Research on Improvement of Low Temperature Fluidity of Biodiesel

Shuaishuai Lv¹, Tao Yang¹, Deqin She², Yonglan Liu¹,², Ya Li², Xingxing Wang¹, Songyuan Li¹ and Hongjun Ni¹*

¹School of Mechanical Engineering, Nantong University, Nantong, Jiangsu Province, 226019, China
²Nantong Vocational College of Science & Technology, Nantong, Jiangsu Province, 226019, China
*Corresponding author’s e-mail: 2548488264@qq.com

Abstract: The effects of CFI and blending ratio on the low temperature fluidity of biodiesel were discussed by adding CFI to biodiesel and blending biodiesel with 0# diesel. Blending biodiesel with 0# diesel oil in low proportion can effectively reduce the CFPP of biodiesel. The CFPP of blended biodiesel oil increases with the increase of the proportion of biodiesel. The CFPP of blended biodiesel oil decreased first and then increased with the increase of CFI.

1. Introduction

Biodiesel is an alternative product of petroleum fuels made from plant oil and animal oil. It has the advantages of biodegradability, renewable resources, non-toxicity and complete combustion. It can be used without revamping the existing diesel engine. It has good performance and great market potential[1-5]. However, compared with traditional petroleum fuels, biodiesel still has some shortcomings such as poor low-temperature fluidity.

The technical indicators for evaluating low temperature fluidity of diesel oil at home and abroad mainly include Cloud Point (CP), Pour Point (PP), Solidification Point (SP) and Cold Filter Plugging Point (CFPP). SP and CFPP are commonly used in China, while CP, PP and CFPP are commonly used in foreign countries to describe the low temperature performance of petrochemical diesel[6]. Compared with the other three indexes, CFPP can evaluate the low temperature performance of biodiesel more accurately. [7] The low temperature fluidity of biodiesel for diesel engine fuel blending in China is measured by CFPP, that is, the highest temperature of oil sample which can not pass through filter screen within 1 minute. [8] Different from petrochemical diesel, the composition and content of fatty acid methyl ester of biodiesel are relatively fixed, and its low temperature fluidity can not be improved by changing the refining process. At present, the main methods to improve the low-temperature fluidity of biodiesel are: winterization, adding cryogenic fluidity improver (CFI), and blending method. At present, many scholars at home and abroad have studied the improvement of low temperature flow performance of biodiesel. Hoo et al. [9] improved the low temperature fluidity of biodiesel by winterization. Yuan Menghong [10] improves the low-temperature fluidity of biodiesel by adding different proportions of alcohol or diesel oil to the biodiesel. Shen Jiaxu et al. [11] studied the combined effects of pour point depressants and antioxidants on the properties of biodiesel. It was found that pour point depressants and antioxidants had a greater impact on the combination of the pour point and the kinematic viscosity of biodiesel. Wang Wenchao et al. [12] optimized the ester structure of biodiesel. It was found that isoamyl
alcohol could effectively reduce the condensation point and CFPP of biodiesel and improve the low temperature fluidity of biodiesel. He Kangkang et al. [13] The low-temperature fluidity of biodiesel was improved by blending petrochemical diesel with rapeseed oil or rice oil and adding branched alcohol to methanol. It was found that blending and adding branched alcohol could effectively improve the low-temperature fluidity of biodiesel.

2. Materials and methods of experiment

2.1 Main experimental materials and equipment
The experimental materials are shown in Table 1.

| materials                  | Manufacturer                  |
|----------------------------|-------------------------------|
| Rapeseed oil               | Jiangsu Zhenjiang Dantu Oil Plant |
| Cottonseed oil             | Jiangsu Zhenjiang Dantu Oil Plant |
| palm oil                   | Jiangsu Zhenjiang Dantu Oil Plant |
| Bangjie Diesel Coagulant    | Sinopec                       |

The main reagents needed for the test are shown in Table 2.

| reagents                  | Purity | Manufacturer                          |
|---------------------------|--------|---------------------------------------|
| Anhydrous methanol        | AR     | Shanghai Kexing Biochemical Reagent Co., Ltd. |
| sodium hydroxide          | AR     | Jiangyin Kailai Chemical Co., Ltd.      |
| Anhydrous sodium sulfate  | AR     | Jiangyin Kailai Chemical Co., Ltd.      |

The test instrument is JSR1506 automatic diesel oil and civil fuel CFPP detector: Hunan Jinshi Petrochemical Instrument Co., Ltd.

2.2 Experimental Process
NaOH and anhydrous methanol were used to prepare sodium methanol solution. The reaction was carried out by stirring and heating the feed oil. Then the reaction mixture is added to the pear-shaped separator funnel. After setting for a period of time, take the upper mixture and stir it with water, then remove the lower water phase until the solution is neutral. Finally, anhydrous sodium sulfate was added to the mixture and stirred to produce biodiesel.

2.3 Cold Filtration Point Measurement
According to the SH/T0248-92 standard method, 45ml biodiesel produced by the above method was injected into the test cup. The test cup was placed in a hot water bath, and the oil was heated to 30±5℃. The test cup is placed in a cold bath under specified conditions. When the test oil is cooled to 5-6℃ higher than the expected temperature, it is sucked at 1.96KPa pressure. The test cup is then placed in a cold bath under specified conditions. When the sample is cooled to 5-6℃ higher than the expected temperature, it is sucked at 1.96KPa pressure so that biodiesel passes through a 363 mesh/square inch filter and stops when the filtered sample reaches 20ml. Continue to cool at intervals of 1℃, then suction and repeated operation. The highest temperature of less than 20 ml through the filter within 1 minute is used as the CFPP of biodiesel.

3. Results and discussion

3.1 Effect of CFI on Low Temperature Fluidity of Biodiesel
The biodiesel produced by experiment conforms to GB/T 20828-2007. By adding cryogenic fluidity improver (CFI) to blended biodiesel fuels B10, B20, B50 and B100, the effects of CFI on low temperature fluidity of biodiesel at different blending ratios were studied.
3.1.1 Effect of CFI on Low Temperature Fluidity of Biodiesel Blended Fuel B10

Fig. 1 shows that CFI has a great influence on Biodiesel Blended Fuel B10. When no CFI is added, the CFPP of B10 is -5°C. With the increasing amount of CFI is added, the CFPP of B10 decreases. When the addition of CFI reaches 0.6%, the CFPP of B10 decreases to the lowest, to -17°C. Adding more CFI when reaching the lowest point, the CFPP of B10 will rise.

![CFI addition ratio (Volume ratio)](image1)

Figure 1. Effect of CFI on Biodiesel Blended Fuel B10.

3.1.2 Effect of CFI on Low Temperature Fluidity of Biodiesel Blended Fuel B20

As can be seen from Figure 2, the influence of CFI on Biodiesel Blended Fuel B20 is not as great as that of B10, and the addition of CFI has also increased a lot. When CFI is not added, the CFPP of B20 is -3°C. With the increase of CFI, the CFPP of B20 decreases. When the addition amount of CFI reaches 1%, the CFPP of B20 decreases to −16°C, and then the CFPP of B20 increases by a large margin with the addition of CFI.

![CFI addition ratio (Volume ratio)](image2)

Figure 2. Effect of CFI on Biodiesel Blended Fuel B20.

3.1.3 Effect of CFI on Low Temperature Fluidity of Biodiesel Blended Fuel B50

Fig. 3 shows that the influence of CFI on B50 of Biodiesel Blended fuel is less than that of B10 and B20, and the proportion of CFI increases obviously. When CFI is not added, the CFPP of B50 is 1°C. With the increase of CFI, the CFPP of B50 shows a downward trend. When the addition of CFI reaches 2%, the CFPP of B50 decreases to the lowest of −8°C, and then the CFPP of B50 increases with the increase of the content of CFI.
3.1.4 Effect of CFI on Low Temperature Fluidity of Biodiesel Blended Fuel B100
It can be seen from Fig. 4 that CFI has little effect on Biodiesel Blended Fuel B100, while the proportion of CFI increases significantly. When CFI is not added, the CFPP of B100 is 7°C. With the increase of CFI, the CFPP of B100 shows a downward trend. When the addition of CFI reaches 3.6%, the CFPP of B100 decreases by 4°C. Then continues to add CFI, the CFPP of B100 tends to remain unchanged.

3.2 Effect of Blending Ratio on Low Temperature Fluidity of Biodiesel
From Fig. 5, it can be seen that the blending ratio has a great influence on the CFPP of Biodiesel Blended fuel. When biodiesel was not added, the CFPP of B0 was -9°C. With the increasing blending ratio, the CFPP of Biodiesel Blended Fuel increased. When the addition of biodiesel is 5%, the CFPP of Biodiesel Blended fuel is equal to that of B0. When the addition of biodiesel is more than 50%, the CFPP of Biodiesel Blended fuel reaches above zero.
4. Conclusions
(1) Blending biodiesel with 0# diesel oil in low proportion (B5) can effectively reduce the CFPP of biodiesel. The CFPP of Biodiesel Blended oil increases with the increase of the proportion of biodiesel.
(2) The CFPP of Biodiesel Blended Oil (B10, B20, B50) first decreased and then increased with the increase of CFI dosage. It shows that the effect of CFI is not the more the better, there is the best point of CFI dosage. This phenomenon can be explained by pour point depression mechanism. When biodiesel crystallizes at low temperatures, cryogenic flow improvers can hinder nucleation and crystal growth. However, when the amount of cryogenic fluidity improver is too much, the original non-nucleated and non-grown crystals will accumulate, and when accumulated to a certain extent the cryogenic fluidity will also deteriorate.
(3) The CFI used in the research has no obvious effect on improving the low-temperature fluidity of biodiesel (B100).

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