Study on testing vehicle’s driving wheel output power

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Abstract. This paper describes the principle, test methods and test procedures of vehicle wheel power based on the chassis dynamometer, as well as analyzes the test methods and factors that affected the test results of the driving wheel rolling resistance. At the same time, through the analysis of the test data of several groups of real vehicles, some attempts have been made to explore practical and feasible methods for automobile power performance test under the current conditions in our country. The relevant conclusions can provide a reference for improving the level of automobile power performance test.

1. The preface

The importance of vehicle detection technology has become increasingly prominent with the development of the automobile industry. The automobile chassis dynamometer can accurately simulate all kinds of working conditions of the actual road, and be used to complete all kinds of automobile detection work, such as the automobile dynamic performance, economy, emission, reliability and other special tests. The power performance of automobile[1], as one of the most important indexes to evaluate the technical performance of automobiles, how to accurately test the dynamic performance of a car is very important. The purpose of this paper is to study the method of using chassis dynamometer to test the output power of driving wheel of automobile. By comparing and analyzing the test data, the test principle and method are clarified, and the simplicity of test operation, the scientificity, preciseness and accuracy of test method are emphasized.

2. Test the significance of driving wheel output power

Detecting the output power of automobile driving wheel can be used to evaluate the dynamic performance of automobile. Compared with the acceleration performance and climbing ability of automobile, the output power of automobile driving wheel can evaluate the dynamic performance of automobile more intuitively and dynamically[2].

In the process of reliability and durability test, by detecting the output power of driving wheels under different mileage conditions and combining with the power loss change of transmission system, the change of vehicle power output and transmission system loss power can be analyzed, at the same time, the technical conditions of engine, accessories and transmission system can be judged, so as to provide data support for the matching of power and transmission system of the whole vehicle.

3. Model and principle of chassis dynamometer testing output power

The chassis dynamometer used in this test is a single drum, alternating current eddy current chassis dynamometer, and the loading method is slope method, so that the vehicle is controlled in the working condition of the external characteristic curve of the engine. During the test, the driving wheel output power value displayed on the control software of the chassis dynamometer, not including automobile
driving wheel rolling resistance and chassis dynamometer resistance loss power, so when testing, must be measured driving wheel output power, driving wheel rolling resistance loss power[3] and the internal resistance loss power of the drum, the measured actual output power of the driving wheel is the sum of the three test projects.

When testing the output power of the driving wheel, the test of the driving force of the side of the driving wheel is mainly carried out, and the output power of the driving wheel can be calculated according to the driving force of the side of the driving wheel and the test vehicle speed, the calculation formula is:

\[ P_V = F_V \times V / 3600 \] .................. (1)

Type: \( P_V \) is the driving wheels' output power (kW);
\( F_V \) is the driving wheel side's driving force (N); \( V \) is the test speed of the vehicle (km/h).

Automobile Chassis Dynamometer Driving on the specific model as follows:

![Car driving model](image)

It can be seen from the figure that when the car is running on the chassis dynamometer, the net power of the engine output after the engine working accessory loses power, and then the power transmitted to the wheels after the loss of the vehicle transmission system is the output power of the driving wheel. After overcoming the rolling resistance of the driving wheel and the internal resistance of the rotating drum, the vehicle is driven. The power displayed on the interface of drum control software is the output power of measured driving wheel.

Driving wheel output on a mathematical formula representation for:

\[ P_{vi} = P_i + P_{Di} + P_{fi} \] ............. (2)

Type: \( P_{vi} \) is driving wheel output power (KW); \( P_i \) is actual driving wheel output power (KW);
\( P_{Di} \) is drum resistance loss power (KW); \( P_{fi} \) is driving wheel rolling resistance loss power (KW);

4. Methods and steps of measuring output power [4]

4.1. \( P_i \) test

The inspector puts the driving wheels of the vehicle on the drum, and after the vehicle has been tightened, it runs before the test to complete the warm-up of the vehicle and the drum. After the test starts, the inspector gradually accelerates the shift to the direct gear driving state, maintains the maximum throttle opening state, and uses the chassis dynamometer control software to adjust the slope, increase the vehicle's driving load, and control the engine speed or vehicle speed. Take 4 or
more engine speeds or vehicle speeds between the rated power condition and the maximum torque condition, and record the measured wheel edge driving force, vehicle speed and the real driving wheel output power.

The driving wheel output power calculation formula:

\[ P_i = \frac{F_i \times V_i}{3600} \] ........................ (3)

Type: \( P_i \) is actual driving wheel output power (KW);
\( F_i \) is the measured driving force of the driving wheel edge (N); \( V_i \) is vehicle's speed (km/h).

4.2. \( P_{fi} \) and \( P_{Di} \) test

4.2.1. \( P_{fi} \) of the floating axle vehicles test. The inspector puts the vehicle drive wheel on the drum. After the vehicle is tightened, the drive wheel half shaft is removed, the tire and drum are warmed up, the vehicle transmission is placed in neutral, the parking brake is released, and the engine is turned off. The motor of the rotating drum is used to drag the driving wheel to rotate reversely, and the test data is recorded after a certain speed is stabilized. At this time, the recorded data is the sum of the rolling resistance of the driving wheel and the internal resistance of the rotating drum. The specific schematic diagram is shown in Figure 2.

4.2.2. \( P_{fi} \) of the non-full-floating axle vehicles test. The front and rear axle of the vehicle is weighed, and the tire pressure of the driving wheel is tested. Then the load is adjusted to make the non driving axle load equal to the original drive shaft mass, and the non driving tire pressure is adjusted to equal to the original driving wheel tire pressure. Finally, the non driving wheel of the vehicle is placed on the drum. After the vehicle is fastened, the tires and the drum are preheated. The motor of the rotating drum is used to drag the driving wheel to rotate reversely, and the test data is recorded after a certain speed is stabilized. At this time, the recorded data is the sum of the rolling resistance of the driving wheel and the internal resistance of the rotating drum. The specific schematic diagram is shown in Figure 3.

4.2.3. Calculation formula of tire rolling resistance loss power. \( P_{fi} = \frac{F_{fi} \times V_i}{3600} \) ........................ (4);

\[ F_{fi} = F_{ri} - F_{Di} \] ........................ (5)

Type: \( P_{fi} \) is driving wheel rolling resistance loss power (KW);
F\(_{\text{D}}\) is the driving wheel's rolling resistance (N); \(V_i\) is vehicle's speed (km/h);
F\(_{\text{r}}\) is driving wheel rolling resistance and the sum of chassis dynamometer resistance (N);
F\(_{\text{Di}}\) is the chassis dynamometer 's internal resistance (N);

4.2.4. Loss power of the drum's internal resistance. After the test vehicle is removed from the dynamometer, and the dynamometer is preheated, the dynamometer is reversely dragged by the motor of the rotating drum to rotate, and the dynamometer's speed is stabilized to be the same as that of the vehicle during the test. The lost power data of the dynamometer under the test state is recorded. At this time, the recorded data is the internal resistance of the rotating drum.

Drum resistance loss power calculation formula:

\[ P_{\text{Di}} = F_{\text{Di}} \times \frac{V_i}{3600} \].......... (6)

Type: \(P_{\text{Di}}\) is chassis dynamometer resistance loss power (KW);
\(F_{\text{Di}}\) is the chassis dynamometer 's internal resistance (N);
\(V_i\) is chassis dynamometer's speed (km/h);

After the test, the data is processed [5], and the output power value of driving wheel is calculated according to the output power formula of driving wheel. The map of output power - vehicle speed of the driving wheel or the map of output power - engine speed of the driving wheel is drew.

5. Driving wheel output power test application

5.1. Evaluate the dynamic performance of the whole vehicle intuitively and dynamically
As shown in table 1, we have used four prototype cars equipped with different powertrains to test the output power of the driving wheel, we compared the power output of the driving wheel to evaluate their power performance.

The test data of driving wheel's output power is shown in Table 1, and the test data curve of driving wheel's output power is shown in Figure 4.

| n (r/min) engine speed | Pi (kW) 1# prototype | Pi (kW) 2# prototype | Pi (kW) 3# prototype | Pi (kW) 4# prototype |
|-----------------------|----------------------|----------------------|----------------------|----------------------|
| 2200                  | 161.20               | 138.61               | 154.94               | 138.58               |
| 1900                  | 167.51               | 143.42               | 156.69               | 137.52               |
| 1600                  | 164.55               | 134.68               | 142.22               | 122.93               |
| 1400                  | 157.53               | 123.01               | 137.33               | 117.35               |

The output power curves of the driving wheels of four kinds of test prototype

Figure 4. Test data curve of driving wheel's output power
Figure 5. Power output of driving wheel during durability test
In order to better evaluate the dynamic performance of the vehicle, we compared and analyzed the acceleration performance of the test vehicle, drew the acceleration time curve of the vehicle from 30-80 km/h in direct gear as shown in Figure 6, and drew the acceleration time curve of the vehicle starting and continuous shifting from 30-80 km/h as shown in Figure 7.

Through the test comparison, the output power value of the driving wheel obtained from the test on the chassis dynamometer is consistent with the dynamic trend of the vehicle during the road test. For example, the output power of the driving wheels is compared at the same engine speed: the numerical value is sequentially No. 1 car, No. 3 car, No. 2 car, No. 4 car, this trend is consistent with the vehicle dynamic performance reflected in the acceleration test process in Figure 6 and Figure 7.

Therefore, the output power of the driving wheel and its variation are related to the vehicle acceleration performance, maximum climbing gradient and other vehicle dynamic indexes. It is worth noting that the comparison of the output power of the driving wheel is easier to produce differences than the acceleration performance and other indicators, and it is more intuitive and dynamic to evaluate the dynamic performance of the car.

5.2. Monitor the power performance of durability test prototype vehicle

During the entire cycle of the produced vehicle, from running-in, normal driving to final scrapping, the output power of the driving wheels at each stage can reflect the change of the vehicle's dynamics. Figure 7 is a trend curve formed after the test values of the driving wheel output power at different test mileage stages are summarized for a certain vehicle undergoing durability test.

From the test trend curve of the above test vehicle, it can be seen that before the test mileage of the durability test vehicle in a certain period of run-in, the output power of the driving wheel tends to increase with the growth in run-in period and is stable. With the continuous increase of vehicle mileage, after reaching a certain test mileage, the use condition of the vehicle began to deteriorate, and the output power of the driving wheel also began to decline.
In the process of durability test, the output power test of driving wheel can understand the technical status of vehicle engine and transmission system, and can better evaluate the vehicle's dynamic performance in combination with the evaluation indexes such as acceleration performance and maximum climbing gradient. Meanwhile, it can provide real test data for the vehicle's dynamic matching and transmission system matching, which can be used for reference by the R & D and design departments.

5.3. Test rolling resistance of the driving wheel of vehicle

The rolling resistance of the driving wheel is a part of the test and detection of the output power of the driving wheel. At the same time, as an important part of the vehicle structure, the tire has an important impact on the fuel economy of the vehicle. The greater the rolling resistance, the greater the road resistance of the vehicle, the greater the fuel consumption, the increase of exhaust emissions, therefore, the pollution to the environment is increased. At the same time, the rolling resistance of the truck wheel also affects the tire wear to a large extent. In terms of energy conservation and environmental protection, it is very meaningful to test the rolling resistance of wheels.

In the past, the rolling resistance measurement of vehicle tires needs professional test equipment, or in the special vehicle test site, it measured by sliding test after the treatment of the driving axle, measurement costs are relatively high. It is very easy to measure the rolling resistance of driving wheel with dynamometer, and the measuring method is accurate, high quality and efficient.

6. Conclusion

Starting from the control and test principle of the chassis dynamometer, the model analysis of the vehicle running on the chassis dynamometer is carried out, and the test principle and method of the output power of the test driving wheel are expounded. Then some successful applications are listed and the significance of measuring the output power of the driving wheel is pointed out.

(1) The output power of driving wheel can be used as an evaluation index of vehicle power performance. At the same time, the ratio of the output power of driving wheel to the output power of engine (percentage ratio) can be used to grade the vehicle.

(2) In the reliability and durability test, the output power of the driving wheel of the vehicle is tested in the course of different mileage, which can provide reference data for the design of automobile products, provide a basis for the matching of the power and transmission system of the vehicle, and better serve the product research and development.

(3) As a measurement item in the research project of driving wheel output power, tire rolling resistance can be accurately detected on the whole vehicle by using the vehicle chassis dynamometer. In the later research, it can be tested and studied together with the output power of the engine and the loss power of the transmission system to detect and observe the change of the whole power transmission process of the vehicle, which can not only assess the technical status of the engine, but also the technical status of the transmission system, so it can provide a better optimization scheme for the matching of the vehicle power and transmission system.

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