out of translucent acrylic sheet. The flow was measured with a digital anemometer. The experimental setup for the study is displayed in Figure 3.

Fig. 3 Experimental Setup

The following is the procedure for experimentation:

- First and foremost, check the velocity from the blower's outlet.
- Then, with the flange, attach the test section to the blower outlet.
- The visualization technique allows you to measure the jet penetration height and incidence angle.

4. RESULTS & DISCUSSION

The first dome velocity was set at 7 m/s, 9 m/s, and 12 m/s via the ANSYS CFD program, which ran a numerical simulation and showed the results [3]. The first set of readings considered a single passage velocity ranging from 35 m/s to 60 m/s, with a 5 m/s increment based on varying hole sizes.

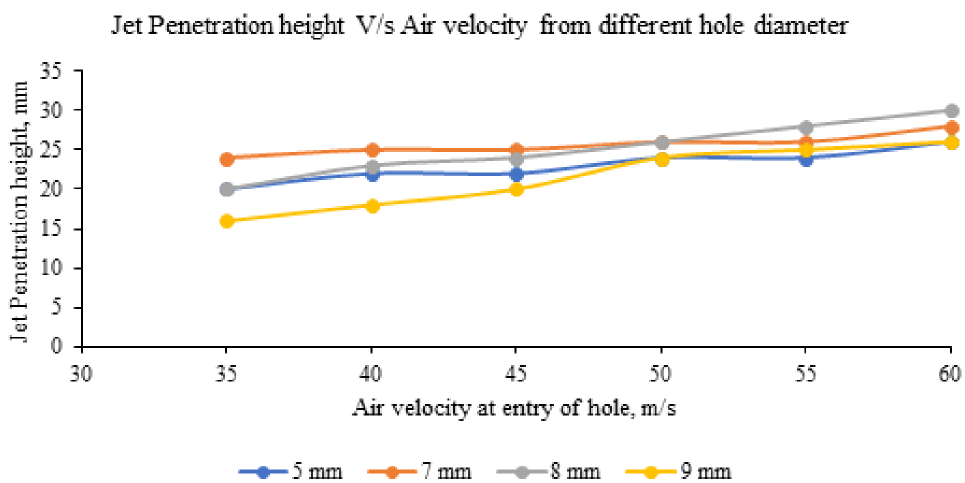

Fig.4 Jet penetration height at 7 m/s dome air velocity from different hole diameter

Using a dome velocity of 7 m/s and velocities passing through holes of varying diameters, Fig. 4 illustrates how, in accordance with the continuity equation, the jet penetration height increases as the passage velocity increases from the hole and the jet penetration height increases as the hole diameter decreases because of the increasing exit velocity of moving air from the hole.

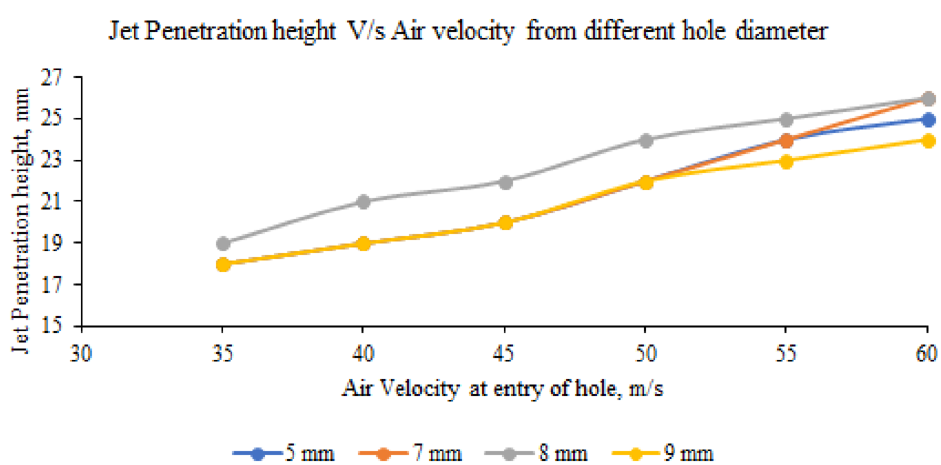

Fig.5 Jet penetration height at 9 m/s dome air velocity from different hole diameter

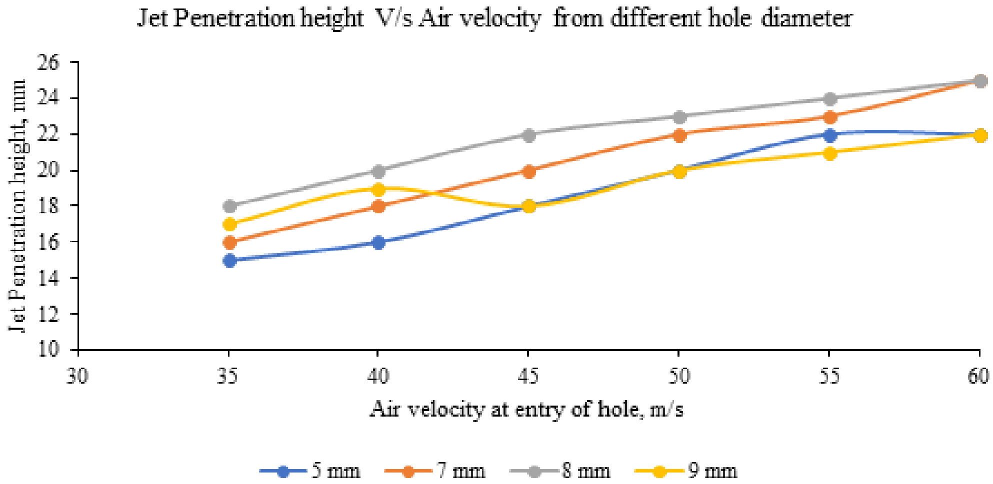

Fig.6 Jet penetration height at 12 m/s dome air velocity from different hole diameter

Figure 5 and Figure 6 illustrate the jet penetration height and dome velocity, respectively, with constant values of 9 m/s and 12 m/s. With the exception of 8 mm for hole sizes, the jet penetration height almost remains constant from 35 m/s to 50 m/s at a velocity of 9 m/s, which is easy to see in the graph. Likewise, the same pattern is seen at a speed of 12 m/s, with only a 9 mm diameter variation in velocity. A minimum jet penetration height of 15 mm was noted for a 12 m/s dome velocity at a passage velocity of 35 m/s, and a maximum jet penetration height of 30 mm for an 8 mm hole diameter at a passage velocity of 60 m/s and a dome velocity of 7 m/s.

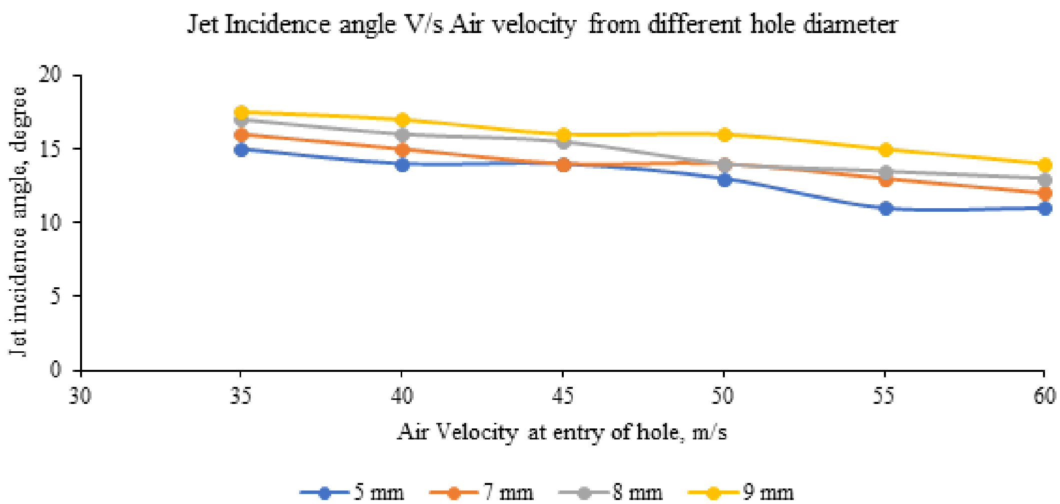

Fig.7 Jet incidence angle at 7 m/s dome air velocity from different hole diameter

Jet incidence angle decreases as the passing velocity rises from a hole when a dome velocity of 7 m/s passes through holes with different sizes, as shown in Fig. 7. Analogously, as the exit velocity of moving air from the hole increases, the jet incidence angle likewise decreases with decreasing hole diameter.

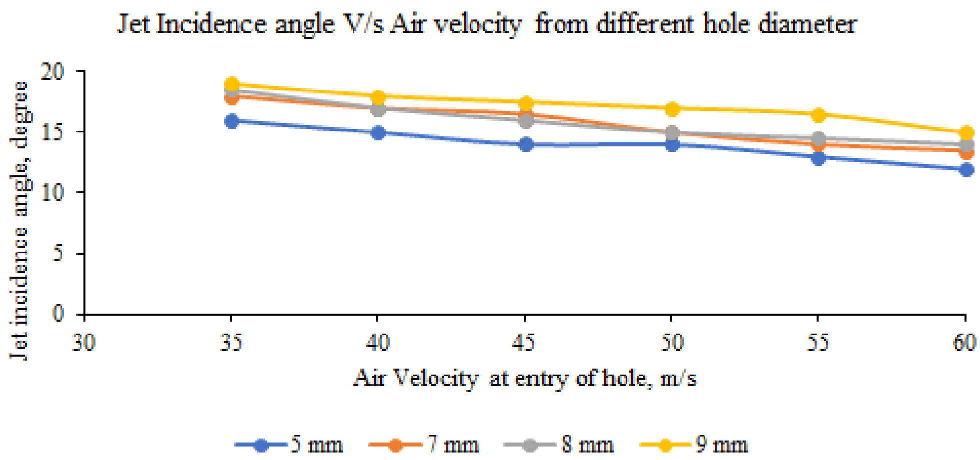

Fig.8 Jet incidence angle at 9 m/s dome air velocity from different hole diameter

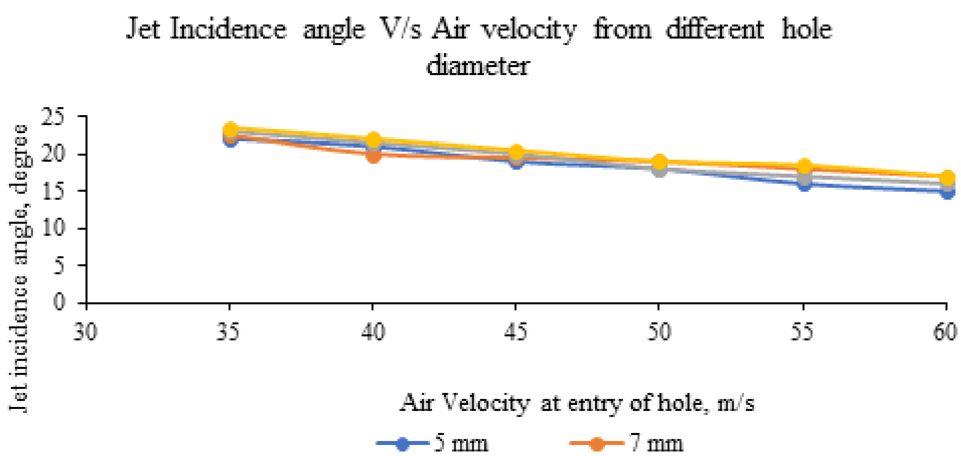

Fig.9 Jet incidence angle at 12 m/s dome air velocity from different hole diameter

Figures 8 and Fig. 9 illustrate the jet incidence angle and dome velocity, respectively, with 9 m/s and 12 m/s velocity, respectively. When the dome velocity was 7 m/s, the identical pattern was seen. Maximum jet incidence angle is found to be 23.5° with a 9 mm hole diameter, a passage velocity of 35 m/s, and a dome velocity of 12 m/s. When the dome velocity was 7 m/s and the passage velocity was 60 m/s, a minimum jet incidence angle of 11° was found.

Following the completion of trials with hole diameters of 7 and 8 mm, the passage velocity was kept at 35 m/s and the dome's velocity was kept at 7 m/s. The results of the experiments were compared with a numerical result, which is shown in Table 2.

Table 2 Numerical and experimental result comparison for jet penetration height and incidence angle

	Jet Penetration Height, Mm		Jet Incidence Angle, Degree	
	7 mm hole	**8 mm hole**	**7 mm hole**	**8 mm hole**
Numerical	24	20	16°	17°
Experimental	22	16	22°	25°

For hole diameters of 7 mm and 8 mm, the comparison of the numerical and experimental findings reveals a dome velocity of 7 m/s and a passage velocity of 35 m/s. In comparison to the experimental data, the numerical results show a higher jet penetration height. Moreover, it is discovered that the jet incidence angle's numerical value is less than the experimental value.

5. CONCLUSION

With hole diameters of 5 mm, 7 mm, 8 mm and 9 mm, the numerical study was conducted at various dome velocities of 7 m/s, 9 m/s and 12 m/s and various passage velocities of 35 m/s to 60 m/s in increments of 5 m/s. It is observed that the minimum jet penetration height was 15 mm for a 12 m/s dome velocity and a passage velocity of 35 m/s. Based on various combinations of all of this, it is found the maximum jet penetration height to be 30 mm for an 8 mm hole diameter with a passage velocity of 60 m/s and a dome velocity of 7 m/s. Also, it is observed the minimum jet incidence angle to be 11° for a 7 m/s dome velocity with a passage velocity of 60 m/s, and the maximum jet incidence angle to be 23.5° for a 9 mm hole diameter with a passage velocity of 35 m/s and a dome velocity of 12 m/s. The same pattern for jet penetration height and jet incidence angle was also noted during experimentation; however, because of the isolated boundary taken into account for numerical simulation and the effect of the atmosphere during experimentation, the values found were lower for jet penetration height and higher for jet incidence angle.

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