Study on combustion and emission of Biodiesel Engine with different angle of oil beam

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Abstract. In order to reduce the excess pollutants caused by environmental factors, on the basis of the installation of post-treatment device, through the use of converse software, the simulation research on the combustion process of non road diesel engines in the cylinder was carried out in the cold environment, and the combustion processed and emission reduction of diesel engine were optimized under the condition of only changing the angle of oil beam. The results show that the temperature in cylinders is the highest, and the pressure in the cylinder is larger, the equivalence ratio and eddy current intensity in cylinder are stronger, the emissions are lower, and the emissions of NOx and soot are the lowest under the angle of 164° fuel beam.

1. Introduction

With the increasingly prominent problems of energy shortage and environmental pollution, it has become the focus on the industry to find an environmentally renewable alternative fuel and develop the technology of energy saving and emission reduction of internal combustion engine. Biomass diesel has the characteristics of green, environmental protection, strong renewable ability, and can be directly used in diesel engines. It has attracted high attention and rapid development in the world. At present, scholars at home and abroad mainly carry out the following aspects in the research of Biodiesel: the incompatibility of biodiesel materials, carbon deposition in the cylinder, filter plug and other applicability studies, which are used to solve the engine fault caused by its physical and chemical properties; the different physical and chemical properties of biodiesel and diesel make their combustion characteristics and emission characteristics different; the engine burning biodiesel mixture. Design alcohol fuel to improve the emission characteristics of diesel engine; change combustion mode at low temperature to improve the emission characteristics of Biodiesel Engine [1]. As for the problem of poor engine power and economy caused by the high cold and low-pressure plateau geographical environment, the research abroad is earlier, and in recent years, domestic scholars have also carried out research [2-5]. Yu Linxiao et al of Beijing University of science and technology have found that the use of biodiesel in high altitude area makes the ignition time advance and the proportion of premixed combustion stage. The emissions of PM, HC and co decrease with the increase of altitude, and the altitude has little effect on NOx emissions [6]. Zheng Pei, Professor of Inner Mongolia University of technology and others [7-8] conducted the dynamic and economic tests of biodiesel and No. 35 diesel under the conditions of Inner Mongolia Plateau and simulated plain, and obtained that the torque and power of the engine burning biodiesel under the plateau environment increased, while the fuel consumption also increased accordingly. It can be seen from the literature retrieval that most of the experimental methods are used to study and analyze the combustion process of the supercharged diesel engine, and the simulation methods are used in the high cold environment. The research on the combustion processes optimization
and emission reduction of the biodiesel is scarce. At present, there are three main technical schemes to reduce engine pollutant emissions: pre-treatment technology, in cylinder purification technology based on new combustion theory and exhaust gas post-treatment technology [9]. Each technical measure has limited effect of / on reducing a certain exhaust component. So it needs to add post-treatment technology on this basis to achieve higher emission standards. But it will cause a large consumption of precious metals and a significant increase in engines cost. On the basis of not changing the engine structure as much as possible , this paper ensures that the overall structure of the engine has not been greatly changed and no aftertreatment device is installed, ensuring that the overall structure of the engine has not been changed and no after treatment device has installed , this paper uses converge software to study the emission of pollutants from burning biodiesel in the plateau area of Inner Mongolia. By changing the injection strategy, the diesel engine with excessive emissions can improve its power performance and be close to the national emission standard, aiming at the pollution caused by environmental factors The improvement to emissions and engine resource consumption provides reference.

2. Model construction and verification
At the same time of strictly controlling automobiles exhaust emissions, non road machinery puts forward higher requirements for the reliability, acceleration and economy of the engine due to its poor working conditions, heavy load and drastic changes [10]. TAF1 single cylinder direct injection air-cooled diesel engines is selected in this paper, which has certain representativeness. See Table 1 for main performance indexes.

| Parameter                      | Technical specifications |
|--------------------------------|--------------------------|
| Diesel engine model            | TAF1                     |
| Bore *Stroke                   | 87.5*110mm               |
| Compression ratio              | 17.5:1                   |
| Speed                          | 1500rpm                  |
| Intake valve open              | 4.5CA BTDC               |
| Intake valve close             | 35.5CA ABDC              |
| Exhaust valve open             | 35.5CA BTDC              |
| Exhaust valve close            | 4.5CA ATDC               |

The Inner Mongolia Plateau has an average altitude of 1000-1500m, an average pressure in 88000-89000pa, and an average temperature of 5-21 ℃. According to the engine technical parameters, the model speed is set to 1500rpm, and the initial intake air temperature is 5 ℃.
China has a vast territory, with plateau area accounting for about 1/3 of the country. Low atmospheric pressure and low temperature and low oxygen are the significant characteristics of plateau area. Inner Mongolia is rich in raw material resources suitable for developing biodiesel. At present, the planting area of Xanthoceras sorbifolia is 13.45 million mus, and the oil resources have great development potential.

3. The influence of the angle of oil beams on combustion and emission performance in cylinder

3.1. Combustion characteristic analysis
Because the injection cone angle determines the drop point of the fuel injection of the cylinder, the injection cone angle is too small, the fuel is concentrated near the fuel beam, the fuel concentration in most of the outer space is thin, which is not conducive to the fuel distribution [11], the injection cone angle is too large, the central air in the combustion chamber is not utilized, which has a significant effect on the overall air utilization rate of the combustion chamber [12].

![Cylinder pressure diagram with different injection cone angles](image1)

As shown in the figure, four jet cone angles of 128°, 140°, 152° and 164° are designed respectively. As shown in Figure 2, the pressure and temperature in cylinders under different injection cone angles had little effect on the cylinder pressure trend. With the increase in the injection cone angle, the combustion is earlier and faster, the ignition delay period is shortened, and the cylinder pressure on 164° injection nozzle angles is the smallest, only 5.32Mpa, which is 6% lower than the original engine. With the increase in jet cone angle, the cylinder temperature increases, and the cylinder temperature of
152 degree jet cone angles is the largest in five kinds. This is because the increase in jet cone angles makes the fuel wall impingement increase, and the contact area of the spray oils to beam of biodiesel increase to the air. The high temperature of the cylinder wall promotes the combustion of droplet's and accelerates the combustion reaction. However, with the increase of the injection cone angle, the central air in the combustion chamber can not be fully utilized, which has a significant effect on the overall air utilization rate of the combustion chamber, the temperature in the cylinder decreases.

| Initial model | I | II | III | IV |
|---------------|---|----|-----|----|
| equiv_ratio   | 0.0 | 0.2 | 0.5 | 1.1 |
| velocity      | 0  | 1  | 2  | 3   |

Figure 3 Cloud chart of equivalence ratio and velocity at different jet cone angles at peak time

As shown in the figure, with the increase of the injection cone angle, the equivalence ratio decreases, the eddy current speed in the cylinder slows down. At 152 °s, the fuel is sufficient, the air flow intensity in the cylinder increases, the increase rate of the equivalence ratio increases slightly, and the eddy current speed in the cylinder is faster. However, with the increase of the injection cone angle, the air utilization rate decreases, which makes the equivalence ratio and the swirl velocity in the cylinder slow down.

3.2. Emission characteristics analysis

| Initial model | I | II | III | IV |
|---------------|---|----|-----|----|
| SOOT          | 0e-000 | 2e-005 | 4e-005 | 6e-005 |
| NOx           | 0e-000 | 2e-005 | 4e-005 | 6e-005 |

Figure 4 Cloud images of root and NOx at different injection cone angles at peak time

The cloud chart of the soot and NOx emissions of / from different injection cone angles at the peak time are shown in the figure. The formation condition of SOET is high temperature and anoxia, and the formation condition of NOx is high temperature and oxygen enrichment. With the increase in the angle
between oil and gas, the mixture of oil and gas in the combustion chamber is more uniform, which speeds up the chemical reaction. With the increase in the area and amount of biodiesel wall impingement, and the increase in fuel atomization level, the mixture of fuel and air is sufficient, the oxidation reaction is accelerated, and the fuel is ignited and fully combusted earlier with high wall temperature. Therefore, the amount of emissions is reduced. Under the 164 ° jet cone angle, the amount of NOx emissions is the lowest, and the amount of soot emissions is almost zero.

4. Conclusion
In the high cold environment, the cylinder pressure in/on biodiesel is the smallest when the injection angle is 164 °s and the cumulative heat release ratio is the first among the five injection angles when the injection angle is 152 °s. The increase rate of equivalence ratio is slightly increased and the eddy current speed in the cylinder is faster. The combustion performance is good, but with the increase of injection cone angle, the generation of soot and NOx emissions is the lowest when the injection angle is 164 °.

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