CHAPTER

6

THE BURNING BEHAVIORS OF HYDROCARBON AND ALCOHOL BASED FUELS POOL FIRES

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6.1 INTRODUCTION

A pool fire is a diffusion flame through which a thin film of volatile liquid fuel evapourates and burns. It is a major threat to a variety of industrial applications. Pool fires also cause explosions, leading to further fires, resulting in massive losses of property and life. Since the frequency and probability of pool fires are both peak, it is very crucial to estimate the risks related with pool fires to expect the behavior of fires accurately. Accidents within the chemical process industries (CPI) can escalate in various ways and lead to domino effect such as jet and open fires, the release of hazardous/toxic substances, or even explosions. Spontaneous fire-related incidents possess the potential to endanger individuals, induce harm to property, trigger substantial economic setbacks, and inflict ecological degradation (Pedersen, 2012; Reddy & Yarrakula, 2016). Hence, the proactive evaluation of assets prone to fire-related events is paramount to ensure the effective emergency preparedness, continuous monitoring, and the establishment of safety countermeasures are in place appropriately. Within this context, it is noteworthy that fire can manifest in diverse forms, such as jet fires, flash fires, pool fires, and fireballs, each governed by distinct influencing factors (Lees, 2012). For instance, a pool fire transpires when a flammable liquid spills onto the ground, inciting combustion. Conversely, jet fires are typically initiated by the leakage of gas from high-pressure equipment.

Fires, explosions, and the release of toxic substances represent the consequences stemming from chemical incidents. A majority of incident assessments have indicated that process-related accidents occur primarily due to deviations from normal operating conditions, which include instances of overheating and excessive pressure, as depicted in Figure 6.1. Notably, research findings emphasise that fire stands as a significant contributing factor to accidents, accounting for 44% of cases, along with containment failure at 51%, explosions at 36%, and gas clouds at 12.1% (Casal & Darbra, 2013).

	Number of accidents	% of known types
Loss of containment	3022	51.0
Fire	2603	44.0
Explosion	2133	36.0
Gas cloud	719	12.1

	Number of accidents	% of known types	% of category
Accidents with at least one of the following types of fire			
Undetemined fires	2211	37.3	84.9
Pool fire	112	1.9	4.3
Tank fire	108	1.8	4.2
Vapour/flash fire	94	1.6	3.6
Fireball	78	1.3	3.0
Torch/jet fire	15	0.3	0.6
Fire storm	1	0.1	0.0

Figure 6.1 Accident analysis in the past (Source: Casal & Darbra, 2013).

Among accidental incidents that can occur within an industrial facility, it was found that pool fires emerge as a prevalent occurrence, often accompanied by notable secondary consequences such as re-ignition and the potential propagation to adjacent flammable liquids (Bubbico et al., 2016). Few significant accidents in the chemical and process industries have been attributed to the domino effect (Khan & Abbasi, 2001). Is a pool fire, on the other side, likely to set off a chain reaction? Although the fire effects typically travel a considerably shorter distance than explosive effects because fire is the most common significant mishap, it is frequently observed as the initial step in domino sequences, in specific case of boiling-liquid expending-vapour explosion (BLEVEs). It can be said that fire has been found to be far more common than explosion in both initiating the domino effect sequence and in intermediate steps (Hemmatian et al., 2015).

This work gives insight into the behaviour of fire from hydrocarbon-based fuels such as n-heptane and kerosene, as well as alcohol-based fuel such as 2-Propanol. This is important to understand the influence of varying pool sizes and fuel reactivity on the average flame height and temperature of pool fire. Moreover, analysis of the impact of a vertical shaft during the combustion of a pool fire has the potential to generate an internal fire whirl since this event will escalate to more dangerous event such as BLEVE. This investigation is poised to enhance protocols for fire prevention and control, thereby leading to a decrease in fire-related occurrences within hydrocarbon refineries and storage sites.

6.2 METHOLOGICAL APPROACH IN POOL FIRES WORK

The pool fire tests were conducted outside, with humidity measured using a hydrometer before the test began, and wind velocity and temperature were determined using daily metrological data from the Malaysian Metrological Department's official website and a wind finder. In the test, n-heptane, kerosene and 2-Propanol fuels were used, and the detailed the properties and characteristics of the fuels are shown in Table 6.1. For the enclosure for the restricted air entrainment experiment, the following gap distance was as follows: 20, 40, and 80 cm.