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A Comparison of the Macroscopic and Microscopic Properties of Impingement Spray of Gasoline and Ethanol from a GDI Injector at Injection Pressures up to 50 Mpa was Conducted

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Abstract

The traditional study of matching gasoline machine and supercharger substantially focuses on the external characteristic conditions, but the reasonable matching of external characteristic conditions cannot guarantee the reasonable matching of supercharger and gasoline machine in the whole operating range [1]. thus, to address the limitation of studying only the external characteristic conditions in the supercharger matching process, a thermodynamic model of a direct injection supercharged gasoline machine was established, grounded on which the matching between the supercharger and the gasoline machine in the whole operating range was studied by the three- line condition system. The results show that the matching performance of the supercharger in the whole machine operating range can be significantly bettered by using the three- line working condition system to match the supercharger [2]. The three- line system takes into account both full- cargo and part- cargo machine conditions, and can visually estimate the operating effectiveness of the supercharger over the entire machine operating range, as well as prognosticate the liability of surging, blocking and over speeding of the supercharger over the entire machine operating range, prostrating the limitation of studying only the external characteristic conditions and furnishing a numerical evaluation system for pre-selection and optimization of the supercharger [3].

Keywords: Gasoline engine; Supercharger; Matching; Part load; Cycle simulation method

Introduction

In 2021, China's auto power reached 302 million vehicles, an increase of 21 million vehicles from 2020, an increase of7.47 time- ontime. Such a large number of vehicles have a huge impact on our lives and terrain. For illustration, air pollution, energy consumption, hothouse gas emigrations and so on. So numerous experimenters are trying to use some means to reduce the energy consumption and emigrations of machines. Among them, turbocharging technology has unique advantages in enhancing power, perfecting frugality, reducing emigrations, reducing exhaust noise and pursuing machine miniaturization, which makes it the mainstream technology of moment's automotive machines [4]. The matching of supercharger and machine directly affects the machine power, energy frugality, emigration and NVH(Noise, Vibration, Harshness) quality, which has come an important factor affecting the performance of supercharged machines [5]. Compared with the diesel machine, the gasoline machine has a high thermal cargo, easy to knock, large speed and cargo changes,etc., which makes how to insure that the supercharger and the gasoline machine in the entire operating range are nicely matched to come one of the key and delicate points in the study of supercharger matching for gasoline machines. In order to achieve a reasonable match between superchargers and gasoline machines, scholars have conducted a series of studies on supercharger matching in gasoline machines. Zhang etal. proposed a system of using numerical simulation to elect suitable superchargers for gasoline machines to ameliorate the power performance and energy frugality of a naturally aspirated machine [6]. Wang etal. proposed a proposition of matching superchargers grounded on vehicle power conditions to overcome the limitation of matching superchargers and gasoline machines at a single operating point. Shinagawa etal. proposed a specialized result of matching a single- scroll turbocharger and combining a VVT(Variable stopcock timing) to realize the low- speed and high- necklace characteristics of the gasoline machines. In order to reduce the quantum of residual exhaust gas of turbocharged gasoline machines to reduce the tendency of knocking, Ismail etal. proposed a scheme to reduce the quantum of residual exhaust gas by matching the palpitation supercharging system to ameliorate the scavenging effectiveness. still, the below studies substantially concentrate on the matching of the supercharger under the external characteristics of the gasoline machine, which doesn't reflect the matching of the supercharger under the part- cargo conditions of the gasoline machine [7]. There's a failure in the literature on the matching of supercharger in the whole operating range of gasoline machine. In order to make donation in this field, a full- cargo thermodynamic model of a direct-injection turbocharged gasoline machine is established by GT- Power software in this paper, and the model is extended to a thermodynamic model applicable to the three- line system for part- cargo conditions, and eventually the thermodynamic model is applied to the matching analysis of two new superchargers. The results show that the three- line working condition system can visually reflect the matching problem of supercharger in the whole operating range of gasoline machine. With this evaluation system, the stylish supercharger can be matched to the gasoline machine and the performance of the gasoline machine can be bettered [8].

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Experimental setup and method

Macroscopic spray characteristics experimental setup and procedures

The GDI injector used in this disquisition is from a binary-injection Spark Ignition(SI) machine. As the perforation figure and spot sketch presented the injector has five holes with a periphery of0.174 mm [9]. In this disquisition, spot spurts are numbered as spurts " 1 " to " 5 ". The utilised energies are marketable gasoline and absolute ethanol, which parcels are listed in Table 1. Regarding the goods of energy parcels in the utilisation of common GDI machines, it would be better to increase the machine's flash power response to use gasoline, which has a fairly low heat of vaporisation. With the advantages of low carbon content, ethanol is typically recognised as reducing the product of PM emigrations during machine combustion process [10]. The relative disquisition on the macroscopic characteristics of gasoline and ethanol smash spray was carried out via Schlieren fashion, which has the advantage of getting the image of gas-liquid two- phase grounded on the differences of refractive indicator slants. The whole experimental setup of macroscopic characteristics can be seen. After connecting to a essence holder, injector can be acclimated and fixed to a specific distance and angle pertaining to a wall, which is a veritably flat aluminium amalgamation plate with a roughness of lower than0.4 mm. Energy injection pressure was named to be 10 MPa, 30 MPa and 50 MPa, representing common, high andultra-high pressures of GDI injector, independently [11]. The drive signal of energy injection was transmitted from a programmable Electronic Control Unit(ECU), which could also synchronise injection with " 768 × 768 pixels at 10 000 frames per second " images captured by a high- speed camera. also, using MATLAB, the captured images were converted to grayscale, followed by image processing and computation. In order to minimise the implicit hindrance of suspended energy driblets caused by the antedating injection, injection palpitation range was set to be1.2 ms, and the injection frequence was fixed to be a veritably low position of0.1 Hz. The aluminium amalgamation plate was gutted and restored completely every five injections. Energy was fitted into an ambient condition of 293 ±0.5 K and0.1 MPa. An air extractor was used to exclude the safety pitfalls of experimental point. either, each condition should be repeated thirty times during the test to ameliorate the dimension delicacy [8].

Experimental setup and procedures of microscopic spray characteristics

Regarding the disquisition of bitsy characteristics of gasoline and ethanol smash spray, the experimental setup substantially grounded on a Phase Doppler patches Analyser(PDPA) system can be seen. For each test condition, in order to guarantee the dimension delicacy, data collection and analysis were from 20000 validated driblets, and the dimension should be repeated three times. The other experimental conditions and rules of bitsy characteristics disquisition are the same with those of macroscopic characteristics [9].

Results and discussion

Matching characteristics of the original supercharger

The concerted operating characteristics of the original supercharger and machine using the three- line working condition system. Then, the low- speed stable operation line corresponds to an machine speed of 1200r/ min, which contains 10 cargo points with cargo degrees ranging from 55 to 100 [10]. The rated speed line corresponds to an machine speed of 5200r/ min, which contains 20 cargo points with cargo degrees from 5 to 100. The external characteristic line corresponds to an machine speed range of 1200r/ min to 5200r/ min. It can be seen that the matching of the original supercharger with the machine has the following problems. Although the range enclosed by the " three lines " is in the high- effectiveness zone of the supercharger, the overall effectiveness of the supercharger is low, its maximum effectiveness is only 70, and the range of high- effectiveness zone is small. The high- speed point of the external machine characteristic line(similar as 4400r/ min) is too close to the maximum speed line of the supercharger, which can fluently beget the supercharger to over speed under extreme machine operating conditions. The low- speed stable machine operating line(1200r/ min) is too close to the swell boundary of the supercharger, especially the fairly low degree of cargo is nearly close to the swell boundary, which will make the supercharger in these operating conditions is veritably susceptible to the miracle of swell [11].

Matching of new superchargers

Grounded on the below computations, two new different superchargers were reselected to match the gasoline machine. The concerted operating characteristics of the two new superchargers(P- type and J- type) and machine using the three- line system. As can be seen in these numbers, the operating range of the two new superchargers is analogous to that of the original supercharger, but the swell boundary is shifted to the left wing, which can ameliorate the swell periphery at low machine pets. Meanwhile, the overall effectiveness of these two new superchargers is slightly advanced than that of the original supercharger [12].

Conclusion

The three- line system takes into account both full- cargo and part-cargo machine conditions, and can visually estimate the operating effectiveness of the supercharger over the entire machine operating range, while also prognosticating the liability of surging, blocking and overspeeding of the supercharger over the entire machine operating range. The three- line system overcomes the limitation of studying only the external characteristic conditions and provides a numerical evaluation system forpre-selection and optimization of the supercharger. The operation of the three- line system revealed that the overall effectiveness of the original supercharger was low, the high speed point at full cargo conditions was too close to the maximum speed line of the supercharger, and the low speed stable operation line was too close to the swell boundary of the supercharger. The three- line system visualizes the matching problem of the original supercharger in the whole machine operating range. Compared with the original supercharger, the overall performance of the two recently matched superchargers has been bettered to some extent, and the P-type supercharger has the most egregious enhancement. Among them, the maximum increase in swell periphery at 1200 r/ min machine speed is30.2, and the maximum increase in compressor effectiveness and turbine effectiveness at full cargo conditions are7.3 and12.5, independently. After matching the P- type supercharger, the measured necklace and power under full cargo conditions increased by about 6 at outside, energy consumption dropped by3.6 at outside, and thermal effectiveness increased by about 4 at outside, which is principally harmonious with the model vaticination results. Both simulation results and experimental test results show that the supercharger option is reasonable. The use of P- type supercharger not only bettered the problems of matching the original supercharger with the machine, but also bettered the machine power performance.

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Conflict of Interest

None

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