



Cairo University

# **EXPERIMENTAL INVESTIGATION OF ENRICHED- HYDROGEN OXY COMBUSTION OF CNG FLAMES STABILIZED OVER A PERFORATED PLATE BURNER**

By  
**Samir Yahia Kamal Youssef**

A Thesis Submitted to the  
Faculty of Engineering at Cairo University  
in Partial Fulfillment of the  
Requirements for the Degree of  
**MASTER OF SCIENCE**  
in  
**Mechanical Power Engineering**

FACULTY OF ENGINEERING, CAIRO UNIVERSITY  
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**Title of Thesis:**

**Experimental Investigation of Enriched-hydrogen Oxy-combustion of CNG  
Flames Stabilized Over a Perforated Plate Burner**

**Key Words:**

**Flammability Limits, Oxy Combustion, Flashback, Enriched Hydrogen**

**Summary:**

Carbon Dioxide emissions resulting from the combustion of fossil fuels in power generation industries are considered to causing global warming. This study experimentally studies the conditions that must be met when burning a mixture of compressed natural gas and hydrogen gas with an oxidizer mixture made of Oxygen and carbon dioxide gases over a perforated-plate burner. The study succeeded to achieve a stabile flame made of 0% to 30% hydrogen fraction and the flammability limits were determined in different hydrogen fractions. Also, the visual flame appearance (shape, length and color) at different oxygen and hydrogen fractions was recorded.

## **Disclaimer**

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and have cited them in the references section.

Name: **Samir Yahia Kamal Youssef**

Date: 12 / 12 / 2019

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# Nomenclature

AFT	Adiabatic Flame Temperature
CNG	Compressed Natural Gas
CCS	Carbon Capture and Sequestration
FGR	Fuel Gas Recirculation
H.F.	Hydrogen Fraction
HRSG	Heat Recovery Steam Generator
IGCC	Integrated Gasification Combined Cycle
LEL	Lower Extinction Limit
LFL	Lower Flammability Limit
L/D	Degree of Premixing (the ratio between the pipe length L to its mean diameter D )
MFMs	Mass flow Meter
$\dot{m}^{\circ}$	Oxidizer Mass Flow Rate
NGCC	Natural Gas Combined Cycle
$n_{H_2}$	Number of moles of hydrogen divided by number of moles of both of hydrogen and methane.
NIS	National Institute of Standards
O.F.	Oxygen Fraction
Re	Reynolds Number
RFG	Recycled Flue Gases
UFL	Upper Flammability Limit

## Greek symbols

Ø: Equivalence ratio

Λ: Excess air factor