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Comparative study on combustion and explosion characteristics of high flash point jet fuel

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Abstract

Jet fuel is a kind of hazardous chemical and it can easily result in combustion or explosion accidents in the process of production, use, storage, transportation and other aspects, so its safety issues are essential and urgent. Explosion performance testing device and combustion performance testing device have been used to study the combustion and explosion characteristics of high flash point jet fuel and No.3 jet fuel. The results show that the explosion pressure and explosion pressure rise rate have a rising trend with the spray pressure increases. The ignition time of high flash point jet fuel was later than that of No.3 jet fuel, showing that high flash point jet fuel is more safety than No.3 jet fuel. The obtained combustion and explosion parameters of the two kinds of jet fuel from the experiments can be used to evaluate their safety quantitatively.

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Keywords: high flash point jet fuel; combustion; explosion; spray pressure; sustainable burning time

1. Introduction

With the successful service of high performance aircraft in China, quality stable, safe and reliable jet fuel will be

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more urgent [1]. Jet fuel is specially made to satisfy particular characteristics of the jet engine. As the jet fuel is used in aeronautical turbine engines, it is necessary to ensure a high level of safety and reliability. With the development of modern flight technology, the requirements of safety and efficient jet fuel are very strict, therefore, air engines made the following main requirements for the quality of the fuel: firstly, good atomization and evaporation. The two indicators depends distillation range, vapor pressure and viscosity of the fuel. 10% distillation temperature directly affects the startup, 90% distillation temperature is to control the heavy fraction, it also explains that the difficulty of atomization and combustion is completely evaporated or not; secondly, good high altitude performance. Suitable saturated vapor pressure and evaporation, uniform distribution of distillation range to ensure that there is no air resistance in the altitude flight and low evaporation loss; thirdly, good combustion performance. Combustion should have an appropriate chemical composition to guarantee rapid, stable, complete combustion under various engine operating conditions [2–4].

There are six kinds of jet fuel in China, high flash point jet fuel (called RP-5) and No.3 jet fuel (called RP-3) are used mostly and normally. RP-3 has been widely used in commercial airplanes and military aircraft during recent years. RP-5 is a kind of heavy kerosene fuel, its prominent feature is the high flash point, the fuel mainly used in navy ship borne aircraft. Although jet fuel have high flash point, it also involve security issues. In the process of storage and use, especially for the good performance evaporation and combustion of the jet fuel, the fuel due to form vapor because of leakage, mixed air and fuel in the cabin or atmosphere became a certain concentration of combustible medium, the medium may occur serious combustion and explosion accidents once get in touch with fire[5–6]. Therefore, it is of great significant to study the combustion and explosion characteristics of high flash point jet fuel.

2. Experimental devices and process

2.1. Physical and chemical properties

The fuel includes RP-5 and RP-3, The main indicators of the fuel such as flash point, freezing point, density, kinematic viscosity, gross calorific value and so on are important parameters that directly related to the atomization and combustion performance. We get physical and chemical properties of the fuel according to the national standard test methods of petroleum products. The main indicators of the fuel are shown in Table 1. As we can see in the Table, the flash point of RP-5 is larger than that of RP-3, the former is 39.2% larger than the latter and RP-5 has advantage in safety issue. The kinematic viscosity of RP-5 is relatively high, it is more difficult to atomize and the particle size is big than RP-3.

Table 1. The main indicators of the fuel.

Properties	RP-5	RP-3
Flash point (ºC)	74	45
Freezing point (ºC)	-52	-58
Density (20ºC) (kg/m^3)	815.0	790.3
Kinematic viscosity (20ºC) (mm^2/s)	5.869	1.792
Gross calorific value (MJ/kg)	42.95	43.07

2.2. Explosion experiments

The explosion performance testing experiments were carried out in a explosion sphere vessel and its volume is 20L. The experiments system was composed of explosion sphere vessel, ignition system, gas circulation system, control system, data acquisition system and some other parts. Essentially, the vessel was designed to withstand explosion pressure up to 4 Mpa. The ignition source was placed in the center of the vessel. Use a pyrotechnic igniter with the energy of 2 kJ as energy source to ignite the gas/vapor system. In the experiment, the vessel was evacuated to a vacuum degree, and then high pressure air carried with fuel though dispersed nozzle sprayed the fuel to the vessel and formed liquid droplets that had high degree of turbulence.

The experiment conditions are as follows: the volume of the sample fuel is 50mL, the closing time of the sample