B-17.1 Quantification for required performance and functions of electric vehicles depending on fields of utilization

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Abstract

The objective of this study is to search required performance estimation methods of electric vehicles(EV) depending on fields of utilization and mainly the following results were obtained.

(1) Actual roads driving data of conventional vehicles were statistically analyzed and then driving characteristics of various road and vehicle types were clarified.

(2) A procedure for calculating driving power ratio from vehicle speed-time data to estimate possible driving distance of EV at 1 time battery charge.

(3)A simulation program was developed for estimating EV performance. Then supposing a small size EV that is applied common technologies at this time and loaded two passengers, its consumed electric power and regenerative power by braking etc. were calculated based on actual driving data and then, the deference of mileage estimation to steady state driving, energy consumed by auxiliary system, or the effect of a regeneration, were considered.

(4)Finally, it was clarified that small electric vehicle is suitable for the commuting use of relatively short distance and will be applicable for commuters used in badly air polluted urban areas.

Key Words Electric Vehicle, Driving Model, Petroleum Energy Substitute

1. Back ground

To prevent the discharge of Green House Effect gases such as CO_2 and harmful exhaust components like NOx caused by the consumption of petroleum energy by automobiles, substitutions of a part of petroleum energy consumed for transportation could be considered by the mass introduction of electric vehicles (here after EV). However, for taking measures of improving environment by the mass diffusion of EV, it is necessary to make clear the performance target of the vehicle depending on the fields of introduction.

2. Objective

The objective is to clarify the guide line of performance and functions for the development of EV.

For this objective, experimental investigation was performed to clarify road driving characteristics of comventional vehicles and the required performance and functions of EV were considered for each utilization fields where introduction of EV are thought to be possible. Then, the minimum required performance of EV for the each field of introduction was estimated.

3. Result

(1) driving pattern measurement

To investigate required performance model for each automotive utilization fields based on the actual driving conditions for private and commercial vehicles, a survey concerning the actual driving conditions was performed for the different field of utilization and the data bases concerning vehicle driving characteristics are constructed. Then, performance models of EV are considered for each field of utilization by using these data bases.

At first, we started with an analysis of algorithm for data processing and then, settled the experimental measuring method for investigating the real state of driving conditions. The driving pattern (speed–time) data were recorded under various road conditions for various types of vehicles and from the results, the construction of driving characteristics data base was considered.

At the measurement of driving patterns, the propeller shaft rotating pulse was detected with a non–contact optical device and converted to analog speed signal with a F/V converter. These analog speed signals were directly converted to digital and stored in a on–board 1 MB RAM unit and then, after the whole day's measurement, the data were transferred to FD. Sample speed of A/D converter was settled to 0.1 sec considered to the RAM capacity and required time for continuous measurements. Speed–time data of the vehicles were processed statistically.

(2) Quantitative analysis of driving characteristics for each road and vehicle types

driving pattern data were sampled with a gasoline fueled passenger car and a middle duty diesel truck under various road conditions. For the road conditions, following 3 conditions were selected, such as urban driving in city area, suburban driving where the traffic is not so heavy and high way driving. Commuting drive data were also gathered for different 7 routs by individual 7 drivers.

Driving data of each road conditions and vehicle types were processed by statistical analysis . Then driving energy was calculated. Fig.1 compares relative frequency of driving energy at each driving conditions. In most cases, required driving energy except high way driving is less than 20kW at the case of passenger cars. However, as the estimation of possible driving mileage at one charge is very important for EV, driving energy rates required for the driving of an unit distance were calculated for different road driving conditions.

Fig.2 shows ratios of driving work rates at each driving conditions to that of 40km/h constant speed driving which is generally used for the index of the driving mileage at one charge in case of EV (the ratio will be expressed R).

It was found out that R varies 1.4 to 2.4 and becomes biggest at high way driving conditions.

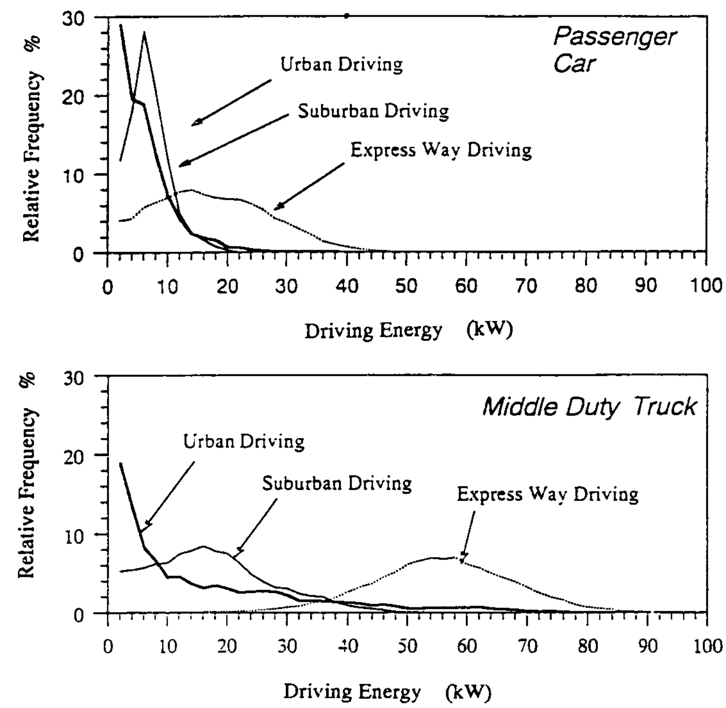

Fig.1 Relative frequency of driving energy at each road conditions

It may be possible to evaluate the possible driving mileage at one charge under actual driving conditions with R as an index.

(3) Simulation of an electric vehicle performance based on road driving data

The required performance limit of an EV which could be substituted for a conventional vehicle under the same driving conditions was considered from the view of energies required for the vehicle operations calculated with measured vehicle road driving data.

A simulation program was developed for estimating an EV performance. Then supposing a small size EV which is applied common technologies at this time and loaded two passengers, its consumed electric power and regenerating power at braking etc. were calculated in the case of the same driving pattern as actual commuting data mentioned chapter 3.3.

Fig.3 shows the one way running distance of 1 trip commuting versus vehicle required electric energy. The available number of trip per 1 charge is also shown in the figure. Although the use of regenerating power is not considered in these cases, the available number of trip is 4 or greater in most cases and then, 1 to 2 round trip may be possible with one battery charge.

Fig.4 shows driving work (R) versus required electric power(RE) at unit distance. Each units are normalized with a ratio to the energy at 40km/h constant driving. Although RE is almost proportional to R, RE is 10 to 20% greater than R and this tendency is more obvious where R is greater.

This may due to the loss energy of the driving motor or the inverter. Thereby, it may be estimated lower for required electric power and longer for possible driving distance at one charge if the performance at actual driving of an EV is calculated from R. So, correction coefficients about 1.1 to 1.2 must be miltiplied to R for precise estimation.

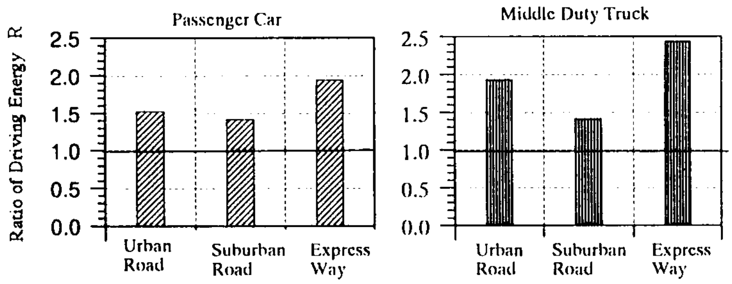

Fig.2 Ratio of driving work energy to energy of 40km/h driving

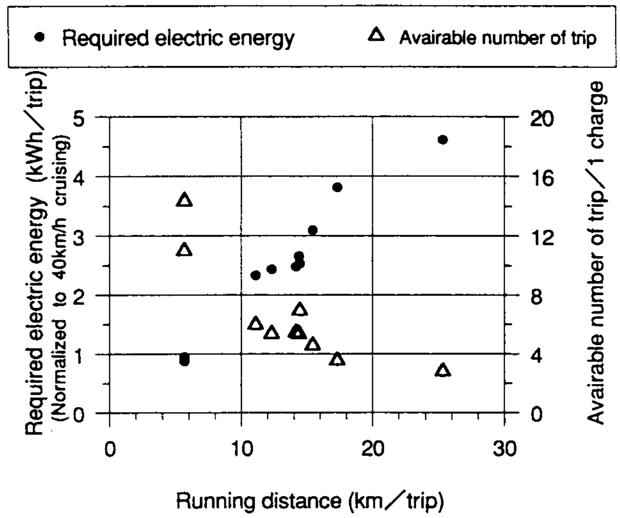

Fig.3 Driving distance and required electric energy at commuting

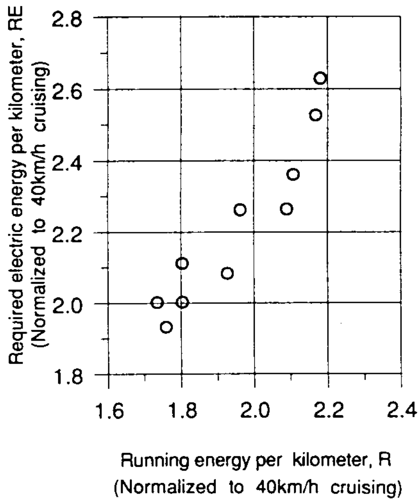

Fig.4 Driving Energy and Required electric energy (ratio to 40km/h cruising)

Fig.5 shows an example of the contents of a calcurated vehicle required electric power. About 70% of the total required power is consumed for driving motor, 25% is loss power (motor, inverter etc.). The average efficiency of the motor is about 82% at this case, however, loss power will go up when R becomes higher as mentioned above. Required electric power for auxiliary components is considered about 6%, but total required power may increase drastically under air conditioning and the percentage of air conditioning power may be relatively high.

Fig.6 shows the comparison of the vehicle electric power consumption under various conditions including air conditioning with battery recovery ratio by regeneration as a parameter. Power consumption is expressed as the normalized value RE.

The increase in RE by the use of lighting in a night is small but it becomes drastically high with the use of air conditioning. Thereby, the possible driving distance at one charge may becomes remarkably shorter under air conditioning because of the increase in RE up to 30 to 40%.

On the contrary, about 15% of save energy may be possible with regenerative braking if 50% of battery recovery ratio is supposed . Thereby 1 round trip of the longest distance in Fig.3 with air conditioning can be possible at 1 charge if regenerating is used effectively. Therefore small EV is thought to be applicable satisfactory for commuting use.

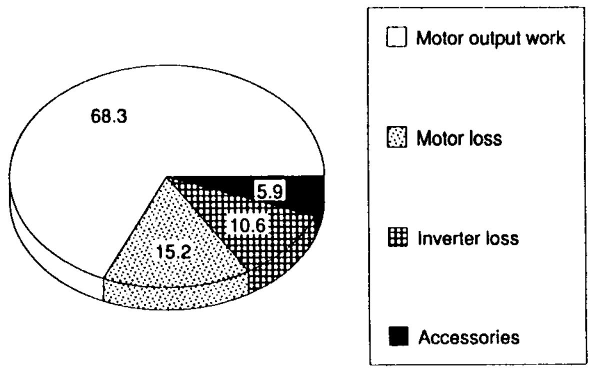

Fig.5 An calculated example of the items in required energy

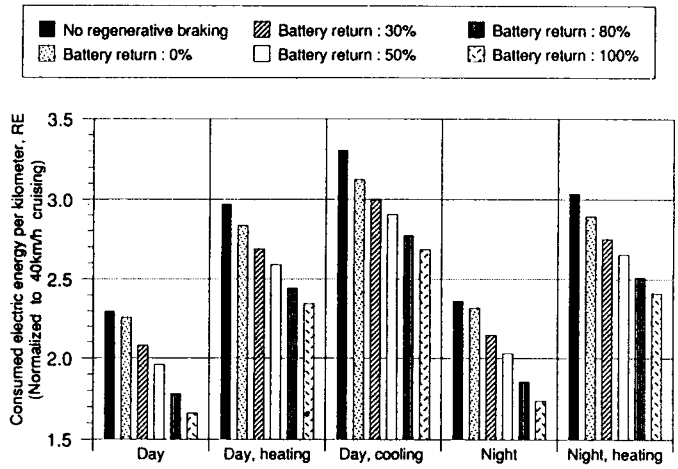

Fig.6 consumed electric power under various conditions

4. Conclusion

Actual road driving data of a passenger car and a medium duty truck were sampled and statistically analyzed to clarify required performance of EV at each application field. As a result, driving characteristics of various road and vehicle types and required performance of the drive train were clarified. Then, a procedure was considered for calculating actual driving energy ratio from vehicle speed–time data to estimate possible driving distance of EV at 1 time battery charge.

On the contrary, a simulation program was developed for estimating an EV performance. Then supposing a small size EV which is applied common technologies at this time and loaded two passengers, its consumed electric power and regenerating power at braking etc. were calculated at actual driving conditions and then the deference of mileage estimation to steady state driving, energy consumed by auxiliary system, or the effect of a regeneration, were considered. Finally, it was clarified that small EV is suitable for the commuting use of relatively short distance and will be applicable for commuters used in badly air polluted urban areas.