MODERN WIRING MANUFACTURING METHODS

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To my parents, sister, and grandmother

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by

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ABSTRACT

The manufacture of automotive wiring harnesses is currently a highly labor intensive and costly operation. Harness fixtures are mounted on huge carousels which traverse up and down the floors of wiring harness manufacturing facilities. These carousels are completely surrounded by manual laborers performing a progressive build of the harnesses as each fixture passes their stations. This manual build of the harnesses includes the insertion of connectors into holders, the insertion and routing of pre terminated wires (often manufactured at a separate facility), and the insertion of clips, wire wrap, and tape. Due to the manual labor intensity of this process, defects are not uncommon, resulting in additional expenditures for rework and inspection.

Much of the labor intensity and fixturing used in the manufacture of wiring harnesses could be eliminated through the implementation of an automated wiring process. An automated wiring process could eliminate the need for pre-terminated wires and reduce the number of fixtures, manual laborers, defects, square feet of floor space, and thus the overall cost of the wiring operation.

The design and testing of an automated wiring process to determine the feasibility of using automated manufacturing for automobile wire harnesses will be demonstrated in this thesis.

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CHAPTER 1 INTRODUCTION

Todays automobile utilizes a complex array of wiring harnesses routed throughout the vehicle. Wiring harnesses are the media used to form electrical connections between different locations of the vehicle. A wiring harness consists of a bundle of wires wrapped with tape to hold it together and provide abrasion protection. Each harness contains a variety of clips ties that are used to attach it to the vehicle. At the ends of each harness are connectors which consist of a plastic insulator containing anywhere from one to sixty separate terminals. These connectors are used to make electrical connections between components (radio, speakers, headlights, etc.) or other harnesses of the vehicle.

The manufacture of the automotive wiring harness is currently a highly labor intensive operation. The existing process can be broken down into two basic categories, subassembly and final assembly.

The subassembly portion of the wiring process consists of manufacturing the separate circuits that will make up the harness. A circuit consists of a wire with a terminal attached to each end. To form a circuit the wire is first cut to length and then the insulation is stripped off of each end. This operation is carried out by machines operated by laborers. Terminals are then installed on each

end of the stripped wire using manual terminating presses. At this point, the wire is ready for assembly into the harness.

The final assembly portion of the process consists of assembling all of the circuits required for a complete harness. This task is accomplished using wiring fixtures that consist of an array of clamps, posts, rails, and connector holders. Several of these fixtures are mounted on huge carousels that are surrounded by laborers performing a progressive build up of the harnesses. Each person on the assembly line is responsible for a certain portion of the harness.

The assembly process begins with the manual insertion of the connector insulators into the connector holders. The circuits are then manually routed around a series of posts that define the configuration of the harness. The terminals at each end of the circuit are inserted into their respective connector cavity. On line continuity testing is performed on each circuit. When all of the circuits have been routed and tested, the harness is wrapped with tape. Then the required clips are taped to the harness followed by the insertion of wedges or secondary locks into each connector. The harness is then removed from the fixture as a complete assembly.

There are several problems associated with the high labor intensity of the existing process. First, due to the

large amount of manual labor, process variability and defects are not uncommon. The result is additional expenditures for inspection and rework. There is also the problem of laborers normal working day being only eight hours long, resulting in limited production, and possible defects due to unfinished work at shift changes. In addition, when design changes are made, every fixture on the carousel must be modified as well as having to train each person to perform the required changes.

An obvious solution to this problem is to automate the process. This would eliminate variances in the process due to the manual labor, and result in higher levels of reliability. Higher levels of output can be obtained because automated equipment can run twenty four hours a day seven days a week. In addition, programmable automated equipment is generally very flexible to changes. Design changes can typically be accomplished with a simple program modification.

This thesis covers the design and testing of an automated wiring process to determine the feasibility of using automated manufacturing for automobile wire harnesses. The process includes terminating, routing, and cutting operations of harness assembly. Since the taping of the harness is a low defect area, and would require additional automated equipment, it is not included, and will be left as a separate project.

CHAPTER 2 REQUIREMENTS

This chapter outlines the requirements that must be met to develop an automated wiring process. The requirements are based on conventional automotive wiring components and processes, thus some requirements may be added or deleted depending on the needs of the specific automated process.

2.1 CONNECTOR SYSTEM:

The first step in designing an automated wiring process is selecting a connector and terminal system which lends itself to automation. The terminal design must allow for easy and reliable termination of wires to the connector body using automated equipment. The connector and terminal system must also be capable of handling a variety of wire gauges and sizes. It is desirable that this connector and terminal system eliminate a portion of the steps used in the conventional (cut, strip, splice, and insert) system.

Once a connector system has been selected, an applicable holding fixture for these connectors must be designed. This fixture must allow for automatic insertion of the connectors prior to the wiring operation and automatic release of the connectors after the process is complete. These holders must also allow for electrical contact to the terminals for testing purposes.

2.2 AUTOMATIC POSITIONING DEVICE:

In order to accomplish an automated wiring process automatic positioning equipment is required. This device must have at least four axis capability, including X, Y, Z, and C (rotation about the Z axis) motions, to perform planar routing applications. In addition a repeatability within + or - 0.001" and an accuracy in the X,Y plane of + or - 0.002" in order to maintain reliability in conventional terminating operations is required. Because this is a tooling and process development project speed is not of utmost importance, but must be a consideration for production. The intent of this project is to develop compact lightweight tooling. Payload capacity will therefore be restricted to ten pounds or less. The automatic positioning device must be equipped with a controller capable of being programmed as well as being taught point to point motion commands and have the capability of controlling external pneumatic solenoids for pneumatic tooling applications. A minimum working area of 385 in^2 in the X,Y plane and a Z travel of 7.75" will be required to accommodate harness sub assemblies.

2.3 WIRE END PREPARATION:

In order to make an electrical contact between the wire and the terminal, an automated end preparation device

must be developed. This end preparation device must be capable of moving with the automatic positioning device to perform operations at different locations on the harness fixture.

2.4 INSERTING DEVICE:

Once the wire has been staked to the terminal the terminal must be inserted into the insulator housing. An automatic insertion tool capable of moving with the automatic positioning device, must be developed.

2.5 FEEDING/ROUTING DEVICE:

After the terminal has been inserted into the connector housing, the wire must be routed through a fixture to another connector location. The routing of the wire requires a feeding and routing device capable of moving with the automatic positioning device to perform routing in the X-Y plane. The wire must be routed through guides that will hold the required configuration of the harness.

2.6 CUTTING DEVICE:

When the wire has been routed to another connector location the wire must be cut to length so that termination can be performed. A compact and lightweight cutter must be

designed to perform cutting operations at different locations around the harness fixture.

2.7 TOOL FOR STRAIN RELIEF CAPS:

All completed circuits require either a secondary lock or a strain relief cap to prevent the possibility of terminal push out (TPO). A TPO is a situation where the mechanical lock between the connector body and the terminal is not completely mated during insertion, and thus, when the connector is brought together with its mate the terminal pushes back out of the connector housing creating an incomplete circuit. A tool is required to install either the strain relief caps or secondary locks, whichever is required by the particular connector system.

2.8 QUICK CHANGE TOOL:

Because the automated wiring operation will require the use of multiple tools in a single work cell, the automatic positioning device must be capable of changing tools. This task can be accomplished with a quick change tool, allowing the device to move to a tool change position where the current tool can be dropped off and the required tool picked up.