Experimental Study on Diesel Engine Fueled with Ethanol-Diesel-Gasoline Blends

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Abstract: The homogeneous and stable ethanol-diesel-gasoline blend fuel is formed by using gasoline as the solubilizer. The performance experiments are carried out on 135 single-cylinder 4-valve diesel engine with different mixture rate of this new blend-fuel and different nozzle modes. The results show the following conclusions: fueled with appropriate rate ethanol-diesel-gasoline blend fuel, the engine power output and fuel economy of engine keep the same level to those of diesel fuel operation while the soot and NO_x emission decreased remarkably; at the same time, ignition delay period prolongs, in-cylinder mean temperature decreases, combustion velocity becomes higher, combustion duration becomes shorter. When HL conical spray nozzle and the E20G15 blend fuel are used, the fuel/air mixing velocity and the homogeneous of mixture are improved; in the whole operation range, in-cylinder pressure and mean temperature are both lower, moreover, soot and NO_x emission are decreased; the combustion process has obvious characteristics of hot premixed combustion mode.

Key words: diesohol; diesel engine; blend fuel; combustion
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Ethanol is a bio-fuel made from plants and crops, the characteristics of reproducible and environmental protection make the researches of its application on internal combustion engine are focused much attention upon. Wherever home or abroad, there are many researches on ethanol[1-2]. Now, ethanol fuel has been extended and applied to gasoline engine successfully. However, there are some problems and difficulties on the application of ethanol fuel in diesel engine, and it is still at researching stage[3-4].

Ethanol molecule contains with 34.8% oxygen, ethanol has the characteristics of low theoretical air-fuel ratio and wide ignition range, which can improve combustion; ethanol and gasoline have similar characteristics: lower cetane number and viscosity, and good consistency with each other; but the characteristics of ethanol are different from those of diesel: ethanol has lower calorific value, higher gasification latent heat and bad consistency with diesel. For gasoline can dissolve with ethanol and diesel respectively, this paper proposes some homogeneous and stable diesohol which fit for diesel engine; the combustion performance experiments are carried out on 135 single-cylinder diesel engine. The effect of burning blend fuel with HL (High dispersion and Long penetration) conical spray nozzle[5] on the combustion and emission performances of diesel engine is researched.

1 Experiment condition

1.1 Confection of blend fuel

Confection of blend fuel adopts volume method, and gasoline is used to be the solubilizer of the ethanol-diesel blend fuel which is confected to fit for diesel engine. For example, the blend fuel is confected by 60% diesel, 20% ethanol and 20% gasoline. It is abbreviated as E20G20 fuel, subsequent blend fuel is written into shortening as this rule, and 100% diesel fuel will be written into E0. For comparison, combustion and emission performances of E0, E15G15, E20G15, E20G20 burning in diesel engine are researched in this experiment.

Fuel consumption in experiment is switched into the fuel consumption of diesel following the conservation of energy principle.

1.2 Experiment apparatus and method

The engine in experiment is 135 single-cylinder 4-valve natural aspiration diesel engine. Performance comparison experiments are done according to constant speed characteristics at rated speed.

On condition of $7\times0.25\times150^\circ$ multi-hole nozzle, blend fuel with different rate are used in comparison experiment.

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Conical spray nozzle was invented by Dalian university of technology at end of 1970's; it is mainly applied to the research of DHPC (Diesel Hot Premixed Combustion)[6-7]. HL conical spray nozzle is the second generation of conical spray nozzle. It can be seen from Fig. 1. In experiment, HL$\Phi 1.5\times 140^\circ$ nozzle is used, and tip diameter of needle d_c is 1.5 mm, orientation surface corner angle β is 140°.

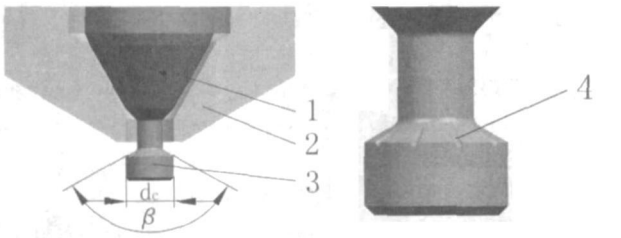

Fig. 1　Schematic diagram of HL conical spray nozzle
1. Needle, 2. Needle seating,
3. Conical protuberance at head of needle,
4. Grooves on cone shape orientation surface.

2　Experimental results and discussion

2.1　Effects of multi-nozzle and different rate of blend fuel

Diesel performance comparison of fueling with different rate blend fuel is shown in Fig. 2 on condition of using $7\times 0.25\times 150^\circ$ multi-hole nozzle.

It can be seen that: stoichiometrical fuel consumption of blend fuel is appreciably higher than the one of E0 fuel at low load, and it is lower than stoichiometrical fuel consumption of E0 fuel at mid load, it is almost equal to stoichiometrical fuel consumption of E0 fuel at full load. Soot emission of diesel engine reduces remarkably at full pad with different rate blend fuel, soot emission of diesel engine is close to zero at low and mid pad. NO_x emission is reduced after burning blend fuel, it is more obvious at low and mid load, but it will not be obvious at full load.

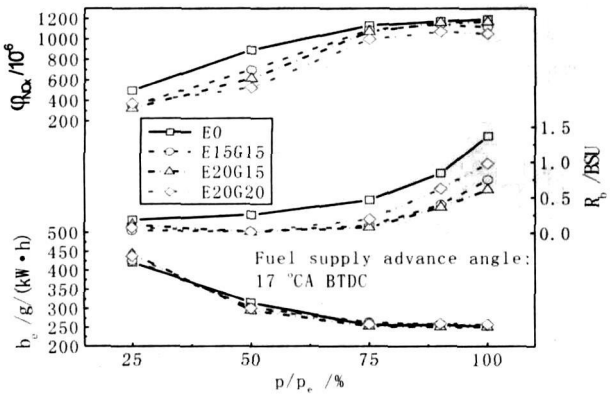

Fig. 2　Effects on diesel engine performance with different rate of blend fuel

2.2　Effects of blend fuel and HL conical spray nozzle

The experiment results which compare HL conical spray nozzle with multi-hole nozzle of injecting E0 and E20G15 respectively are shown in Fig. 3. Comparison of ignition delay periods can be seen in Fig. 4. From Fig. 5, it can be seen that the comparison of different fuel pipe pressures, in-cylinder pressures, heat release rate and in-cylinder mean temperatures at 100% pad.

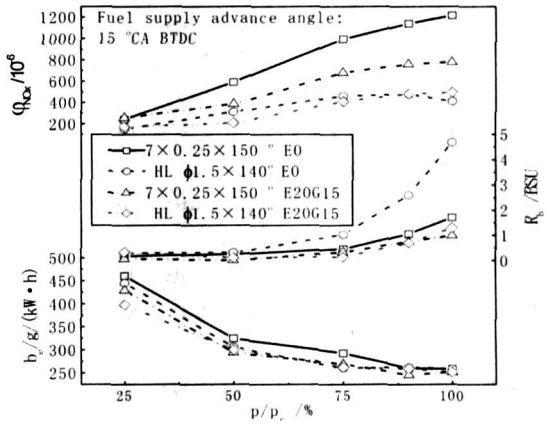

Fig. 3　Performance comparison of different nozzle modes with different rate of blend fuel

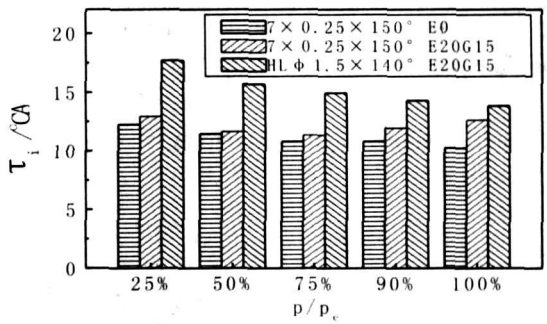

Fig. 4　Comparison of ignition delay periods

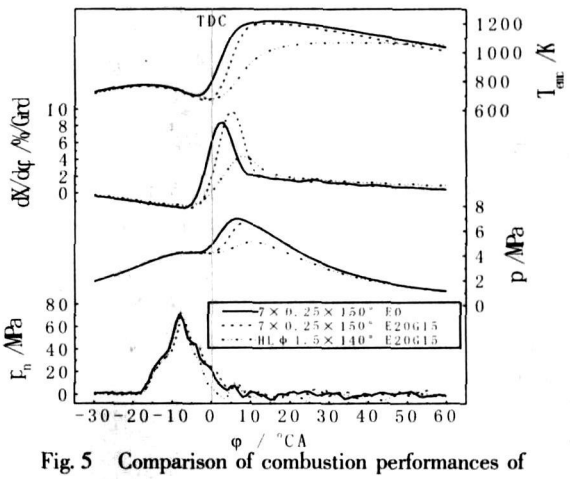

Fig. 5　Comparison of combustion performances of different nozzle modes with different fuel

From above comparison, it can be seen that NO_x and soot emission reduce remarkably with HL conical spray nozzle and ethanol-diesel-gasoline blends; at the same time, ignition delay is prolonged correspondingly, and in-cylinder mean temperature decreases, fuel/air

mixing time and mixing rate increase remarkably these can improve the formation of in-cylinder homogeneous mixture, finally hot premixed combustion of diesel engine can be achieved.

3 Conclusions

(1) Gasoline can be used as the solubilizer of diesohol. In appropriate rate, full soluble and stable ethanol-diesel-gasoline blend fuel can be confected. About 20% substitutive rate can be achieved on diesel engine.

(2) After using ethanol-diesel-gasoline blend fuel, diesel engine emission character is improved remarkably, soot and NO_x emission are reduced obviously when using HL conical spray nozzle and fueling with E20G15 blend fuel, homogeneity degree of in-cylinder mixture is improved further, combustion velocity will be higher at all load range, the in-cylinder pressure and mean temperature are lower, and NO_x and soot emission will be reduced simultaneously, the whole combustion progress has the obvipus characteristics of DHPC.

(3) Experiments show that ethanol-diesel-gasoline blend fuel has the characteristics of good atomization performance, good mixture formation quantity, long ignition delay period, high combustion velocity and short combustion duration. New fuel design project is good for achieving diesel engine hot premixed combustion.

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柴油机燃用乙醇—柴油—汽油混合燃料的试验研究

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摘 要: 以汽油为助溶剂配制出均匀稳定的乙醇—柴油—汽油混合燃料, 在单缸四气门 135柴油机上对燃用不同配比混合燃料及使用不同油嘴型式进行了性能试验。结果表明: 燃用适当配比的乙醇—柴油—汽油混合燃料, 柴油机动力性、经济性基本不变, 碳烟和 NO_x排放下降明显; 着火滞燃期延长, 缸内平均温度下降, 燃烧速率加快, 燃烧持续期缩短; 当使用 HL伞喷油嘴燃用 E20G15燃料时, 着火滞燃期进一步延长, 油气混合速率和混合气均匀度明显提高, 在整个工况范围内, 气缸压力和缸内平均温度均较低, 碳烟和 NO_x排放同时降低, 其燃烧过程具有明显的热预混合燃烧特征。

关键词: 柴油醇; 柴油机; 混合燃料; 燃烧
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