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GEOMETRICAL STUDY FOR A PRIVATE BURNER MIXING PIPE

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Abstract: *The study goal is to find the best design for the mixing pipe of a private burner. This study is used by local industry of burners. A numerical model and CFD is used for this purpose. Starting from the initial existing design, by reducing the pipe diameter, the elliptic flow zone for air and gas mixture is stabilized in the convergent section of the pipe. The new burner geometry works with lower gas pressure and the amount of sucked air is greater. In the final design, the elliptic flow zone is almost eliminated and the ejection factor has a higher value.*

Key words: *burner, CFD, mixing, pipe, geometry*

1. INTRODUCTION

Most common low power burners use a gas-air mixture obtained by using the potential energy of gas transformed into kinetic energy in order to suck the surrounding air. The mixing process takes place in a pipe, well known in the literature. (Otto, 1989) The mixing pipe has two sections: the conic section and the cylindrical one. The problem is to find the best dimensions for these sections in order to obtain a good mixing between air and gas and to keep this behaviour for low gas pressure. It is also important to stabilize the elliptic flow zone and to reduce its area.

Similar studies were performed by other authors on different burner shapes and by using other simulation software. (Bode et al., 2006; Hodor et al., 2006) These studies were focused on processes that take place in the combustion chamber offering less information about the mixing process inside the pipe burner.

In order to solve the above problem we use the general fluid flow code named Phoenics. Using a numerical model an elliptic flow zone for gas and air was revealed around the centre of the mixing pipe. It was assumed that by changing the diameter of the mixing pipe, the elliptic flow zone in the cylindrical section would be reduced. Numerical study uses KE-EP steady state turbulence model (Ferziger & Milovan, 1999; Patankar, 1980).

2. RESULTS AND DISCUSSIONS

It started with the initial solution, characterized by a cylindrical section diameter of φ=30 mm. Numerical simulation were made for diameters φ=24, φ=18 and φ=12 mm.

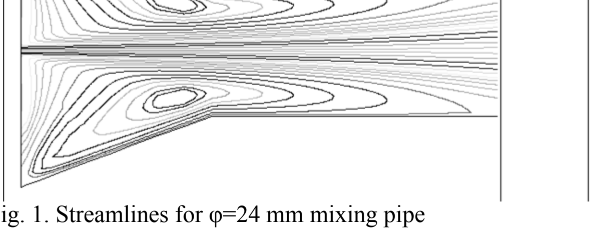

Fig. 1. Streamlines for φ=24 mm mixing pipe

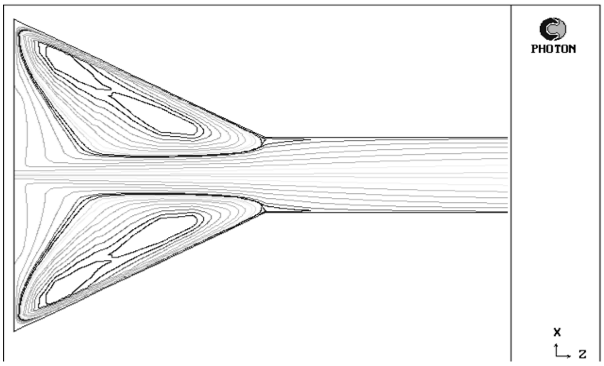

Fig. 2. Streamlines for φ=12 mm mixing pipe

The input parameters of gas and air were kept constant, so the other geometric dimensions. Figure 1 shows the current lines for tube diameter φ=24 mm. By comparison to where the tube has a diameter φ=30 mm, is seen as central elliptic flow zone has moved in the downstream region. By using smaller diameter cylindrical region, the elliptic flow zone is stabilized in the conical section of the mixing pipe, as shown in figure 2. Streamlines does not show turns into cylindrical region.

Velocity vector field for the case of using φ=24 mm tube is shown in figure 3. Near the cylindrical wall there is a movement in the opposite main flow direction. When using φ=12 mm diameter, (figure 4) velocity is directed towards the positive direction of Z-axis for the entire cylindrical section. Due to shrinking flow path, the absolute value for velocity is greater. At first, there is little difference in gas velocity at the centre of the tube for the four gas mixing tube diameters. The differences appear in the cylinder section and are similar downstream. Substantial changes occur on velocity along the tube wall because of the decrease of diameter from φ=30mm to φ=12 mm as shown in figure 5. The graph shows both the velocity and position of elliptic flow area by tracking on each curve the point where the velocity is positive. Elliptic flow zone ends about the coordinate z = 3.5 mm for φ=12 mm diameter. Looking at pressure variation in a plane perpendicular to Z-axis at z = 0, note that at lower diameter the negative pressure value is higher: from 60 Pa for φ=30 mm to 210 Pa for φ=12 mm.

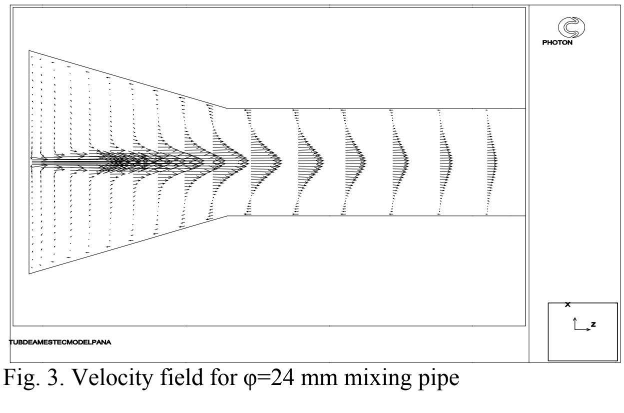

Fig. 3. Velocity field for φ=24 mm mixing pipe

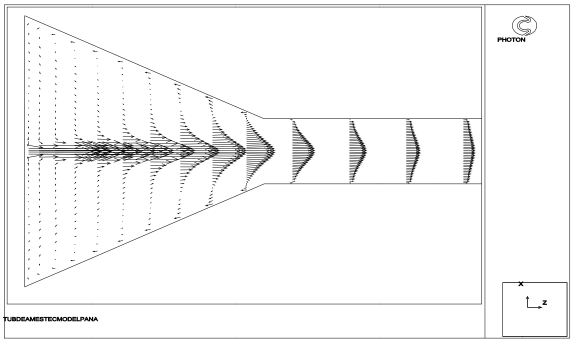

Fig. 4. Velocity field for φ=12 mm mixing pipe

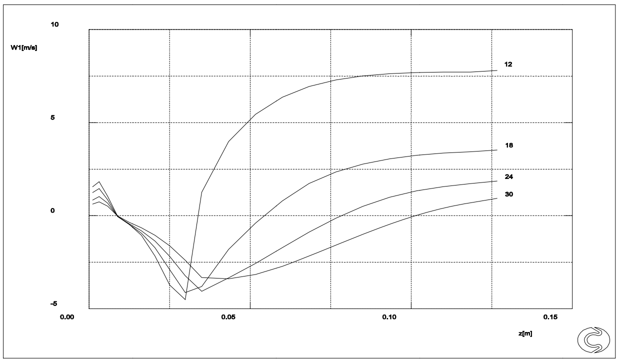

Fig. 5. Velocity near the mixing pipe wall

This means that the amount of sucked air is greater when using a mixing tube diameter φ=12 mm compared with initial solution. Since the fuel pressure is the same, one obtain a higher efficiency because with the same energy consumption the mass flux of free air is higher. Reducing mixing tube diameter below a certain limit, which depends on nozzle size and shape, gas nature, working pressure, produces flow diversion, undesirable phenomenon that compromises proper function.

The velocity in the final section of the conic zone increases as the area of the tube decrease. Higher velocities are located near the wall due to shrinking of the elliptic flow phenomenon. Observing the streamlines in figure 2 and velocity vectors in figure 4, the elliptic flow zone is seen as lacking in functionality. There are areas of stagnation and movement of gas follows concentric curves. These phenomena do not help either aspiration or gas-air mixing process. Therefore we propose to remove this area by shortening the mixing tube converging region from the original length z = 35 mm to z = 12.5 mm. Streamlines for this case are shown in figure 6.

There is a small area of elliptic flow in the starting portion of the cylindrical section that occupies a lower volume and has no substantial influence on flow. Complete elimination of this area is possible if the shape of the mixing tube follows the streamlines shown in figure 6. Practical realization of this profile is not difficult, economic considerations will lead to the choice of design.

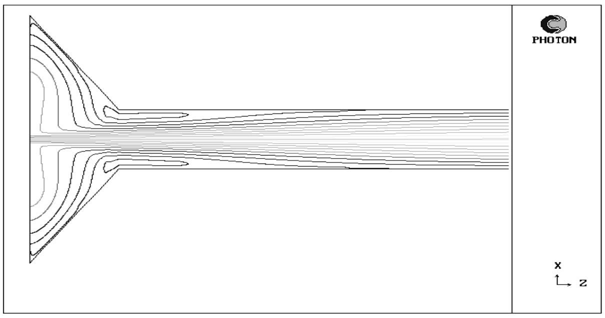

Fig. 6. Streamlines for new mixing pipe

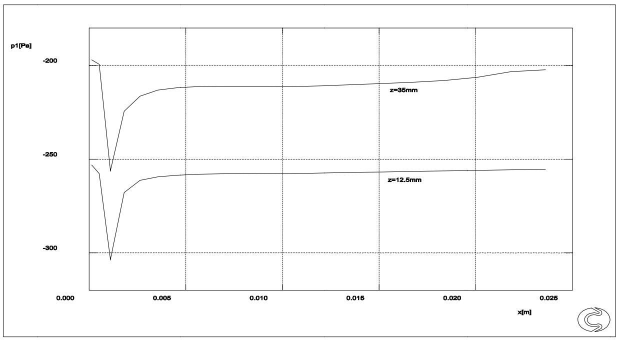

Fig. 7. The pressure in the upstream section

In order to evaluate the quantitative benefits of the new constructive solution presented in figure 6, figure 7 shows the variation of pressure in inlet section for atmospheric air. The inlet section is perpendicular to the tube axis Z, at z = 0.

There are two geometric designs represented in figure 7: the initial one that has the length z = 35 mm for the conic section and the new one with the length z = 12.5 mm. Both designs have tube diameter φ=12.5 mm. As shown, the pressure drops 50 Pa, which increase furthermore the ejection factor.

3. CONCLUSIONS

This research was made in order to find out the dimensions of the mixing tube which allow the entry of an enlarged amount of air at a given gas pressure. In the same time, the area of the elliptic flow zone which appears in the convergent section is intended to be as small as possible as this flow dissipates energy. Applied research strategy consists of changing diameter of the cylindrical tube and shortening the conical section than observe the effects on pressure and streamlines.

Based on this work the future research will study different pipe dimensions. Further research will be made for different shapes and different configurations of the mixing pipe. The grid will be refined for better precision. The future goal is to design a family of mixing pipes for different burners with better mixing conditions at low gas pressure. Numerical study is the best approach because in a short time many configurations can be analysed. The local burner industry is already interested in this research.

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