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EV Conversion Kit for Light Truck

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Abstract

We developed an EV conversion kit for light truck to promote “pure (battery)” commercial EV. Operation of EV trucks can be arranged according to the capacity of battery installed generally because light trucks for deliveries inside cities are used in limited areas, fixed routes and scheduled operation time. Light delivery trucks are mostly used in food industry to make small amount deliveries and most of such trucks are equipped with freezer-refrigerator. We mounted a freezer-refrigerator on the converted EV truck, optimized the specification through demonstration and validated amount of CO2 reduction.

Keywords: BEV(battery electric vehicle), demonstration, EV(electric vehicle), truck

1 Introduction

Electric vehicles, especially compact car and passenger car type EVs, are starting to spread since auto-makers have released numbers of new models. On the other hand, car makers are reluctant to develop commercial EVs, especially trucks because they need to cover wide-ranging applications. Commercial EVs are hardly seen due to such background, however, replacing ICE vehicles with EVs in the transportation businesses is considered to be effective in reducing CO2 from automobiles. We therefore developed an EV conversion kit to boost the popularity of EV trucks focusing on light delivery trucks that are used in limited applications.

Light delivery trucks used by couriers and convenience store chains are equipped with freezer-refrigerator to control temperature of food during delivery. Light trucks with freezer-refrigerator are now used also as mobile convenience store. Our conversion kit includes a kit to motorize freezer compressor as well adding another practicability.

We built an electric mobile shop using the kit, carried out a year-round demonstration test, optimized its performance and validated its reliability as an EV truck.

2 Development of conversion kit for Light truck

In Japan, classifications of truck differ by regulation and there is no standard classification. The trucking industry classifies vehicles that have; maximum payload below 4t as the “light” truck, and max payload over 4t as the “regular” truck, according to the manufacturers’ classification.

Upon converting a light delivery truck into an EV; our plan was to avoid any additional work on the base vehicle main frame and to bolt all parts and devices on the frame so that any ordinary diesel engine vehicle could easily be converted into EV. Also, to reduce cost of the conversion kit, we carried over the base vehicle gear box and the transmission configuration including clutch system as is.

Traction battery packs are fitted on both sides of the frame within the wheelbase. Light truck's wheel base vary from 2500mm to 3800mm according to the user applications, and we designed the battery packs to fit into the shortest option that is 2500mm. Capacity of traction battery is 24kWh on one side, making the total capacity at 48kWh.

Traction motor unit sub assembles motor, motor inverter, DC-DC converter, vacuum pump and air-con auxiliary on a mount bracket as an integral unit to ease installation.

In the current project, we built 2 prototype vehicles. Proto 1 was used to; verify the specification, evaluate electric mileage and durability, and sort out points to be improved through road tests. We then reflected the points to be improved on Proto 2, built an EV conversion kit that enables any body shop to convert a truck into an EV in 5 days, and prepared an conversion manual.

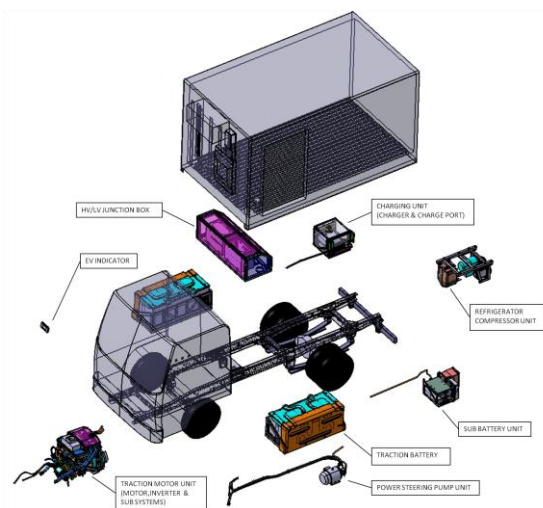


Figure 1: Conversion kit parts



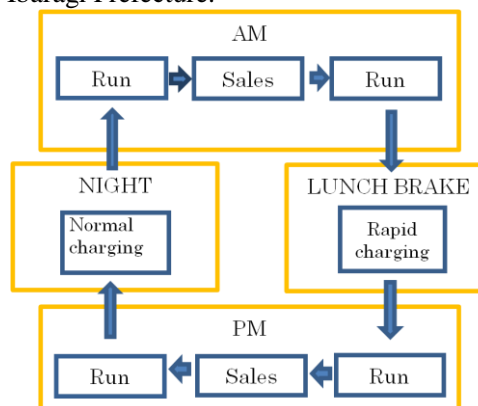
Figure 2: Converted Light Truck, Proto 1

Table 1: Performance of the Proto 1

| Items | Performance |
|----------------------|-------------|
| GVW | 7,365kg |
| Payload | 2,244kg |
| Duration (JC08 mode) | 107km |
| Max speed | 104km/h |

3 Demonstration test on public roads with Proto 1

We operated mobile shop over a period of approx. 10 month from April 2012 to January 2013 to confirm performance and validate the vehicle's reliability on the Proto1. Trials were carried out in following daily operation pattern in Tsukuba City, Ibaragi Prefecture.



Tests were executed 5days a week through Monday to Friday and the total mileage ranged up to 18,000km. We had no trouble throughout the test period and we confirmed reliability enough for business use.

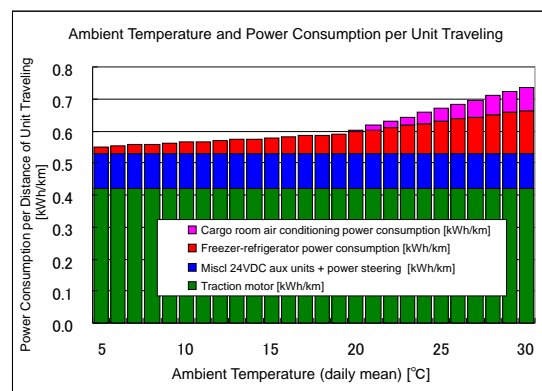


Figure 3: Results of Road Test (ambient temperature and power consumption)

We evaluated the relation between power consumption and ambient temperature from the results of demonstration tests. A large proportion of the entire power consumption was consumed by the traction motor inverter (as shown in GREEN in the graph) which is quite a constant value regardless of the ambient temperature, amounting to a little over 80% in lower ambient temperature and a little below 60% under 30 degrees C ambient. Amount of power consumed by 24VDC aux units,

besides cargo room air conditioner, plus the power steering (as shown in BLUE in the graph) also is a constant value regardless of the ambient temperature, amounting to approx. one-fourth of that of the traction motor inverter. Amount of power consumed by the freezer-refrigerator (shown in RED above) and the cargo room air conditioner (in PURPLE) shows dependency to ambient temperature; the higher the ambient temperature, the higher the power consumption. As the ambient temperature gets higher, power consumed by these units may reach up to 30% of the entire power consumption.

From the results of power consumption measured on demonstration tests, the energy consumption in practical business use is calculated to reach approx. 50% of the JC08 mode. It is conceivable that running the freezer-refrigerator at all times including long-time stoppages for store operation during a day to control food temperature is the primary factor of energy consumption.

4 Estimated CO2 reduction

From the results of energy consumption rate measurement test comparing electric and diesel engine delivery trucks on JC08 mode, and the power consumption measured during the demonstration tests, we estimated the CO2 reduction, and the per-vehicle CO2 emission reduction is calculated to be 0.35kgCO2/km.

| | | |
|------------------------------------|---------------------------------|-------|
| EV truck (electricity) | Power consumption rate [km/kWh] | 1.35 |
| | CO2 emission factor [kgCO2/kWh] | 0.378 |
| | CO2 emission [kgCO2/km] | 0.28 |
| Diesel truck (diesel oil) | Fuel consumption rate [km/l] | 4.15 |
| | CO2 emission factor [kgCO2/l] | 2.62 |
| | CO2 emission [kgCO2/km] | 0.63 |
| CO2 emission difference [kgCO2/km] | | 0.35 |

Table 2: Estimated per-vehicle CO2 reduction

5 Conversion of Proto 2 vehicle

We built an entire set of EV Conversion Kit reflecting the feedbacks we attained through the demonstration tests with the Proto 1. We handed a second-hand diesel truck, an entire set of EV conversion kit and the conversion manual over to a local body shop who carried out the conversion in a 3-day time. We also prepared a set of vehicle remodelling application documents and acquired a license through the same local body shop.



Figure 4: Converted Light Truck, Proto 2

Table 3: Performance of the Proto 2

| Items | Performance |
|----------------------|-------------|
| GVW | 4,985kg |
| Payload | 1,600kg |
| Duration (JC08 mode) | 120km |
| Max speed | 120km/h |

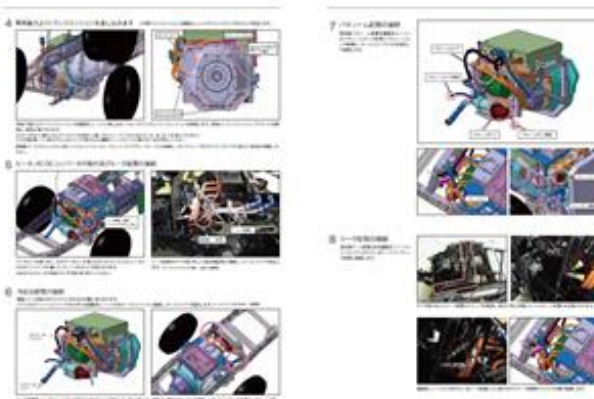


Figure 5: Conversion Manual



Figure 6: Conversion at Local Body Shop
(engine dismantling and motor unit instalment)



Figure 7: Proto 2 on Vehicle Inspection Ground



Figure 8: Vehicle Remodelling Application Document

6 Conclusions

We developed a conversion EV truck focusing the target on urban delivery light truck that operates within limited area, carried out demonstration tests on public roads and developed the results and technology into an EV conversion kit. Based on the feedbacks we collected from the local body shop engineers who carried out the conversion of the Proto 2, we implemented the results of hearings and improved the ease of assembly of the conversion kit as well.

The kit has performance and reliability that satisfies use in practical business, however, we will further propel activities such as cost reduction, infrastructure improvement, discovery of business partners, etc., and the promotion of commercial EV.

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