AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING

STUDYING COMBUSTION OF FUEL /AIR MIXTURES PASSING THROUGH ELLIPTIC SWIRLERS

By

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A Thesis Submitted in Accordance with the Requirements For the Degree Of Master Of Science

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Cairo
2016

AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING

Master Thesis

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Thesis Title **:** Studying Combustion Of Fuel /Air Mixtures Passing Through Elliptic Swirlers

Degree **:** Master of Science

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Statement

This thesis is submitted to Ain Shams University for the grade of Master from Mechanical Power Engineering division.

The Work included this thesis was carried out by the author in the Mechanical Power Engineering, Ain Shams University from 24/3/2013 to 22/12/2016.

No partition of this thesis has been submitted for a grade or a requirement at any other college or institution.

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ACK NOWLEDGEMENT

I am deeply indebted to my supervisors, Professors **Dr. Mahmoud Mohammed Kamal Abd El-Aziz** and **Dr. Hamdy Ahmed Hussein Abotaleb** for their successful command, encouragement and continuous support.

I highly appreciate their productive guidance and help in my research.

I am deeply grateful to my mother and my wife who supported me during the daily work of the investigation.

Finally, I would like to thank the technical group who shared me the effort in the laboratory.

ABSTRACT

An experimental work has been carried out to characterize the combustion performance in terms of flame length, temperatures and emissions for a triple flame structure of concentric fuel rich mixture surrounded by fuel lean mixture premixed flame combined with the cross flow stream. The combustion performance of flames with using a set of elliptical double swirlers of different angles and aspect ratios were compared to that with using a circular double Swirler to investigate the effect of swirling direction modes (co- versus counter swirl), the effects of swirl angles, and ellipticity. It was found, for counter and co-swirl, that counter swirler leads to higher enhancement of combustion process than co-swirler, due to higher levels of premixing, insignificant differences in the flame length were observed. The counter swirl induces higher levels of turbulence than co-swirl with the consequent enhancement in the mixing of the mixtures and reducing the flame peak temperatures thus decreasing NO_X by 36%, CO by 29%, and UHC by 35% emissions comparison to that of the co-swirl. In addition, increasing the inner swirling angle shortens the flame length. Increasing the inner swirl favorably produces flames of higher average temperatures and lower emissions of CO and NO_X emissions. In this sense, it was found that the elliptic swirl of (45^oi, 30^oo) produces higher flame temperatures and lower emissions concentrations of NO_X by 38%, CO by 10%, and UHC by 29% compared to the elliptic swirl of (30^oi, 45^oo). Furthermore, it was found that the elliptic swirl shows shorter flame length than circular swirler, while the elliptic swirl of AR=1.25 produces the shortest flame length relative to other Swirlers of different aspect ratios. The effect of the ellipticity was noticeable, since it was found that the elliptic swirl of AR=1.25 produces flame of higher temperatures and lower $NO_X$and UHC emissions than any other Swirlers of different aspect ratios. Increasing the aspect ratio leads to decrease

of the concentrations of CO emission. Finally, it was concluded that double circular swirl produces higher CO, $NO_X$and UHCthan double elliptic swirl.

Regarding to changing the inner equivalence ratio, it is found that decreasing the inner equivalence ratio, from 3.6 to 2.7, has a favorable combustion performance of decreasing flame length, increasing flame temperature and decreasing the emissions.

Key Words: Combustion, Premixed flames, triple flames, Swirlers, elliptic swirlers, elliptic ports.

Table of Contents

List of Figures

List of Tables

NOMENCLATURE

A	Area	m^2
A/F	Air to fuel mass ratio	-
Cd	Coefficient of discharge	-
C.R.Z	Central recirculation zone	-
D	Combustor diameter	m
d	Thermocouple junction diameter	m
g	Gravitational acceleration	m / S^2
h	Water manometer height	m
K	Thermal conductivity	W/m.K
m^o	Mass flow rate	kg / s
Nu	Nusselt Number	-
P	Pressure	N / m^2
Pr	prandtl Number	-
R	Radial distance from combustor centerline	m
Re	Reynolds number	-
T	Temperature	K
X	Axial distance from the swirl face	m
AR	Aspect Ratio	-
Co-	Co-axial arrangement	-
CN-	Counter arrangement	-
LPM	Lean premixed	-
LIF	Laser Induced Fluorescence	-
PIV	Particle Image Velocimetry	-