AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

Mechanical Power Engineering

Studying the Swirling Flames Using Elliptical Cross-Sections

A Thesis Submitted in partial fulfillment of the requirements of the degree of

Master of Science in Mechanical Engineering

(Mechanical Power Engineering)

By

Mohamed Mohy El Din Mohamed Morsy

Bachelor of Science in Mechanical Engineering

(Mechanical Power Engineering)

Faculty of Engineering, Ain Shams University, 2011

Supervised By

Prof. Mahmoud Mohammed Kamal Abd El Aziz

Dr. Hany El Sayed Abdel Haleem Saad

Cairo – (2016)

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Date: 22 December 2016

Statement

This thesis is submitted as a partial fulfillment of Master of Science in Mechanical Engineering, Faculty of Engineering, Ain Shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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Thesis Summary

The current experimental work presents a comparative study on some factors influencing the combustion characteristics of LPG diffusion flame issuing from double concentric elliptic swirl burners using a radial exit multi-hole fuel nozzle. The factors under investigation were; the variation of the ellipse aspect ratio, the variation of the inner and outer swirl angles and the variation of the swirling mode (co vs counter swirl).

All experiments were conducted at the same air to fuel ratio corresponding to excess air 20%. The performance assessment of the burners under investigation was based on the analysis of the local flame temperature values, pollutant emissions concentrations of CO, UHC and NOx in addition to flame length measurements. The quantification of these parameters was coupled with frontal photos of the confined flame and the plotted flame temperature contours in order to attain a more comprehensive analysis. Investigating the effect of the variation of the burner aspect ratio, the performance of three elliptic swirlers having aspect ratios of 1.25,1.4 and 1.5 was compared to a circular baseline swirler, all the swirlers had equal inner swirl angle of 30° and outer swirl angle of 45° with a co swirling mode. It was found that there was a progressive enhancement in the burner performance with the increase of the aspect ratio. A decrease in values of CO, NOx and UHC was recorded with the increase of the aspect ratio, this decrease was most significant for the 1.5 aspect ratio swirler recording a decrease of 47%,58% and 45% in the average values of CO,NOx and UHC respectively. The flame length became increasingly shortened with the increase of the aspect ratio, the 1.5 aspect ratio swirler recoded the shortest flame length with a reduction of 44% in the flame length. Furthermore, investigating the plotted flame temperature contours along the major and minor axes directions of the elliptic swirlers, it was found that there was a difference in the shape of the contours along both directions where the contours had a narrower silhouette along the minor axis and higher peak flame temperature value. For the second comparative study two elliptic swirlers with an aspect ratio of 1.4 were compared one having an inner swirl angle of 45° and outer swirl angle 30°, the second swirler had an inner swirl angle of

30° and an outer angle of 45°. The 45(inner)-30(outer) swirler recorded lower values of pollutant emissions as a consequence of higher turbulence levels and enhanced mixing associated with the stronger inner swirl, a reduction of 14%,13.5% and 27% in the average values of CO,NOx and UHC was exhibited by the 45(inner)-30(outer) swirler. In addition to that, the flame of the 45(inner)-30(outer) swirler had a shorter length with a decrease in length of 15%. Finally investigating the effect of varying the swirling mode, two swirlers were compared each having an inner swirl angle of 30°, an outer swirl angle of 45° and an aspect ratio of 1.4. The co swirl recorded lower values of pollutant emissions with a reduction in the values of CO,NOx and UHC by 15%,12% and 17.5% respectively. in addition, the flame of the co swirling scheme was shorter by 10%. The previous results establish the superiority of the performance of the co swirl over that of the counter swirl mode. Finally, it is worth mentioning that the factors that lead to an enhanced burner performance (for the investigated parameters range) are; Co swirling scheme, an increase in the inner swirl strength and an increase in the swirler aspect ratio.

Key words:

Diffusion Flame, Elliptic Double Swirl, Aspect Ratio, Co swirl,Counter Swirl.

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