

Analysis of Behavior of Fuel Consumption and Exhaust Emissions under On-road Driving Conditions Using Real Car Simulation Bench (RC-S)

Yuichi GOTO, Daisuke KAWANO

National Traffic Safety and Environment Laboratory

Koji SATO, Kentaro ECHIGO

Ono Sokki Co., Ltd.

Copyright © 2009 SAE International

ABSTRACT

The investigation of vehicle performances under on-road conditions has been required for emission reduction and energy saving in the real world. In this study, Real Car Simulation Bench (RC-S) was developed as an instrument for actual vehicle bench tests under on-road driving conditions, which could not be performed by using conventional chassis dynamometer (CH-DY). The experimental results obtained by RC-S were compared with the on-road driving data on the same car as used in RC-S tests. As a result, it was confirmed that RC-S could accurately reproduce the behavior of fuel consumption and exhaust emissions under on-road driving conditions.

INTRODUCTION

According to the strengthened the emission regulations and the fuel consumption standard for vehicles, technologies of fuel consumption and after-treatment system were drastically improved. Moreover, due to the beginning reduction of the number of vehicles in Japan since 21 century, the amount of environmental load caused by vehicles has been gradually reduced. Air quality in Japan has been improved by these countermeasures.

However, the improvement of air quality is not enough yet. While the test driving modes for the exhaust emission tests in Japan are determined statistically based on the internal on-road, not all on-road conditions are simulated by the test driving modes. In these actual driving conditions, which are unable to be reproduced by test driving modes, it was noted that exhaust emission performances become worse caused by A/F richer control, etc., under high-loaded driving conditions⁽¹⁾. This is especially regarded as the cause of increasing environmental load in a local roadside. Moreover, since CO₂ emission from vehicles is recognized as one of the main causes of the Global warming, the improvement of fuel consumption performance not only in mode driving but also on-road condition is required.

Therefore, to improve environmental performance of vehicle in the real world it is necessary to conduct accurate measurement of exhaust emissions and characteristics of fuel consumption under on-road conditions, and to comprehend their precise performances.

Because of these reasons as above, various on-board vehicle measurement devices such as Portable Emissions Measurement System (PEMS) have been developed in recent years, and thus a number of measurements of vehicle performance under on-road driving conditions have been conducted⁽²⁾. Simultaneously, Virtual and Real Simulator (VRS) as a test bench was also developed. Using actual power train, VRS is able to realize the dynamic characteristics on-road with a virtual model, and it is now really starting to be applied as a vehicle development tool⁽³⁾.

In order to further improve VRS, Real Car Simulation Bench (RC-S) was developed as an instrument for bench tests using an actual car under on-road driving conditions. This system has low inertia dynamometers and also includes a tire-less system in spite of using an actual car. That is, this system can drastically reduce the impact of measurement variation by tire losses on fuel consumption.

This is a kind of a virtual real simulator based on a real vehicle. This seems to be a Chassis Dynamometer (CH-DY) without the impact of tire losses on fuel consumption and emissions. So when fuel consumption is measured, measurement errors from tire losses don't occur because of the tireless system. And also this system can reproduce tire slip behavior at the starting of a car. Fuel consumption tests can be carried out very accurately by this instrument because of no impact of tire losses variations.

This study focuses on each test under on-road conditions which are not able to be simulated on the CH-DYs and aims to research and develop a bench which enables to conduct these above-mentioned tests without

dismantling actual vehicles. Following shows the outline of RC-S and reports the results of the applicability evaluation.

OUTLINE OF RC-S

Fig.1 shows the system outline of RC-S. Unlike the feature driving on a roller such as a CH-DY, RC-S absorbs a driving force by directly connecting a drive shaft in driving wheels to a dynamometer. Moreover, by adopting a low inertia dynamometer, it also enables to reproduce a minimal velocity behavior at acceleration and deceleration.

In addition, VRS also enables to conduct the same test, but in that case, it is necessary to dismantle a vehicle and remove only power train parts, and then to install it into the bench.

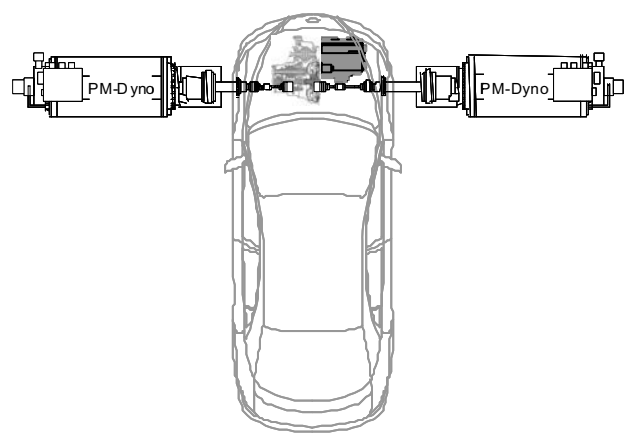


Fig. 1 Schematic diagram of RC-S system

On the other hand, RC-S has adopted bearing wheels (Fig.2) between wheel hub and dynamometer. It enables the feature to connect a drive shaft with a dynamometer only by changing wheels without dismantling a vehicle. It is also easy to expand to a 4WD vehicle by connecting all four wheels with dynamometer.

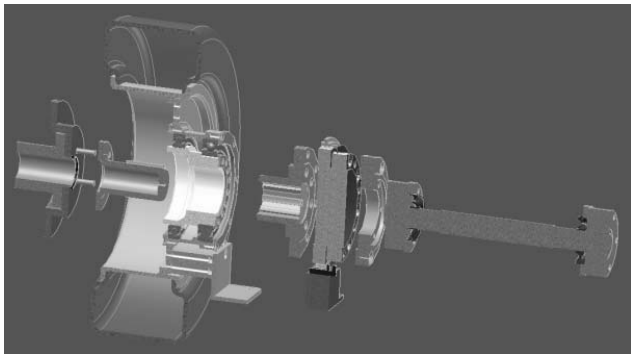


Fig. 2 Schematic diagram of wheel with bearing

As a test method using an actual vehicle, table 1 shows the performance comparisons between CH-DY, on-road driving, and RC-S. Although the existing CH-DY demonstrates the advantages of reproductive test conditions, it is impossible to accommodate changes of road surface conditions such as a sloping road and slippery road, nor transient driving conditions.

Analyses of these influences can be conducted by on-road driving, but it is difficult to reproduce the target test condition due to the influence of weather, etc, and thus more consideration for safety than on CH-DY is required.

On the other hand, RC-S enables to reproduce a wide range of transient conditions under on-road driving on the bench with a high degree of accuracy and safety. In fact, RC-S is the most applicable test system, for the analyses of exhaust emissions and fuel consumption performance in real world, since it has adopted the

Table 1 Specifications of vehicle test methods

	On-road driving	CH-DY	RC-S
Steady-state fuel consumption	😊😊	😊😊	😊😊
Transient fuel consumption	😊😊	😊	😊😊
Mild acceleration	😊😊😊😊	😊😊	😊😊
Full acceleration Passing acceleration	😊😊😊😊	😊	😊😊
Mild braking	😊😊😊😊	😊	😊😊
Full braking Low friction road	😊😊😊😊	😞	😊😊
Transient steering Swing motion	😊😊😊😊	😞	😊
Stability control	😊😊😊😊	😞	😊😊
Repeatability	😊	😊😊	😊😊

😊😊😊😊 Excellent 😊 Fair
😊😊 Good 😞 N/A

benefits of both CH-DY and on-road driving test.

EXPERIMENTAL METHOD