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Method of Bench Test of Engine for Motorcycles and Mopeds

摩托车和轻便摩托车发动机台架试验方法

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Method of Bench Test of Engine for Motorcycles and Mopeds

1 Scope

This document describes the test conditions, performance test method, reliability test method, durability test method and effective power correction for the bench test of engines for motorcycles and mopeds, as well as the bench test method of engines for hybrid drive systems. It also provides the content of the test report.

This document applies to spark-ignition and compression-ignition engines for motorcycles and mopeds (hereinafter referred to as the “engines”).

2 Normative References

The contents of the following documents constitute indispensable clauses of this document through the normative references in the text. In terms of references with a specified date, only versions with a specified date are applicable to this document. In terms of references without a specified date, the latest version (including all the modifications) is applicable to this document.

GB 4569 Limit and Measurement Method of Noise Emitted by Stationary Motorcycles and Mopeds

GB 14622 Limits and Measurement Methods for Emissions from Motorcycles (China IV)

GB 18176 Limits and Measurement Methods for Emissions of Pollutants from Mopeds (China IV)

GB/T 21404-2022 Internal Combustion Engines - Determination and Method for the Measurement of Engine Power - General Requirements

3 Terms and Definitions

This document does not have terms or definitions that need to be defined.

4 Test Conditions

4.1 Standard Environmental Conditions

The standard environmental operating conditions shall comply with the relevant provisions of Chapter 5 in GB/T 21404-2022.

5 Performance Test Methods

5.1 Starting Performance Test

5.1.1 During the test, the engine shall be started without connecting to a dynamometer in accordance with the starting method specified in the product manual. For engines with both electric and kick-start modes, both shall be tested:

a) For kick-start, from the start of the starting operation, until the engine begins to independently run, measure the starting time and number of starts;

b) For electric start, from the moment the starter motor is connected, until the engine begins to independently run, measure the starting time and number of starts;

c) If the starting test cannot be conducted on a test bench due to limitations in the engine structure and starting method, the engine is allowed to be mounted on a matching vehicle frame and tested in accordance with the test methods and requirements in 5.1.1 a) and 5.1.1 b).

Record the lubricating oil temperature, starting time, number of starts and atmospheric parameters.

NOTE 1: starting time does not include auxiliary operation time before the start, but does include starting failure time and auxiliary operation time between each start.

NOTE 2: each time the pedal is depressed, or the starter lever is rotated by more than 90° in the starting direction, it is considered a start.

5.1.2 Normal-temperature start: conducted at an ambient temperature of 278 K ~ 318 K. Before testing, place the fuel, lubricating oil, a fully charged battery (only for battery-powered starters), and the engine at the above-mentioned ambient temperature. Wait for the temperature to reach equilibrium (temperature difference not exceeding 1 K), then, carry out the test.

5.1.3 Low-temperature start: conducted at an ambient temperature of 263 K ± 2 K. Before testing, place the fuel, lubricating oil, a fully charged battery (only for battery-powered starters), and the engine at the above-mentioned ambient temperature. Wait for the temperature to reach equilibrium (temperature difference not exceeding 1 K), then, carry out the test.

5.1.4 Hot engine start: the air-cooled engines shall be subjected to pre-heating operation, until the spark plug gasket temperature reaches 413 K, then, stop, and immediately receive the starting test; the water-cooled engines shall be subjected to pre-heating operation, until the coolant outlet temperature is within the range specified by the manufacturer. If there is no such provision, the engines shall be subjected to pre-heating operation to 353 K, then, stop, and immediately receive the starting test.

5.2 Minimum No-Load Steady Speed (Idle) Test

controlled within 483 K ± 10 K. The coolant outlet temperature for water-cooled engines shall be within the manufacturer's specified range. If there is no such provision, it shall be controlled within 353 K ± 5 K.

5.3.2 Partial-load speed characteristics

When conducting the partial-load speed characteristics test, the throttle (or fuel injection pump) is respectively fixed at 100%, 75%, 50% and 25% maximum net power at the speed corresponding to maximum net power (25% maximum net power is not required for engines with a total displacement not greater than 50 mL). Gradually increase the load and decrease the speed. Within the stable operating speed range, select no fewer than six speed points to carry out the test.

During the full-load and partial-load speed characteristics tests, measure the speed, torque, fuel consumption, spark plug gasket temperature, coolant temperature and ambient conditions. Other parameters (lubricating oil temperature, lubricating oil pressure, etc.) may be measured as appropriate.

5.4 Universal Characteristics Test

5.4.1 Perform the universal characteristics test using one of the following two methods:

a) Speed characteristics method: based on the percentage of maximum net power at the speed corresponding to maximum net power, select at least eight throttle openings (or fuel injection pump load states). In accordance with the method of 5.3, at these selected throttle openings (or fuel injection pump load states), carry out the test;

b) Load characteristics method: within the engine's stable operating speed range, select at least eight speeds, and maintain the engine speed constant at each speed. Select at least six load points for each speed, and change the load and throttle opening (or fuel injection pump load states) to carry out the test.

5.4.2 During the universal characteristics test, measure the speed, torque, fuel consumption, spark plug gasket temperature, coolant temperature and ambient conditions. Other parameters (lubricating oil temperature, lubricating oil pressure, etc.) may be measured as appropriate.

5.5 Cylinder Operating Uniformity Test

The single-cylinder flameout method is used to determine the power non-uniformity of each cylinder in a multi-cylinder engine.

During the test, fix the throttle (or fuel injection pump) at the maximum net power position. After the operation becomes stable, stop one cylinder in turn. Then, reduce the load, until the speed returns to the speed corresponding to maximum net power, and measure the power.

The indicated power of each cylinder is calculated in accordance with Formula (3):

$$P_{ii} = P_{ed} - P_{ei} \qquad \cdots\cdots (3)$$

5.8 Determination of Idling Emission of Pollutants

The idling emission of pollutants from the engine shall be determined in accordance with the provisions of GB 14622 or GB 18176.

5.9 Noise Determination

Engine noise shall be determined along with the whole vehicle in accordance with the provisions of GB 4569.

6 Reliability Test

6.1 Running-in

In accordance with the provisions of 4.6, perform running in, and record in detail the number, phenomena, and causes of faults occurred during the running-in period. In addition, replace the lubricating oil.

6.2 Performance Test

6.2.1 The idling emission of pollutants shall be determined in accordance with the method specified in 5.8.

6.2.2 The full-load speed characteristics shall be conducted in accordance with the method specified in 5.3.1.

6.3 Reliability Test

6.3.1 Prior to the reliability test, the baseline maximum net power shall be promptly measured as a criterion for measuring changes in engine power. This measurement shall be performed with the throttle at full open (or the fuel injection pump in the full-load state) and the engine speed adjusted to the speed corresponding to the manufacturer's specified maximum net power. If the manufacturer does not specify a maximum net power, the actual measured maximum net power shall prevail. Continuously operate for 15 minutes, and starting from the 3rd minute, measure the power once every 3 minutes. The average value of the five power measurements shall be the baseline maximum net power value.

6.3.2 The reliability test operating cycle shall be continuously conducted on the test bench in accordance with the requirements of Table 6. Including running-in, the cumulative operating time shall be 60 hours. If the running-in time is less than 20 hours, the insufficient time shall be incorporated into the reliability test.

6.3.3 During the reliability test, the cooling system shall be strictly controlled. In addition to complying with the provisions of 4.7, the following applies to the cooling conditions: for air-cooled engines, the spark plug gasket temperature shall be controlled within the manufacturer's specified range. If the manufacturer does not specify otherwise, the spark plug gasket temperature shall be controlled between 423 K ~ 493 K. For water-cooled engines, the cooling water outlet temperature shall be controlled within the manufacturer's specified range. If the manufacturer does not specify otherwise, the cooling water outlet temperature shall be controlled between 353 K ± 5 K.

6.3.4 The reliability test shall be continuously conducted, with the engine shut down every 10 hours. In addition to engine maintenance as specified in the instruction manual, lubricating oil replacement, carbon deposit removal, spark plug, breaker contacts and valve clearance inspection and adjustment, cleaning of the transmission, carburetor, throttle body, muffler, lubricating oil filter and air filter, and inspection of the tightness of all components are allowed. Maintenance shutdown time shall not exceed 1 hour.

For four-stroke engines with a displacement greater than 400 mL, shutdowns for inspection or lubricant replenishment are allowed as specified by the manufacturer, but the interval between each shutdown must not exceed 0.5 hours.

6.3.5 During the test, detailed records of various conditions observed during engine operation and during maintenance shutdowns shall be kept, including the number of shutdown faults, the phenomena and causes of the faults, the names and quantities of non-critical parts replaced (including during maintenance shutdowns), and damage to critical parts.

During the test, parameters such as speed, torque, fuel consumption, spark plug gasket temperature and coolant temperature shall be measured at least once every hour. Other parameters (lubricating oil temperature, lubricating oil pressure, etc.) may be measured as appropriate. Ambient temperature, relative humidity and atmospheric pressure shall be recorded for each cycle.

6.4 Performance Re-test

After the reliability test, maintenance and adjustments shall be performed in accordance with the provisions of 6.3.4, and the test contents of 6.2 shall be repeated.

7 Durability Test

7.1 Running-in

In accordance with the provisions of 4.6, perform running in, and record in detail the number, phenomena, and causes of faults occurred during the running-in period. In addition, replace the lubricating oil.

7.2 Performance Test

7.2.1 The idling emission of pollutants shall be determined in accordance with the method specified in 5.8.

7.2.2 The full-load speed characteristics shall be conducted in accordance with the method specified in 5.3.1.

7.3 Durability Test

7.3.1 Before the durability test of baseline maximum net power, the baseline maximum net power shall be promptly measured as a criterion for measuring changes in engine power. This measurement shall be performed with the throttle at full open (or the fuel injection pump in the full-load state) and the engine speed adjusted to the speed corresponding to the manufacturer's specified maximum net power. If the manufacturer does not specify a maximum net power, the actual measured maximum net power shall prevail. Continuously operate for 15 minutes, and starting from the 3rd minute, measure the power once every 3 minutes. The average value of the five power measurements shall be the baseline maximum net power value.

7.3.2 The durability test operating cycle shall be continuously conducted on the test bench in accordance with the provisions of Table 7. Including running-in, the cumulative operating time shall be 100 hours. If the running-in time is less than 20 hours, the insufficient time shall be incorporated into the durability test.

7.3.3 During the durability test, the cooling system shall be strictly controlled. In addition to complying with the provisions of 4.7, the following applies to the cooling conditions: for air-cooled engines, the spark plug gasket temperature shall be controlled within the manufacturer's specified range. If the manufacturer does not specify otherwise, the spark plug gasket temperature shall be controlled between 423 K ~ 493 K. For water-cooled engines, the cooling water outlet temperature shall be controlled within the manufacturer's specified range. If the manufacturer does not specify otherwise, the cooling water outlet temperature shall be controlled between 353 K ± 5 K.

7.3.4 The durability test shall be continuously conducted, with the engine shut down every 10 hours. In addition to engine maintenance as specified in the instruction manual, lubricating oil replacement, carbon deposit removal in the combustion chamber, piston top, piston ring and exhaust muffler, inspection and adjustment of the clearance of each part, cleaning of the transmission, carburetor, throttle body, muffler, lubricating oil filter and air filter, and inspection of the tightness of all components are allowed. Maintenance shutdown time shall not exceed 1

hour.

For four-stroke engines with a displacement greater than 400 mL, shutdowns for inspection or lubricant replenishment are allowed as specified by the manufacturer, but the interval between each shutdown must not exceed 0.5 hours.

7.3.5 During the test, detailed records of various conditions observed during engine operation and during maintenance shutdowns shall be kept, including the number of shutdown faults, the phenomena and causes of the faults, the names and quantities of non-critical parts replaced (including during maintenance shutdowns and disassembly after the durability test is completed), and damage to critical parts.

During the test, parameters such as speed, torque, fuel consumption, spark plug gasket temperature and coolant temperature shall be measured at least once every hour. Other parameters (lubricating oil temperature, lubricating oil pressure, etc.) may be measured as appropriate. Ambient temperature, relative humidity and atmospheric pressure shall be recorded for each cycle.

7.4 Performance Re-test

After the durability test, maintenance and adjustments shall be performed in accordance with the provisions of 7.3.4, and the test contents of 7.2 shall be repeated.

8 Correction of Effective Power

8.1 Spark-ignition Engines

8.1.1 Standard environmental conditions

The requirements for the standard environmental conditions are as follows:

a) Standard temperature (T_0): 298 K (25 °C);

b) Standard dry pressure (P_{s0}): 99 kPa.

8.1.2 Test environmental conditions

The test environmental conditions shall be within the following given ranges:

a) Test temperature (T): 28 3K ~ 318 K;

b) Atmospheric dry pressure (P_s): 80 kPa ~ 110 kPa.

8.1.3 Correction of effective power

When the engine is tested under non-standard environmental conditions, its effective power shall be corrected to the standard environmental conditions. The correction of effective power shall be calculated in accordance with Formula (10):

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