INFRARED (IR) INVESTIGATION OF THE FLAME STRUCTURES IN LABORATORY SCALE FIRE WHIRLS

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APPROVAL

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Approved:

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DECLARATION

I, the undersigned, hereby declare that this report is my own independent work except as specified in the references and acknowledgements. I have not committed plagiarism in the accomplishment of this work, nor have I falsified and/or invented the data in my work. I am aware of the University regulations on Plagiarism. I accept the academic penalties that may be imposed for any violation.

Signature ....

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ABSTRACT

Fire whirl, or used to be known as Firenado, has been very catastrophic to the nature as well as the property and life. Due to that fact, this research is being done to better understand the disaster. This report discusses the fire whirl in a laboratory-scale experiment with the objective to enhance the understanding of fire whirl by investigating the flame structure using IR camera, observing the fire characteristic from several orientations, analyzing the fire whirl state which are categorized to pool fire, small fire whirl, medium fire whirl, and long fire whirl. The experiment was set up with one half acrylic cylinder and 3 sizes of pan which are 0.045 m, 0.058 m, and 0.066 m respectively. The pan was placed in 2 placements. First placement is to be set with 5 inch/ 0.127 m gap and another placement are 0.076m. It was found that the fire will always twist to the direction of air entering the boundary. Also, throughout the scenario, medium fire whirl which is ranging from 0.15m to 0.3m is more dominant as it occurs about 50% to 70% for 3-inch gap and 70% to 80% for 5-inch gap. It was also observed that small pan has the highest fire whirl among all the three pans. When the fire is given more spaces or gaps, it tends to have a longer fire whirl.

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I would like to take this precious time to extend my gratitude to INTI International University that has provided this subject for the students to enhance their learning ability and prepare the student before embarking to the real world experience.

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Without all those mentioned above, this experiment would not be done. Thank you.

DEDICATION

This thesis is dedicated to my parents, family, and friends.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

CRZ	Central Recirculating Zone
CVP	Counter-Rotating Vortex Pair
ERZ	External Recirculating Zone
FLIR	Forward Looking Infrared Camera
IR	Infra Red
MPF	Multiple Pool Fire

NOMENCLATURE

Symbol	*Definition*
Z	Vertical distance from the ground
H	Flame height
R	Radial distance from the centerline [m]
$\dot{q}''$	Radiative heat flux in radial condition

CHAPTER 1

INTRODUCTION

1.1. Background

Fire whirl is a special swirling diffusion flame that may happen not only in urban areas but also wildland areas with the probability of causing a disastrous damage to both property and life. In fact, fire whirls are spinning diffusion flames which are strong convection. Its formation depends on the condition of the wind velocity and the physical structures around the fire. Its process can create a destructive effect to the surrounding despite the fact that the fire whirls linger for a few seconds to a few minutes. Fire whirls are often present in the earthquake, the building fire, and the forest fire.

Fire tornadoes are characterized by large-scale whirling flames that rise in 2 to 360m diameter vortices from 10 to 1200m high as described by Meroney (n.d.). The fire whirls accelerate combustion and they produce a substantial suction pressures and lifting forces. As a result, the fire whirls are able to carry burning debris, logs, and even buildings thousands of meters from the main fire. As the building atrium gets bigger, the control over the fire will get harder as it will generate vortices and internal fire whirls.

Fire whirls comprise of a core and an invisible pocket of rotating air that feeds fresh oxygen to the core which is the part that is on fire. The core of a typical fire whirl is 0.3 to 0.91 m wide and 15 to 30m tall. Under several conditions, large fire whirls can be induced up to several tens of meter wide and more than 300 m tall. The temperature inside the fire whirl core can reach up to 1,090 ^{o}C. Fire whirls are often formed when a wildfire or firestorm creates its own wind and it will turn into spinning vortex of flame (Shahan, 2014).

For some cases, combustible and carbon-rich gases released by burning vegetation on the ground can fuel most fire whirls as well. When it is sucked up, the unburned gas travels up to the core until it reaches the region which is enough fresh and heated oxygen to set it ablaze. It results on the tall and skinny appearance of a fire whirls core. Fire whirls can set objects in their paths to be on fire. It can throw burning debris out into their surroundings. Large fire whirls can create wind speed that is more than 160km/h which has the power to bring down trees.

According to Forthofer and Goodrick (2011) ,severely large fire whirls have been reported in urban fires that depict their destructively potential nature. In 1871, the Great Chicago Fire generated whirlwinds that lifted and transported burning planks 600 meters ahead of the main fire, which are involved greatly to the spread and destruction of the fire. On the same day, the catastrophe happened in Peshtigo, Wisconsin where a fire generated a strong enough whirl to lift up a hose from its foundation. A much more large and devastating whirl was formed in 1921 by a 7.9 magnitude earthquake in Tokyo, Japan which caused a mass urban fire. The fire formed an extremely devastatingly large fire that killed an estimated 38,000 people in less than 15 minutes. This catastrophe which is well known as The Great Kanto Earthquake fire is regarded as the worst in the history of fire whirl(Smithsonian, n.d.).

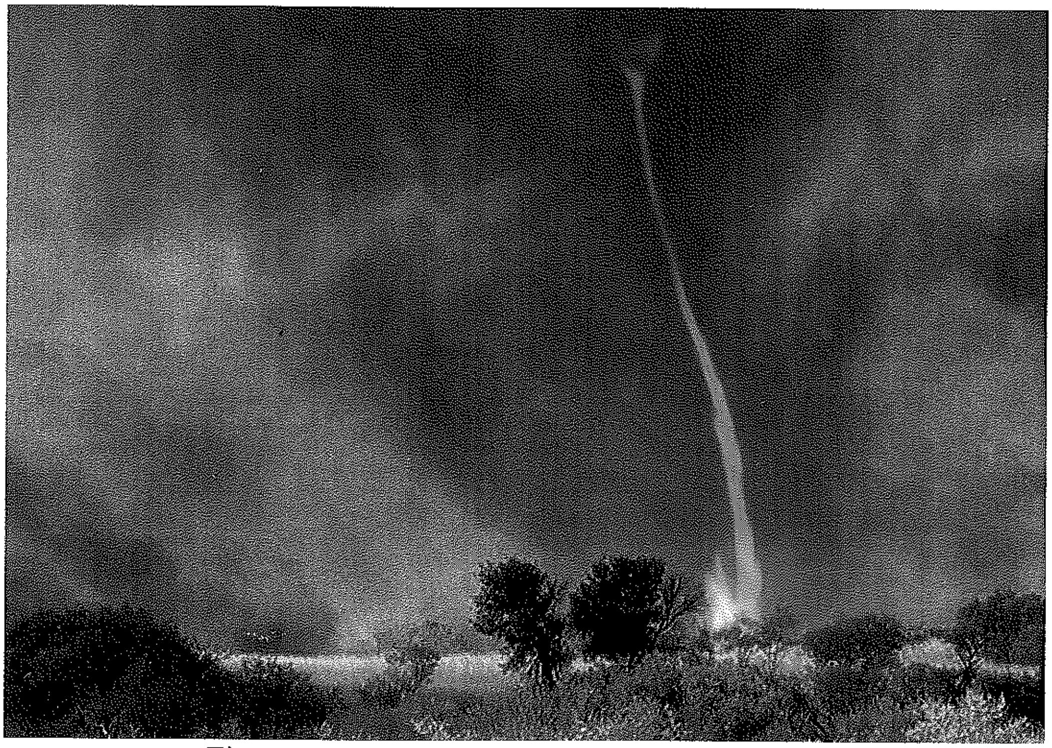

Figure 1-1 : Fire whirl that appeared in Australia
(South West News Service , 2012)