Aluminum Pipe Shielded High-Voltage Wiring Harness

Yasushi ITANI*, Yoshio MIZUTANI, Masanori KUWAHARA and Shogo HASHIMOTO

In hybrid electric vehicles (HEVs), which have spread rapidly recently, the hybrid system consists of a high voltage battery, an inverter and a motor connected with a high-voltage wiring harnesses, and has good mileage performance. An under-floor wiring harness is required to perform as a protection against stone chipping when the car is moving, and as a shielding against the electromagnetic effect. The conventional wiring harness has resin protectors from stone chipping and braided wires for electromagnetic shielding. An aluminum pipe shielded high-voltage wiring harness with the aim of the unification of protection and electromagnetic shielding was developed in 2005 for hybrid electric vehicles of Honda Motor Co., Ltd. In this report, some features of the aluminum pipe shielded high-voltage wiring harness are described.

Keywords: hybrid electric vehicle (HEV), pipe shield, high-voltage wiring harness

1. Introduction

Recently, the exhaustion of fossil fuels and global warming, caused in part by increasing CO_2 emissions, has accelerated the development of hybrid electric vehicles (HEVs)[*1], plug-in hybrid electric vehicles (PHEVs)[*2] and electric vehicles (EVs)[*3] for the purposes of mileage improvement and reduction of CO_2 emissions in the automotive industry. Particularly, HEV sales are now spreading rapidly because many more service stations are available for refueling.

The hybrid system of the HEV consists of an internal combustion engine with gasoline direct injection and an electrically driven motor. The high-voltage wiring harness supplies electricity between each component constituting the electrically driven system. For more than 10 years, we have been delivering high-voltage wiring harnesses for many vehicles.

Using this experience of wiring harness production, we have developed an aluminum pipe shielded high-voltage wiring harness for HEVs, which in part performs as a protection against stone chipping and as a shielding against the electromagnetic noise, and adapted it to the CIVIC HYBRID[(1)] released in 2005, the INSIGHT in 2009 and other vehicles of Honda Motor Co., Ltd since then.

In this report, the structure and the major features of the aluminum pipe shielded high-voltage wiring harness are described.

2. Overview of Hybrid System

Figure 1 shows an overview of a hybrid system of HEVs. The electric energy of a high-voltage battery is supplied to a motor through an inverter to convert it from direct current into alternating current.

The HEV system precisely controls the output balance between the engine and the motor, deciding the output distribution depending on the running situation of the vehicle. Depending on this system layout, the environment around the high-voltage wiring harness also changes.

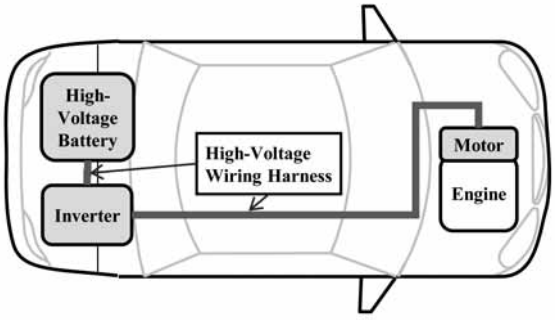

Fig. 1. An overview of a hybrid system

In the case of this report, a setup is simulated in which the high-voltage wiring harness passing through under the floor connects the motor located at the front side of the vehicle to the inverter located at the back side of the vehicle.

An under-floor wiring harness is required to have performance parameters such as, mechanical reliability at the high temperature induced by the engine or the exhaust pipe, flexibility to connect to other systems, protection against stone chipping, chemical resistance to salt water and snow melting agents, and shielding against electromagnetic noise to prevent neighboring electronic equipment and signal lines from being influenced.

3. Structure and Features of Aluminum Pipe Shielded High-Voltage Wiring Harness

3-1 Overview of aluminum pipe shielded high-voltage wiring harness

Photo 1 shows an aluminum pipe shielded high-voltage wiring harness. The orange aluminum pipe, three-dimensionally bent, is used as a part of the under-floor of the vehicle.

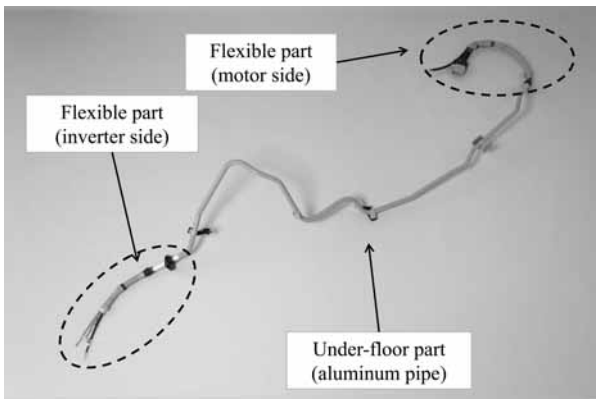

Photo 1. The appearance of an aluminum pipe shielded high-voltage wiring harness

A conventional wiring harness includes: individually shielded wire and a shielded braided bundle of wires to carry electric current from the inverter to the motor, a resin protector and convoluted tube to protect the sheath of electric wires from damage, and the braided wire to shield against electromagnetic noise.

The pipe shielded structure we developed to unify the protecting and shielding performances uses an aluminum pipe in place of the resin protector and braided wire. The aluminum pipe is stronger than resin and has enough protecting ability against possible damages. As shown in **Fig. 2**, the big resin protector is not used, so the wiring harness can be downsized.

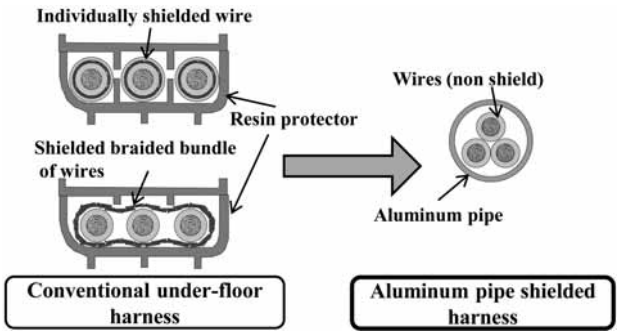

Fig. 2. Downsizing with aluminum pipe wiring harness

Furthermore, it is more convenient to attach the wiring harness to a vehicle because the aluminum pipe is hard and rigid. This makes it possible to reduce the number of attaching components and to improve the efficiency of the vehicle assembly operation.

On the other hand, the flexible parts at both ends of the aluminum pipe to connect the pipe shielded wiring harness to the inverter and the motor include braided bundle shielded wires and convoluted tubes, the same as the conventional wiring harness.

The electromagnetic shielding performance is improved by connecting the aluminum pipe to the braided wire, which realizes the integration of the protecting and shielding performances.

3-2 Shielding property

Figure 3 shows the measurement results of shielding properties with each structure. The current probe method was used for this measurement in conformity with the international standard CISPR25[*4]. First, the individual shielded structure consists of electric wires shielded one by one, the same as in a conventional structure. Next, both the shielded braided bundle structure[(2)] and pipe shielded structure[(3)] are categorized as a bundled shielded structure, and both are used in the aluminum pipe shielded wiring harness. The pipe shielded structure is used at the under-floor part and the shielded braided bundle structure is connected at the both ends of the pipe.

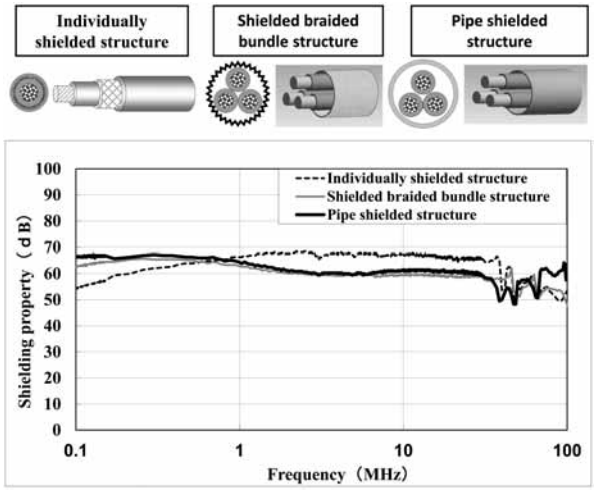

Fig. 3. Comparison of shielding properties

The shielding property of the pipe shielded structure is almost the same as the property of the shielded braided bundle structure because both are a bundle shielded structure. Even with the fact that the performance of both bundle shielded structures is, compared with the conventional individual shielded structure, slightly advantageous in the frequency band less than 1 MHz and inferior in the range of more than 1 MHz, there is almost no problem in the use of these structures.

3-3 Heat resistance

The inner wires of the under-floor wiring harness produce a large amount of heat by the large current flowing to drive the motor. Furthermore, in the area near the exhaust pipe, the temperature of the under-floor wiring harness rises due to radiant heat from the exhaust pipe, so is in a very severe heat environment.

Therefore, as shown in **Fig. 4**, it was necessary to avoid the direct heat influence from the exhaust pipe by locating the conventional wiring harness in the shade of the under-

floor panel or aside a reflection panel attached near the exhaust pipe.

On the other hand, in the case of the aluminum pipe shielded harness, it is easy to reflect radiant heat, because of its low heat radiation coefficiency, and to release heat along the pipe, because of its high thermal conductivity. Therefore the temperature rise of inner wires of the pipe shielded wiring harness can be reduced. In addition the design of the wiring harness layout becomes easier and a shorter wiring harness located near the exhaust pipe without detouring can be expected.

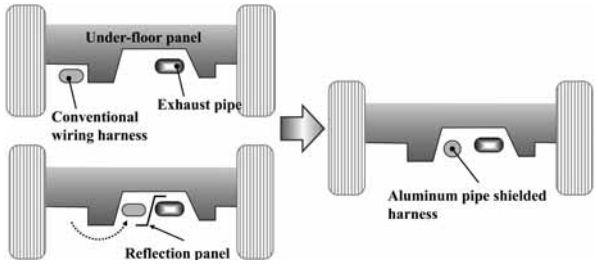

Fig. 4. The under-floor layout of aluminum pipe shielded wiring harness

3-4 Pipe bending process

A three-dimensional layout is necessary for an under-floor wiring harness that passes through small free space after determining the equipment arrangement put on the vehicle.

Both ends of the pipe shielded wiring harness are flexible for connection to equipment. The rigid aluminum pipe used for the under-floor area, however, requires a bending process (plastic forming) depending on the three-dimensional layout.

When passing several thick wires through an already-bent pipe, a ground fault or a short circuit is likely due to possible damage of the wire insulation caused by the friction with the inner surface of the pipe. Therefore, a straight pipe is bent after passing wires through it and some negative outcomes can be expected, such as the influence of sagging wires and increase of bending radius due to coreless bending.

To solve these problems, self-manufacture of the bending process was achieved by installing a pipe bending machine (pipe bender) in our plant and by applying appropriate bending conditions.

In this way, when a layout change according to the specifications of a vehicle is required, the three-dimensional shape can be easily and quickly changed with only a modification of the programs of the bending machine.

4. Conclusion

The pipe shielded high-voltage wiring harness reported this time has the same, or better, protecting and shielding performances in comparison with a conventional under-floor wiring harness using a resin protector, and has the following features:

1. The large resin protector becomes needless and a downsizing can be realized.
2. The number of attaching components is reduced and workability in the vehicle assembly can be improved.
3. Heat influence from the exhaust pipe can be reduced and layout design becomes easier.
4. Modification of the pipe shape becomes easier.

We have started sales expansion by publicizing these features.

Technical Terms

∗1 HEV: Hybrid Electric Vehicle.
∗2 PHEV: Plug-In Hybrid Electric Vehicle.
∗3 EV: Electric Vehicle.
∗4 CISPR25: CISPR25 is a standard for “Vehicles, boats and internal combustion engines - Radio disturbance characteristics - Limits and methods of measurement for the protection of on-board receivers” which special committee (CISPR: *Comité International Spécial des Perturbations Radioélectriques*. English: International Special Committee on Radio Interference) founded in IEC published.

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