Development of a Flexible-Wiring Junction Block

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ABSTRACT To improve the productivity of the automobiles' wire harness systems that are becoming ever more diversified, a production method called "complete sub-assembly system" constitutes the mainstream presently. In response to this circumstance, the authors have developed a flexible-wiring junction block, which accommodates the jointing sections of wire harnesses thereby eliminating a number of joint connectors conventionally used. The product has been adopted in the minor model change program of Toyota's Land Cruiser, and began to appear in the marketplace since August 2002.

1. INTRODUCTION

As the electric components installed in vehicles improve in function, wire harnesses grow in size accompanying the increase of joint connectors (hereafter called J/C). We have developed, therefore, a flexible-wiring junction block (hereafter called J/B) that allows flexible configuration of circuit wiring thus accommodating many J/Cs. The structure is shown in Figure 1.

The employment of this new J/B has resulted in significant reductions in mounted components including 20 J/Cs and 30 circuits together with a cost reduction of 350 yen.

2. DEVELOPMENT OF EACH COMPONENT

2.1 Center Plate

The center plate shown in Photo 1 is an important component that constitutes a base, on which electrical wires are wound and terminals are connected by insulation displacement.

The product developed here has a terminal interval of 2.5 mm, since use of 1.0 Ⅲ connector was assumed at first. Taking into consideration the necessities of winding electrical wires at these regular intervals and of assuring a structure capable of holding the connected terminals, it was decided to divide the terminal section into two rows up and down, each of which taking a staggered configuration. In this case, the maximum wire diameter will be 1.0 mm, since the width of the intervening rib has to be about 1.5 mm so as not to influence the formability of the center plate.

Moreover, since the number of winding turns of electrical wires changes depending on the number of circuits

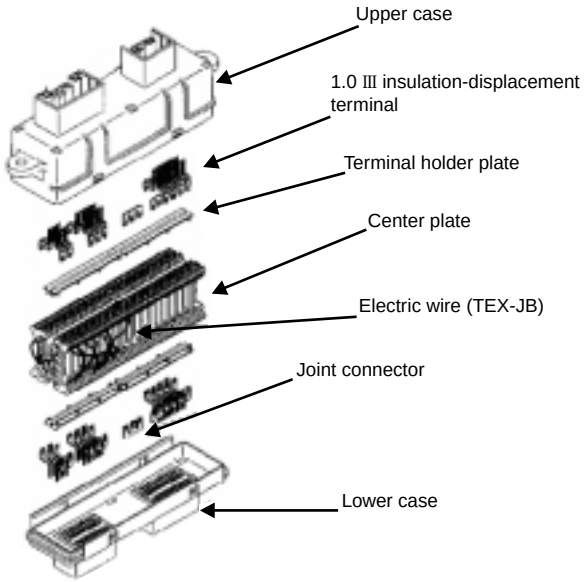

Figure 1 Structure of flexible-wiring junction block.

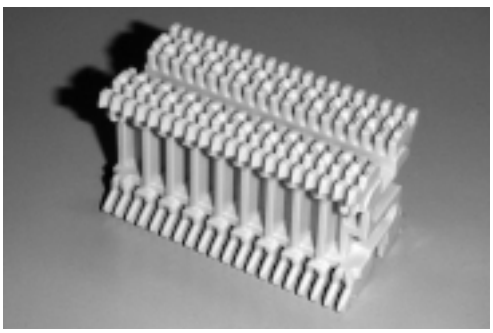

Photo 1 Center plate.

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required, the center plate was provided with connectable projections and press fit sections, making the structure capable of arbitrary numbers of connection.

2.2 Insulation-Displacement Terminal

The insulation-displacement terminal shown in Photo 2 has a slit section that is required to penetrate the insulation of electrical wires by a single action to come into direct contact with the conductor. Besides, the connected portion must pass reliability tests including thermal shock test and the like.

We therefore carried out a stress analysis (shown in Figure 2) and reliability evaluation tests (shown in Figure 3) using prototype terminals, and were successful in obtaining a suitable slit width.

Moreover, it was requested to supply the products in the form of tape carrier mounting in order to shorten the cycle time of assembly, so that the center carrier was set to an appropriate position that would not interfere with the slit on the insulation-displacement section.

Because, as mentioned in Section 2.1, the terminal section of the center plate is designed to have a staggered configuration, it became necessary to prepare two types of terminals. Despite this, they share the mold to reduce the costs.

2.3 Electrical Wire

As mentioned in Section 2.1, electrical wire to be used had to be not more than 1.0 mm in outer diameter, whereas its conductor had to be about 0.8 mm in the outer diameter corresponding to 0.5 sq. in cross sectional area, and we were unable to find any appropriate wire among conventional insulated wires.

We therefore directed our attention to the triple-insulated wire developed by the Winding Wire Division of the company, and, after partially modifying its insulation adhesion to make it applicable to wiring J/Bs, adopted the wire in the J/B developed here under the name of TEX-JB. TEX-JB has sufficient insulation performance and flexibility despite its small insulation thickness of 0.1 mm. In terms of insulation-displacement connection using the terminal, satisfactory results were obtained with cross-section photographs and reliability tests.

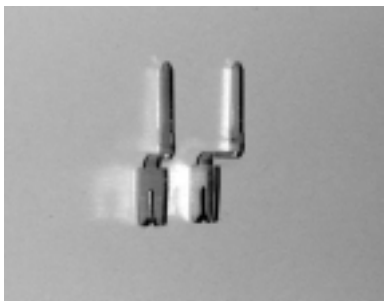

Photo 2 Insulation-displacement terminal.

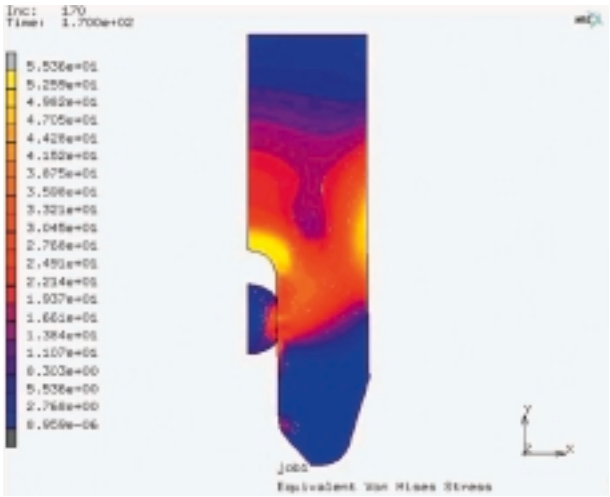

Figure 2 Example of stress analysis of insulation-displacement terminal.

2.4 Cases

Basically cases were to be installed manually, so that their structure was required to be able to prevent wrong connection and avoid interference with the insulation-displacement terminals. Accordingly, the projections provided for jointing with the center plate were used to prevent installations in the reverse direction, and the grooves for electrical wire winding were reinforced with guide ribs on the case to help smooth insertion. See Photo 3.

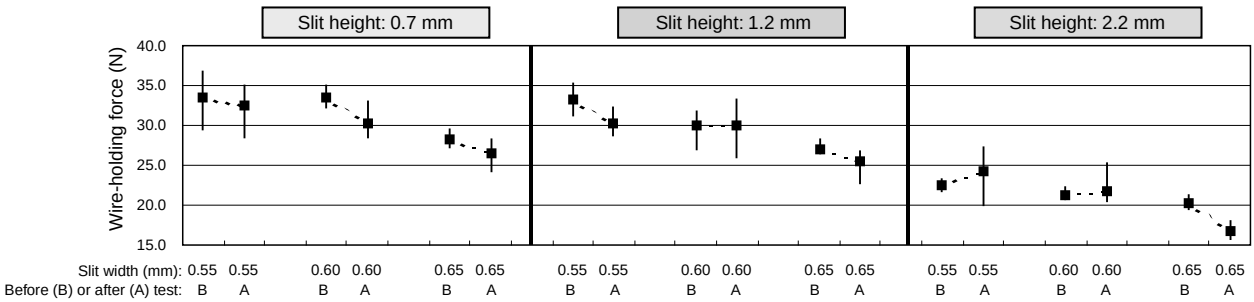

Figure 3 Comparison of wire-holding force of insulation-displacement terminals before and after thermal shock test. Speed of insulation displacement is 10 m/s.

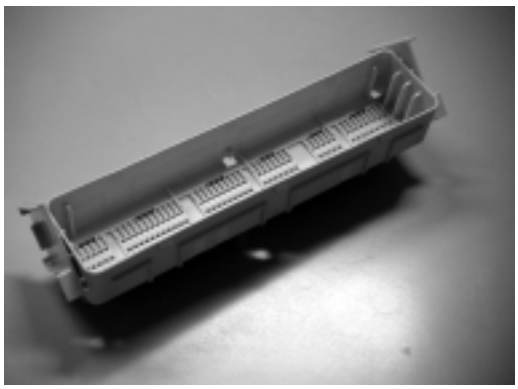

Photo 3 Upper case.

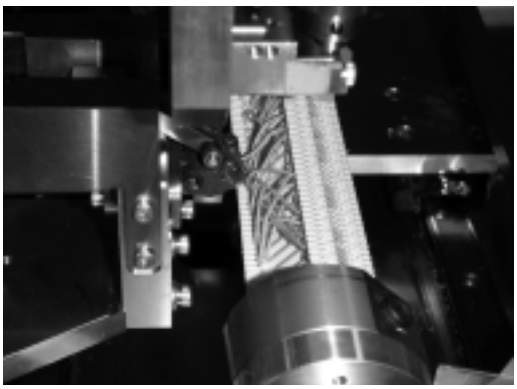

Photo 5 Wiring instrument.

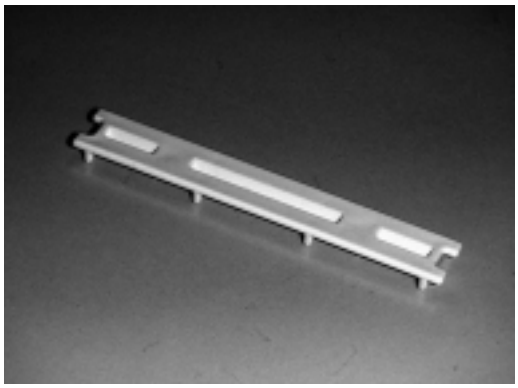

Photo 4 Terminal holder plate.

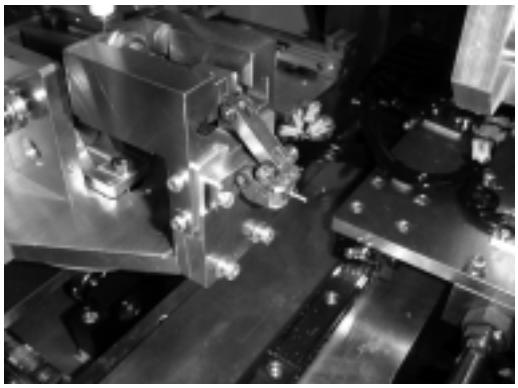

Photo 6 Wiring head.

2.5 Terminal Holder Plate

The terminal holder plate is placed on the center plate to prevent the insulation-displacement terminals in cranked figure from deformation and falling off. In spite of its simple structure, the holder plate presented certain problems of warping and terminal falling, and it was after several changes that the plate was finally settled to have the current structure. See Photo 4.

During that period, the holder plate underwent various improvements such as the reexamination of the dimension of ribs that are connected to the center plate by press fit, the provision of V-grooves to prevent warping, as well as the provision of a plane surface for vacuum suction at the assembly instruments, thereby establishing a stabilized assembly process.

3. DEVELOPMENT OF ASSEMBLY INSTRUMENTS

3.1 Wiring Instrument

The wiring instrument shown in Photo 5 was developed on the assumption that it should operate fully automatically without any manual operations, which was aimed at stabilizing the quality of the product of a new structure.

The form, structure and action of the wire supply section called wiring head shown in Photo 6 constitute the main factors of wiring performance. The structure of the wiring head was so designed that the head would operate in contact with the center plate. This enabled the head to guide electric wires to a suitable groove, thus realizing high-speed winding while decreasing wrong winding. The average winding speed was 3.5 sec/turn at the initial stage of the development, but it reached 1.2 sec/turn with the volume production instrument.

Furthermore, the wiring head was made to be capable of motion in three axes. While the X-axis direction is naturally necessitated for guiding the wire to the groove, two movements in the up-and-down and back-and-forth directions were added to follow the rotation of the center plate, thus enabling smooth and high-speed winding of wire without damaging the wire insulation.

3.2 Wire-Cutting Instrument

With this J/B, multiple wires have to be cut out of about 50 wires 1.0 mm in diameter, which are arrayed on the one side at 2.5-mm intervals. These wires are to be designated arbitrarily and specifically in accordance with the part number of J/B. In this wire cutting, it is essential that the specified lengths of the wires be removed without fail not to cause electric current leaks. Also it is an essential requirement from the standpoint of quality assurance to keep the wire chips from mingling with the product.

To meet these requirements, a new rotating cutter was developed. The cutting machine enabled, with a small footprint, cutting of each electric wire, and the wire chips

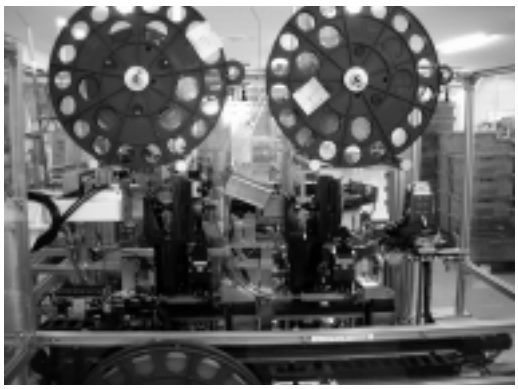

Photo 8 Instrument for connection of insulation-displacement terminals.

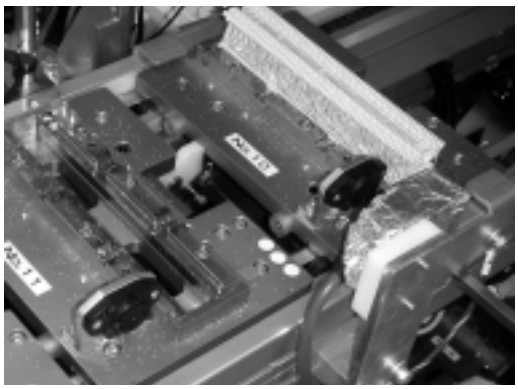

Photo 9 ID tag and reader.

are accommodated temporarily in the cutter blade to be ejected one by one.

The wire cutting instrument for volume production is provided with a mechanism which detects ejected wire chips one by one, and discriminates a J/B as a defective product in case no wire chips are detected, thereby contributing a great deal to upgrading of quality. See Photo 7.

3.3 Instrument for Connection of Insulation-Displacement Terminals

Insulation-displacement connection of multitudes of terminals arrayed at regular pitches in two rows, which constitute one of the proprietary structures of this product, was carried out aimed at realizing a high production rate of no longer than one sec per one piece. Mechanism adopted for the purpose was such that, unlike those methods in which separated terminals are supplied to other driving sections using a parts feeder, as soon as the terminals on the carrier tape were separated respectively, they are directly connected by insulation displacement. See Photo 8.

Thus we achieved a high rate of insulation-displacement connection of 0.8 sec per one piece, contributing significantly to the reduction of production cycle time for the product.

3.4 Serial Number Control

There are six different part numbers representing car's specifications and destinations of each J/B developed here. Different part number means different wire winding, different wire cutting and different position in insulation-displacement connection. To manufacture a variety of products on a single line of facilities without making errors at each production step, we have adopted a manufacture control system using ID tag. The ID tag and its reader are shown in Photo 9.

In this system, a tag is attached to the conveyor palette used between the process steps, on which necessary information such as part number and serial number is memorized, enabling recording of information on work or problems. Using this information at each production step, products that became defective at intermediate steps are rejected to omit processing at downstream steps, thus preventing confusion of part numbers or launch of defective products.

4. DEVELOPMENT IN THE FUTURE

4.1 Downsizing

Although the J/B developed here uses 1.0 Ⅲ terminals, a one size smaller product that will use 0.64 terminals is under development in response to customers' needs, which is aimed at entering into volume production in 2003.

4.2 Multifunctional Products

Whereas the product developed here accommodates to wire winding of only one kind, there is an increasing need for products capable of accommodating to wire winding of multiple kinds, i.e. so-called hybrid type. We are also investigating the feasibility of various ideas for new products including those that mount other components such as fuses.