Intermodal transport system and energy storage system for global warming prevention

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Abstract

The amount of CO\textsubscript{2} exhaust from automobiles is still increasing in the world. Therefore, a drastic innovation of traffic policy and technology is needed. We have designed and manufactured a new-concept flywheel battery system with sliding bearings, using tribology and traction control technologies, for a hybrid electric vehicle (HEV). The results of vehicle running tests show more than 80\% energy efficiency of the whole flywheel battery system including the auxiliary units. We are studying an innovative HEV intermodal transport system using this flywheel. One main feature of this transport system is the movable cyber-expressway using jumbo trains. The effect of jumbo trains that substantially cut the CO\textsubscript{2} emission from automobiles is discussed when they are integrated with a new concept of road traffic in an intelligent transport system (ITS).

Keywords: global warming prevention, intelligent transport system, road-to-rail transhipment, intermodal traffic, broad gauge, energy storage, flywheel battery.

1 Introduction

While the world is moving towards reducing CO\textsubscript{2} emissions, such emissions have increased in Japan, regrettably making it difficult to achieve the internationally pledged limits. As the world’s second largest consumer of petroleum, Japan has a heavy responsibility to help prevent global warming. However, due to the increasing market share of energy-inefficient highway transportation, achieving the internationally pledged 6\% reduction of CO\textsubscript{2}
emissions has become difficult. Moreover, in connection with the increased market share of the highway transportation sector, foreign payments affecting the overall national economy also increase, and drastic reform has become necessary from the standpoint of financial and economic efficiency, as well as environmental and health concerns.

![Figure 1: CO₂ emissions by the transportation sector in Japan.](image)

The main causes of these difficulties in Japan, contrary to Europe, are the highways and lack of freight-dedicated railroad lines. In order to improve an automotive society with minimal effects on the environment, methods were examined for positive utilization of railroad lines which were excellent in terms of transportation energy efficiency (Fig. 2). The basic design was the result of considering cooperation with railroads, energy conservation, and vessels.

![Figure 2: Transportation energy efficiency by freight means of transportation (source unit comparison of CO₂ discharge).](image)

A freight train is 1/38 of a truck
Studies were made of the development of the world and Japan in the 21st century, and of global environmental preservation. The result is the “Intermodal Ecoway / Preliminary Plan for an Environmental Large Mainline” presented here. This is a combination of the railway technology used Japan and advanced technologies such as information technologies, automotive technology, and overseas heavy-haul railway and ferry train technology, and can thus be said to be a barrier-free intermodal low-energy traffic concept. Abroad in the EU and USA, the standard expansion of railroads is already being performed, and beginning to produce results; ITS technology is being utilized in the profitability of freight railroads, the expansion of the market share, and the improvement of the environment.

Figure 3: Le Shuttle [containing a double-deck bus/large-sized intermodal vehicles].

2 Research & development for new intermodal transport

2.1 Jumbo-train vehicle design

In the realization of the design, one main factor is the technical development of a jumbo train, because the productivity of a big body improves greatly in a large market. When advancing improvement in productivity of land traffic, and the reduction of costs, the improvement in the rate of increasing the body size and speed / operation of freight trains for a large market is indispensable, just as for air traffic. Therefore, the size of the optimized body of the inter-modal vehicle becomes nearly the size of a jumbo jet that travels between large cities.

Figure 4: Size comparison of main railroad vehicles and the newest airplanes.
Figure 5: Example of variation of body composition and loading method.

Figure 6: Transportation cost (inclusive carbon-tax, in the case of 500 km movement).
2.2 Energy-conserving maintenance-reducing method

Today’s railroad harnesses the firm and very small contact of the iron wheel and steel rail in contrast to rubber-tire transportation systems, and has realized land transportation of the highest speed, heaviest load, and greatest energy conservation. In addition, an electric multiple-unit railroad can re-use dynamic movement energy using regenerative braking. The concept of the Shinkansen Electric Multiple Unit (EMU) is applicable also to future intermodal transport systems. In order to reduce the cost of electric power converters, this train will use this new EMU traction drive system.

The key to conserving energy and reducing maintenance while also reducing the costs of this system is the optimized flywheel battery, in which energy is stored without using chemical batteries.

Figure 7: The new loading method to reduce time loss and spatial loss.

Figure 8: Low cost high-efficiency all-axles drive system for a new EMU.

Figure 9: Simple traction method (low cost gearless direct traction drive system by long rotor induction motors).
2.3 New ITS concept on the Intermodal Ecoway

Intermodal ITS is a new type of ITS which utilizes cyber-rail and the mobile telephone. This new ITS navigates cars in parking and loading on to jumbo trains using the service areas (SA) along the highways as cyber-stations. Therefore, each station is arranged in parallel to an SA along the highway of a large trunk line. Furthermore, by linking this system with the hub port of major international containers, the market share of a huge physical distribution market can be secured. The jumbo train can carry many cars because cars are much lighter than coal and iron-ore carried by heavy-haul freight trains. Therefore, even if the body is large, there is less axle load than a heavy-haul train. Moreover, the effects of air resistance are equivalent to that of the Shinkansen, in terms of the cross-sectional area as well as the cross-sectional perimeter. Although the cross-sectional perimeter (area) of the jumbo train is about twice (four times) as large as that of the Shinkansen, the jumbo train travels at less than half the highest speed of the Shinkansen of 300 km/h, and the total length of the jumbo train is
about twice that of the Shinkansen. Drive power is also equivalent to a heavy-haul train or the Shinkansen.

Table 1: Analogy of data transmission line and the concerned Automobile conveyance (by the Inter-modal jumbo train).

<table>
<thead>
<tr>
<th>Data transmission</th>
<th>Concerned automobile conveyance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Member circuit</td>
<td>Door, general road</td>
</tr>
<tr>
<td>Node</td>
<td>Cyber-station (Moving Interchange, Service Area)</td>
</tr>
<tr>
<td>Basic circuit line</td>
<td>Intermodal ecoway (virtual)</td>
</tr>
<tr>
<td>Packet frame</td>
<td>Jumbo train</td>
</tr>
<tr>
<td>Slot</td>
<td>Parking lot</td>
</tr>
</tbody>
</table>

Table 2: Basic composition of an inter-modal navigation system and new ITS: Intelligent Transport Systems.

<table>
<thead>
<tr>
<th></th>
<th>Conventional ITS</th>
<th>Intermodal ITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information</td>
<td>Car navigation by GPS, VICS: Vehicle Information and Communication System, RACS: Road/Automobile Communication System</td>
<td>Car navigation with mobile-phone (3rd generation), mobile free VICS</td>
</tr>
<tr>
<td>Payment</td>
<td>ETC: Electronic Toll Collection System</td>
<td>Cyber-money by the mobile-phone</td>
</tr>
<tr>
<td>Auto operation</td>
<td>AHS: Automated Highway System, SSCS: Super Smart Vehicle System</td>
<td>Jumbo train &amp; intermodal ecoway</td>
</tr>
<tr>
<td>Active safety</td>
<td>AHSS: Advanced Highway Safety System, ASV: Advanced Safety Vehicle</td>
<td>Jumbo train &amp; intermodal ecoway</td>
</tr>
<tr>
<td>System equipment</td>
<td>Ground equipment, point information, charge</td>
<td>Mobile terminal, continuation information, free</td>
</tr>
</tbody>
</table>
3 Study for an ideal scale of public investment

Another main factor in the realization of the design is the construction of an ecoway. Since the transport capacity per area of this system is ten or more times of a highway, it can provide solutions to various traffic problems, requiring only one main ecoway trunk line of 2,000 km for the entire country. The construction expense for this 2,000 km would be about 1.5 trillion yen per year for four years for the case of landfill structures, which is just several percent of road-related investment program of Japan. Furthermore, since it has a function of using the time spent at the service area as part of the travel time move, it is quicker than traveling on a highway, and cheaper when traveling over 30-90 km. Moreover, the passengers can move more safely and comfortably.

![Figure 13: Time reducing effect (example of 500 km trip).](image)

![Figure 14: Productivity per person per year.](image)

![Figure 15: Operation route design used for calculation.](image)
4 Utilization

Although Japan is an advanced nation in the world of railroads, it has neither sufficient tracks for freight trains, nor tracks for intermodal railroads. The construction expense of the track for an intermodal railroad or freight railroads is equivalent to investing about 10% of the total road budget (17 trillion yen per year) of Japan for four years. To secure a source of revenue, the traffic administration of roads in Japan needs to be changed radically, and prior
extensive activities to facilitate such changes are required.

Acknowledgements

The authors thank Mr H. Hata, Mr T. Ogino, Mr T. Tsuchiya, Mr Y. Sato, Mr K. Ono, Mr M. Snaga, Mr M Kondo, Mr M Ogasa of RTRI, Mr Y. Takakado of Shinko-Electric, and Mr K. Kawaike of Daido-Metal for the Study of the intermodal-ecoway and development of the flywheel battery.

References