FLEXIBLE AUTOMATED WIRING HARNESS ASSEMBLY

Warnecke, H.J.
Walther, J. and
Schlaich, G.

Abstract

In the field of wiring harness assembly an important potential of rationalization is expected, especially for complex harnesses like those in the automotive appliance, domestic or aircraft industries. The Fraunhofer-Institute for Manufacturing Engineering and Automation (IPA) in Stuttgart (West Germany) has developed a variety of concepts for flexible automated assembly stations. Furthermore several test set-ups and pilot work stations with industrial robots and automatic auxiliary equipment are realized. All concepts are featuring an automatic -feeding of wires, -terminating and stripping, -lugging, -routing, -lacing and linking, -testing and -interlinking with the final assembly.

The possibilities and limits for an economic application of industrial robots in this assembly field are shown and test results are discussed.

The problem

Industrial robots till now mostly are used for point- and arc welding, for varnishing, for palletization and other simple handling problems. The flexible automation of assembly with industrial robots became realized only in a few cases of industrial application. The reason herefor are problems, which are specific for the assembly like the high number of types and variants, the cutting life of products becoming more and more short and finally the fact, that products are not designed for automated assembly.

One subdomain, the assembly of non-rigid parts until today nearly has been excluded completely even in research, for it is necessary to solve the difficult boundary conditions for assembly as well as the problem of handling those elements. At the Fraunhofer-Institute for Manufacturing Engineering and Automation (IPA) at Stuttgart (West Germany) investigations are going on, which try to automate the assembly of those non-rigid work pieces, exemplary the wiring harness assembly.

In the most important industrial sectors such as the household and small appliance industry, automobile and vehicle manufacture and the aircraft industry wiring harness are currently made for the most part manually (Fig. 1 and 2). This process has not been automated in the past for the following reasons:

- because wires are very flexible items are automatically difficult to handle,
- wiring harnesses contain a large number of different types and varieties of components (e.g. leads, plugs, contacts),
- complicated connecting techniques (e.g. crimping, ultrasonic welding) are required for assembling wiring harnesses.

State-of-the-art

The attempts at automation carried out to date have been restricted to rigid automation of the processes for cutting the wire to size, where highly automated sectioning, stripping and crimping machines are used. These machines are only designed for a limited range of workpieces and resetting is a complicated procedure even when it is only the wire diameter or type of contact that is changed.

Initial pilot systems with programmable handling systems already exist in various locations for complete assembly of wiring harnesses. In these systems only some of the tasks are automated they are closely tailored to specific problems /1,2,3 and 4/.
An example of this type of system is the IBM assembly cell which was designed for the complete assembly of wiring harnesses (figure 3, 4, and 5). The system is only suitable, however, for one type of wire and one type of contact. Different contacts and wires can only be handled after considerable resetting of the system. With this system, as with other known systems for flexible automation of wiring harness assembly, the economic feasibility would appear to be inadequate.

**Development aims**

One of the most essential rationalization measure is the flexible automation of wiring harness assembly by means of industrial robots. By using suitable, in some cases still to be developed, assembly procedures and peripheral components, continuous automation from cutting of the wire to the automatic positioning of the wiring harness in the final assembly is aimed at. To this end the following assembly tasks have to be automated and integrated into an overall automated system:

- cutting of wire sections,
- stripping of wire ends,
- fitting of different contacts to wire ends,
- soldering of contacts and wire ends if necessary,
- placing pre-assembled wires in magazines,
- routing of wires,
- fitting of wire ends in plug,
- bundling of wiring harness,
- wrapping/protecting of wiring harness,
- testing of fitted wiring harness,
- releasing of wiring harness and
- automatic conveyance of wiring harness to final assembly.

Through the use of flexible handling systems and feed devices and newly developed sensors different types and varieties of wiring harnesses can be assembled without retooling. Further rationalization steps include work preparation. In this respect off-line programming using CAD data (CAD/CAM link), particularly for complex or different types of wire strands, is of great importance.

**Concepts for flexible automated complete assembly of wiring harness**

The design of a flexible automated assembly system for wire strands depends essentially on the required cycle time, size and complexity of the wiring harnesses to be assembled. The following section describes several flexible automated wiring harness assembly concepts for different areas of application.

Figure 6 shows an assembly cell for the complete assembly of small wiring harnesses with the aid of a horizontal articulated arm assembly robot which positions all plug housings on the harness board and takes hold of a wire which is stripped and fitted at both ends with its routing tool. The next step is to insert the contacts in the plug housings in sequence. After all wires have been routed the wiring harness is tied off with wire binders and released in its own lattice box. This cell is suitable for the assembly of small wiring harnesses with a minimal variety of components and a cycle time between 5 and 10 minutes.

By using gantry robots with greater working areas larger wiring harnesses can also be assembled automatically using the above method. There is, however, a specific upper limit to the complexity of the wiring harness (number of individual and different components) in the case of a one-station solution of this type.

If there are too many different parts in the single station the non-productive time for handling the parts becomes excessive. For flexible automated assembly of large batches of complex wiring harnesses several linked handling systems are used (see fig. 7). The harness boards serve as workpiece holders for the linking system which also permits direct coupling to the final assembly line. The first assembly robot fits routing pins into the harness boards together with the required plug housing. At the next two work stations the wires which are prepared by a freely programmable wire preparation machine, are routed and the contacts fitted in the plug housing. Then the wiring harness is tied off at a further industrial robot work station with wire binders.