A Study on the measurement method of dynamic regenerative energy efficiency of traction motor system on electric vehicles

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1. Introduction

Regenerative energy of traction motor system (motor & inverter) increases of overall energy efficiency of a vehicle and cuts down on pollution related to electricity generation.

There are no unambiguous standards for test method and conditions for performance from traction motor system at the motor dynamometer and needs to verify performance on each part before applying assembly system. We need to promote uniform testing method and test conditions for traction motor system in electric two-wheeled vehicle. We must use with the motor dynamometer, and then need to specify on the test system. It is necessary to compare the results of evaluations conducted under the same standards and conditions, and in particular, this proposal intends to set the standards for the references, conditions, and methods for measuring the efficiency of regenerative energy of the traction motor system for electric two-wheeled vehicles based on the performance evaluation methods for industrial driving motors since the measurement methods for the efficiency and performance of regenerative energy concerning the performance of the traction motor system is not defined in terms of energy efficiency..

2. Dynamic regenerative energy efficiency of traction motor system

A typical motor dynamometer is designed to facilitate constant speed and constant torque control, so the recovery efficiency is measured by a change in speed and torque at an agreed measuring point based on the design specifications of the test motor. However, the portion of regenerative braking efficiency of electric drive systems (motors and inverters) in real vehicles is very difficult to measure. The regenerative efficiency of electrical actuation system can be characterized by a curve made with torque and speed points. If the load motor system of the motor dynamometer is able to control the variable speed by the program, tests may be made imitating the regenerative braking of real vehicles. In general, when the vehicle is regenerative braking, the vehicle speed difference is decreased over time, and the regenerative braking force changes with time.

However, the actual implementation of regenerative braking depends on the vehicle vendor, so, in this study, measurement method of dynamic regenerative efficiency of traction motor system was studied, simulating regenerative braking on real vehicles, only taking into account the proportionally fast deceleration of an electrical drive system for testing over time.

3. Transient regenerative breaking efficiency measurement test

Fig. 1 shows a typical test setup consisting of a load motor system and a test motor system that are mechanically connected through coaxial coupling, power supply, torque and speed measuring sensors, power analyser and data processing equipment.

When the test motor is operating as traction motor in driving mode, the load motor shall be able to simulate any predefined road load in terms of angular velocity and torque. When the traction motor is operating as a generator in regenerative braking mode, the load motor shall be able to generate braking torque at a specified speed defined in test procedure.

In transient regenerative braking efficiency measurement, efficiency is measured with linearly decreasing speed and constant torque to simulate typical situation of braking as shown in Fig 2. n1 and n2, respectively, represents speed of motor at the starting time, t1, and at the ending time, t2, and T12 is constant regenerative braking torque.

Since the relative magnitude of mechanical fiction braking torque and regenerative braking torque differs for each regenerative braking system, the rotation speed at the start time, t1, and end time, t2, as well as the torque, T12, during the regenerative braking of motor should be determined in consultation with the parties involved. In Table 1, two scenarios that specify speed, torque and duration time are given for references for braking in low speed and high speed.

Table 1 *Scenario of speed and torque for transient test*

Scenario	Percentage of	Percentage of	Duration: $t_2 - t_1$	Percentage of

	maximum rpm: n_1 %	maximum rpm: n_2 %	s	maximum motor torque: T_{12} %
Braking at low-speed driving	40	10	8	10
Braking at high-speed driving	60	40	10	10

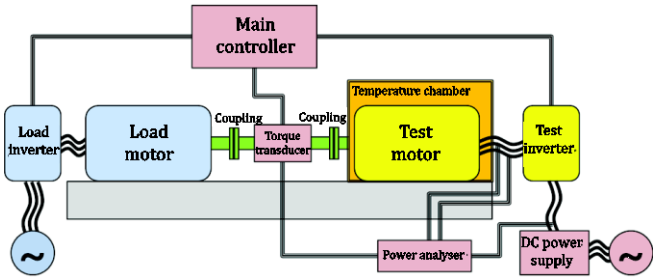

Fig.1 Schematic diagram of the test system

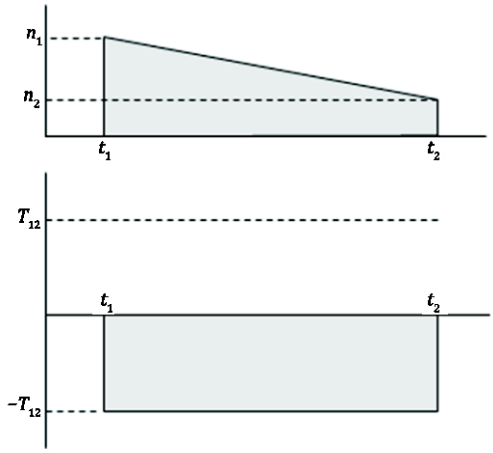

Fig.2 Rotating speed and breaking torque during regenerative braking (*n;* speed, t ; time, T ; torque)

References

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