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Key Influencing Factors Research of Domestic and Import Aviation Lubricating Oil Foam Characteristics

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Abstract. The foam characteristics plays a key role towards the application of aviation apparatus, which also affected by several influencing factors. This paper focuses on researching the key factors of the foam characteristics of the domestic and imported aviation lubricating oils, by comparing a certain type of domestic aviation lubricating oil or imported aviation lubricating oil's foam characteristics at different oxidation temperature or oxidation length by virtue of utilizing aviation lubricating oil oxidation experimental device. The influencing factors that impact foam characteristics were analyzed to provide important theoretic and experimental support.

Keywords. Aviation Lubricating Oil; Foam Characteristics; Influencing Factors; Oxidation temperature; Oxidation time

1. Introduction

With the continuous improvement of the performance of new aviation turbine engines, studies on key factors influencing foam characteristics of domestic and imported aviation lubricating oil are attracting more researchers and funding. Due to the increasing rotation speed, working power and load, important parameters such as the turbine front temperature, pressure, supercharging ratio and thrust-weight ratio are constant increasing for better performances, which makes aviation lubricating oil subject to more intense oscillation and agitation. This puts forward higher requirements for foam characteristics of aviation lubricating oil. As aviation lubricating oil inevitably mixes with air during work, bubbles are formed under the action of interfacial tension, which will not only significantly increase the foam volume of aviation lubricating oil and seriously affect the lubrication condition of aviation engine, but also cause the oil to have obvious physical and chemical properties decay under the action of high temperature. Make its lubrication wear reduction, cooling and heat dissipation, clean dispersion, sealing and plugging, corrosion and rust prevention functions are adversely affected. Existing studies [2] have found that the amount of foam produced by the oxidation of gasoline oil at 150 ℃ increases significantly. The results show that the increase of oxidation temperature will lead to the increase of foam volume and the decrease of foam resistance. The addition method [3] and the blending method [4] may also lead to the uneven dispersion of the anti-foaming agent, and the settlement of the anti-foaming agent after standing, leading to the deterioration of the anti-foaming performance of the oil, or even the unqualified phenomenon. In addition, the selection and cleaning of gas diffuser also have an important influence on the measurement of foam characteristics. It is found that for some oil products with good foam characteristics, the aperture size of the diffuser has little influence on the test results. However, for oil products with certain foaming properties, the smaller the aperture, the larger the test data [5]. At the same time, the gas content of oil [6], inorganic salts [7], silicon [8] and laboratory conditions [9] will also affect the foam characteristics of lubricating oil.

This paper intends to conduct a comparative study on the foam characteristics of a certain type of domestic and imported aviation lubricating oil, investigate the change law of the foam characteristics of this type of domestic and imported aviation lubricating oil under different oxidation conditions, and study the key influencing factors of the foam characteristics of domestic and imported aviation lubricating oil, so as to provide a beneficial practical basis for solving the problem of engine performance limitation caused by the increase of aviation lubricating oil foam.

2. Experimental Section

The two types of aviation lubricating oil studied in this paper are purchased from Henan Aviation Materials Technology Co., LTD., in which the operating temperature of domestic aviation lubricating oil is -40 ºC to 200 ºC, and that of imported oil is -40 ºC to 175 ºC. In order to further study the key influencing factors of foam characteristics of this type of domestic and imported

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aviation lubricating oil, This type of domestic and imported aviation lubricating oil was oxidized at 175 ºC, 200 ºC and 230 ºC respectively by using the aviation lubricating oil oxidation test device shown in Figure 1. The specific experimental steps are as follows: 200 mL oil sample is added into the clean and dry oxidation tube, and the dry air flow rate is 10 L/h. After the oil bath at the corresponding temperature (175 ºC, 200 ºC, 230 ºC), the oxidation tube is cooled to room temperature, and the simulated oxidized oil sample is prepared. Table 1 shows the preparation conditions of aviation lubricating oil samples at 175 ºC, 200 ºC and 230 ºC for 0.5 to 8 hours:

Table 1. Preparation scheme of simulated oxidized oil sample for aviation lubricating oil.

Oxidizing temperature	Oxidation time
175 oC	0.5h, 1h, 4h, 8h
200 oC	0.5h, 1h, 4h, 8h
230 oC	0.5h, 1h, 4h, 8h

The oxidized oil samples of the domestic and imported aviation lubricating oil were prepared by oxidation reaction. According to GB/T12579-2002 standard, the foam characteristics of the two types of aviation lubricating oil before and after oxidation were measured at 24 ºC。

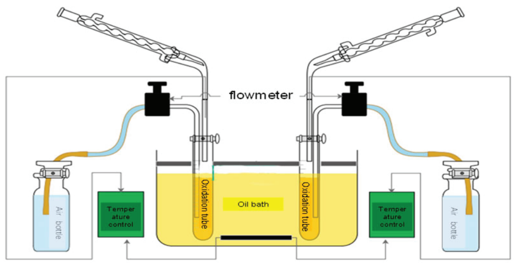

Figure 1. Oxidation test device for aviation lubricating oil.

3. Restle and discussion

3.1 Foam characteristics of a domestic aviation lubricating oil after oxidation at 175 o C

Oil samples of this type of domestic aviation lubricating oil oxidized for 0.5h, 1h, 2h, 4h and 8h were prepared at 175 ºC by simulated oxidation test. The foam characteristics of the new oil and the oxidized oil samples were determined respectively, and the influence of oxidation time factors on the performance of this type of domestic aviation lubricating oil at 175 ºC was analyzed.

Figure 2. Oil samples of a certain domestic aviation lubricating oil oxidized for 8h, 4h, 1h and 0.5h at 175 oC.

Table 2. Foam volume of domestic aviation lubricating oil (oxidized at 175 oC

Simulated oil sample	Total volume (mL)	Foam volume (mL)
New oil	215	55
0.5h	220	60
1h	295	180
4h	335	215
8h	345	220

Firstly, the foam volume of the new domestic aviation lubricating oil was obtained through foam characteristic test. Table 2 shows the foam volume measurement results of the simulated oil sample. The experimental results show that the foam volume of this type of domestic aviation lubricating oil is 60mL when oxidized for 0.5h at 175℃, and 215 and 220mL after oxidizing for 4 and 8h, respectively. The foam volume of this type of domestic aviation lubricating oil is about 4 times higher than that of the oxidized oil sample at 0.5h. In general, with the increase of oxidation time of the domestic aviation lubricating oil, the foam volume increases significantly and the foam characteristics become worse.

3.2 Foam characteristics of a certain domestic aviation lubricating oil after oxidation at 200℃

After oxidation at 200℃, the color of this domestic aviation lubricating oil gradually deepened, but the oil did not precipitate, indicating that there was no obvious abnormality in the appearance of this oil at 200℃. The foam volume of this oil will be determined in accordance with GB/T12579-2002 standard.

Figure 3. Oil samples of a certain domestic aviation lubricating oil oxidized for 8h, 4h, 1h and 0.5h at 200℃

The foam characteristics of the domestic aviation lubricating oil samples oxidized for 0.5h, 1h, 4h and 8h at 200 ℃ were tested. It was found that the foam characteristics changed significantly with the oxidation time.

Table 3. Foam volume of domestic aviation lubricating oil (oxidized at 200℃)

Simulated oil sample	Total volume (mL)	Foam volume (mL)
New oil	215	55
0.5h	215	50
1h	360	245
4h	400	280
8h	440	345

Table 3 shows the measurement results of foam volume of simulated oil sample. Measured results show that the foam volume of this type of domestic aviation lubricating oil is 50mL when oxidized for 0.5h at 200℃, and the foam volume corresponding to oxidized oil for 1h is 245mL. The foam volume is 390% higher than that of oxidized oil sample for 0.5h, and the foam volume corresponding to oxidized oil sample for 4h is 280mL. Compared with the oxidized oil sample at 0.5h, the foam volume increased by 460%, the foam volume corresponding to the oxidized oil sample at 8h was 345mL, and the foam volume increased by 590% compared with that of the oxidized oil sample at 0.5h. It can be seen that the foam volume corresponding to the oxidized oil for 0.5h was basically the same as that of the new oil at 200℃. However, after oxidizing for 1h, the foam resistance deteriorates and the foam volume increases significantly. The foam properties of the oil sample oxidized for 8h were the worst, and the foam volume of the oil sample oxidized for 0.5h increased by 590% compared with that of the oil sample oxidized for 0.5h.

3.3 Foam characteristics of a certain domestic aviation lubricating oil after oxidation at 230℃

After oxidation at 230℃, the appearance color of oxidized oil sample shown in Figure 4 changes greatly, and there is no precipitated substance. Table 4 shows the foam volume measurement results of 230℃ simulated oxidized oil sample of this domestic aviation lubricating oil. The measured results show that the foam volume of this type of domestic aviation lubricating oil is 110mL when oxidized for 0.5h and 30mL when oxidized for 4h and 8h at 230℃. At 230℃, the foam characteristics of oxidized oil sample decreased instead of rising, and its foam volume was even smaller than that of new oil, which was different from the previous foam volume test results measured at 175 ℃ and 200℃.

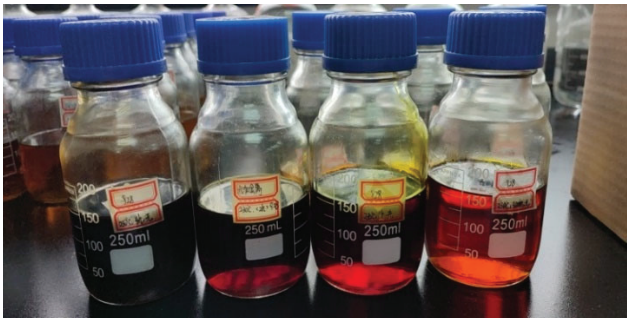

Figure 4. Oil samples of a certain domestic aviation lubricating oil oxidized for 8h, 4h, 1h and 0.5h at 230℃

Table 4. Foam volume of domestic aviation lubricating oil (230℃)

Simulated oil sample	Total volume (mL)	Foam volume (mL)
New oil	215	55
0.5h	225	110
1h	220	60
4h	210	30
8h	210	30

3.4 Foam characteristics of a certain imported aviation lubricating oil after oxidation at 175℃, 200℃ and 230℃

The oil samples of this type of imported aviation lubricating oil oxidized for 0.5h, 1h, 4h and 8h were prepared by simulated oxidation tests at 175 ℃, 200 ℃ and 230℃ respectively. The foam characteristics of the imported aviation lubricating oil were determined respectively and the influence of oxidation factors on its performance was analyzed.

Table 5. Foam volume of imported aviation lubricating oil (oxidized at 175℃, 200℃ and 230℃)

Simulated oil sample	Total volume (mL)			Foam volume (mL)		
	175℃	200℃	230℃	175℃	200℃	230℃
New oil	205	205	205	10	10	10
0.5h	205	205	205	10	10	10
1h	205	215	205	10	20	10
4h	205	210	215	10	10	15
8h	210	210	215	15	10	15

Table 5 shows the foam volume measurement results of simulated oil samples of imported aviation lubricating oil at 175, 200 and 230℃. The measured results show that the foam volume of this type of imported aviation lubricating oil is less than 20mL when oxidized for 8 hours at 175 ℃, 200 ℃ and 230℃, and the foam characteristics are very excellent.

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Specific view, oxidative 0.5 hours after the simulation sample of bubble volume is almost the same with the new oil, that import aviation lubricating oil bubble features at the beginning of the oxidation with oxidation temperature insensitive. With the increase of oxidation time, the foam increases slightly, indicating that the oxidation has an effect on the oil composition, and then affects the foam characteristics. In general, the foam characteristics of imported aviation lubricating oil are significantly better than those of domestic aviation lubricating oil. Under the same oxidation decay condition, the foam volume of imported aviation lubricating oil is about 1/10 to 1/20 of domestic. At the same time, even when oxidized at 230℃, the foam volume of imported aviation lubricating oil is still below 15mL, which basically conforms to the foam characteristic standard of this new imported aviation lubricating oil, indicating that its foam characteristics still have great potential at higher oxidation temperature.

3.5 Analysis on key influencing factors of foam characteristics of domestic and imported aviation lubricating oil

According to the above experimental studies, the foam characteristics of imported aviation lubricating oil are better, and the foam volume of domestic aviation lubricating oil is still lower than 30mL (24℃) under relatively strict experimental conditions (8h oxidation at 230℃). By contrast, the foam characteristics of domestic aviation lubricating oil are worse, and the foam volume of domestic aviation lubricating oil is as high as 345mL (24℃) after 8h oxidation at 230℃. It shows that domestic aviation lubricating oil is greatly affected by experimental factors, especially oxidation temperature has a significant effect on foam characteristics of domestic aviation lubricating oil. The foam volume of oil samples oxidized at 200℃ for 8h is significantly larger than that of oil samples oxidized at 230℃ for 8h, indicating that the foam characteristics of this type of domestic aviation lubricating oil decrease significantly with higher oxidation temperature. In addition, the foam volume of oxidized oil samples at 175℃ and 200℃ increases with the increase of oxidation time, suggesting that oxidation time is also a key factor affecting the foam characteristics of this type of domestic aviation oil.

In addition, it was found that the foam volume of the aviation lubricating oil decreased significantly after oxidation at 230℃, and even the foam volume of the aviation lubricating oil after oxidation for 8 hours was smaller than that of the new oil. It is found in the research literature that a variety of domestic and imported aviation lubricating oil products will undergo physicochemical property jump at 230℃ [10]. The viscosity decreased significantly and acid value increased significantly. In order to investigate the reasons for the abnormal changes, the PAO base oil of this domestic aviation lubricating oil was oxidized and its kinematic viscosity changes at 40 and 100℃ were measured, as shown in Figure 5.

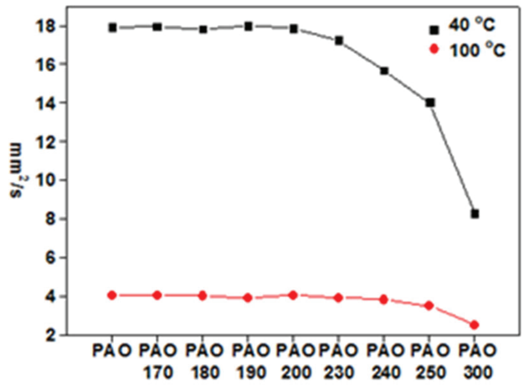

Figure 5. Movement viscosity of oil samples in PAO high-temperature oxidation tests at 40 ℃ and 100℃

The experimental results showed that for PAO oxidized oil samples, the motion viscosity at 100℃ was relatively flat, while the motion viscosity at 40℃ was more obvious, and the reference value was higher than that at 100℃. Therefore, the PAO high-temperature reoxidation test oil samples at 40℃ were used as the reference for analysis. The kinematic viscosity of PAO oxidized oil at 40℃ did not change significantly when the oxidation temperature was lower than 230℃. However, if the oxidation test temperature continued to rise, the kinematic viscosity would change significantly, which can be clearly seen from FIG. 5: The motion viscosity of PAO oxidized oil starts to change gently at 40 ℃ , and decreases significantly from 230℃ to 230℃. With the increasing of the oxidation temperature, the curve presents a steep slope and the viscosity gradually increases. Therefore, it is concluded that the molecular structure of the oil sample changes little when the oxidation temperature is below 230℃, and the degree of pyrolysis reaction is shallow. When the oxidation temperature exceeds the temperature, the degree of pyrolysis deepens abruptly. The foam characteristics of lubricating oil are related to the viscosity of oil. When the oxidation temperature of oil is above 230℃, the viscosity decreases and the molecular structure is damaged obviously, which affects the foaming properties of oil and reduces the foam volume. However, when the oxidation temperature is below 230℃, the decrease of foam volume does not indicate that the quality of the oil becomes better, and the decrease of its viscosity may lead to the significant deterioration of the service performance of the oil.

4. Conclusion

In this paper, the variation law of foam characteristics of domestic and imported aviation lubricating oil is studied. It is found that domestic aviation lubricating oil is greatly affected by oxidation time and temperature, while imported aviation lubricating oil is not sensitive. At low oxidation temperature (175℃), the foam volume of domestic aviation lubricating oil showed a significant increase trend, and the trend expanded further at 200℃, but when further increased to 230 ℃ , the viscosity decreased significantly, resulting in a significant decrease in foam volume, indicating that oxidation temperature, oxidation time and kinematic viscosity are the key factors affecting the foam characteristics of domestic aviation lubricating oil.

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