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Liquid butane as an alternative fuel for diesel oil burners

Alejandro Sáez [a], Alex Flores-Maradiaga [b], Mario Toledo [a,*]

[a] Department of Mechanical Engineering, Universidad Técnica Federico Santa Maria, Av. España 1680, Valparaiso, Chile
[b] École de Technologie Supérieure, 1100 rue Notre-Dame Ouest, Montréal, Québec, Canada

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ABSTRACT

The experimental tests performed to study the combustion process of liquid butane employing a diesel oil burner are presented. For these tests, a dual pumping and injection system was designed to operate with pressures varying from 0.8 to 2.0 MPa. Five distinctive cases were tested for each fuel, obtaining a complete characterization of the combustion processes in comparable conditions. Flame geometries, temperatures and the main chemical products of the combustion process were recorded experimentally for both liquid butane and diesel oil. It was observed that liquid butane flames present elongated conical shapes, with low radiation cyan color at the base position, followed by a higher radiation zone in the core and flame front positions. Also, the temperatures and NO_x concentrations of liquid butane flames are lower than those of diesel oil flames. In general, it is feasible to modify the combustion technology of diesel oil burners to use liquid butane as an alternative fuel.

1. Introduction

In the last two decades, with the worldwide energy crisis, the price of diesel oil has sharply increased, imposing a huge economic burden to produce power at a reasonable cost for residential needs, commercial facilities and industrial production. This situation demands a constant search for alternatives that ensure a highly efficient power generation at the lowest possible cost. Thus, it is vital to analyze the feasibility of modifying the technology currently used for combustion processes to introduce alternative fuels that substitute diesel oil.

Diesel and fuel oil are the most consumed fuels in the industrial facilities and thermal power plants, which represents a major problem due to the permanent price increments and high speculation in oil markets. Additionally, as pointed out by Martyr and Plint [1], the hazardous pollution caused by handling and consumption of diesel oil has contributed to the rapid environmental degradation, which turns unfeasible the use of these fuels in the nearby future. Therefore, an opportunity to introduce alternative fuels has motivated detailed studies of biofuels, fuel blends, polluting exhaust emissions and comparative analysis of fuel prices.

Generally speaking, biofuels seem to be attractive substitutes to petroleum-based fuels, mostly because the majority of biofuels are obtained from renewable sources and the greenhouse effect gases are reduced. Nonetheless, experimental studies, such as the ones presented by Yoon and Lee [2] and Crookes et al. [3], have proven that some biofuels, under certain conditions, may retard the ignition phase and reduce the combustion performance, compromising any cost-effective power generation. In the case of biodiesel blends from vegetable oils, Agarwal et al. [4] explain that, without much chemical processing, usually these blends present high viscosities and fairly low volatility, causing high droplet size due to poor fuel atomization and jet-mixing. Hence, operational performance and durability of combustion technology are severely reduced.

Also, as clarified by Atsbury [5], the high soot formation from the combustion of some biodiesel blends and the flammable/explosive nature of biogases, bioethanols and hydrogen-based fuels may become safety hazards and environmental drawbacks to their complete approval for commercial thermal machines. Nonetheless, with the appropriate treatment and manipulation, biofuels still are good alternatives which mostly improve in the emission reduction of carbon monoxide (CO), unburned hydrocarbons (HC) and particulate material (PM) as demonstrated in the studies by Sayin and Canakci [6] and Rodrigues de Souza et al. [7].

From an economic point of view, an interesting result presented by Demirbas [8] indicates that, even though biodiesel blends have lower economic performance than diesel oil (in terms of plant capacity, process technology, raw material cost and chemical costs), they are strong competitors of natural gas and diesel oil for urban transportation and industries. Demirbas also remarks that biofuels provide the prospect of new economic opportunities by creating jobs for people in rural areas of developing countries, which usually are highly dependent in oil consumption. However, Chang and Su

* Corresponding author. Tel.: +56 32 2654162; fax: +56 32 2797472.
E-mail address: mario.toledo@usm.cl (M. Toledo).

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