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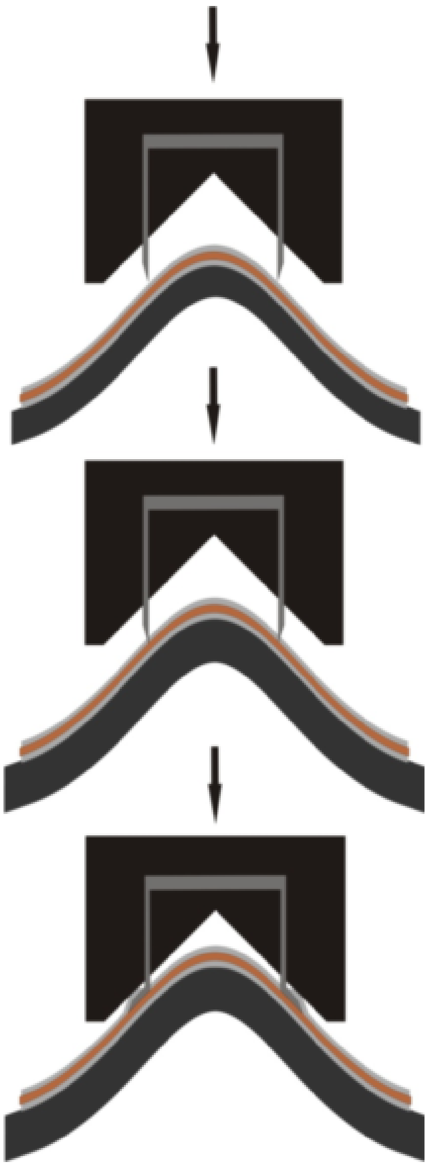
Press Release

Research: Assembly alternatives for wiring harnesses in vehicle dashboards.

Lighter cars are easier on the wallet and the environment



Contact clip sits over the flat cable......

..... cuts through the insulation.....

.... And makes contact with a large area on both sides

Direct Contact Spring Clip assembly via "Contact Mound"

Automatic Assembly & routing of flat conductor cable reduces cost and weight

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The automotive industry has set the course for change. In the battle against global warming politicians and consumers are now demanding cars which use less fuel and emit significantly less CO_2. In addition to research into a dependable alternative drive to the conventional Internal Combustion Engine, cost-saving potential is also in focus. One approach is the reduction of vehicle weight.

Today the most popular accessories in a new car are the electronic devices. However it is these vehicle instruments which drive up the cost and weight of a vehicle. Weight, because the conventional wiring harnesses have increased so much in volume and costs because automatic alignment and assembly of wiring harnesses based on existing assembly and connecting technologies is almost impossible.

Installing flexible flat conductor cable instead of standard wiring harnesses could reduce the cost and weight of the vehicle. Scientists at the Institute for Manufacturing Automation and Production Systems (FAPS) at the Friedrich-Alexander-University Erlangen-Nuremberg have based their research on this idea and also the automated handling and assembly of flexible flat cables. Their research has resulted in the development of a system prototype.

The FAPS research equipment enables robot-guided assembly & routing of multi-core flat cables onto a three dimensional module (e.g. a vehicle door Panel) and assembly by means of hot-melt adhesive coating or laser welding. Central to the research is the means of electrical connection between the cable and functional components. Because the cables are only accessible from one side after they have been positioned, it was necessary to develop a new connection technology for this application. The equipment had to be automated and include the additional step of penetrating the wire insulation. The patent pending "Direct Contact Spring Clip" is the successful result of this development project.

In this design the flat cables are positioned in a "Contact Mound". As the component(s) to be connected are applied to the flat cable in a linear motion, blades on the patented Direct Contact Spring Clip legs cut through the layer of insulation on the flat cable, slide over the copper conductor and simultaneously slip under the insulation

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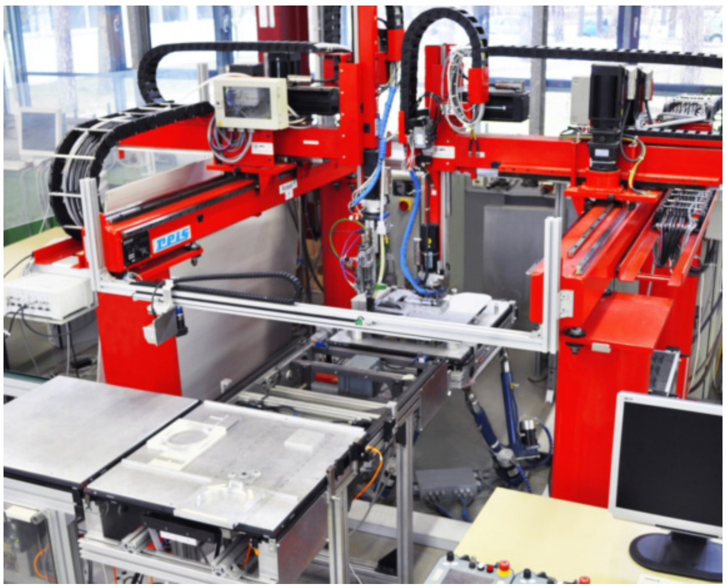
resulting in a large contact area. Now a clamping force must be applied to the connection, which counteracts the pressure from the spring clips, until the device is assembled (e.g. a loud speaker) to its functional component (door panel), After screw assembly the required clamp force is removed from the connector and the redundant electrical connection between the flat cable and connected device is realized. The feasibility of the Direct Contact Spring Clip has been demonstrated and evaluated on various assembly cells at the FAPS-Institute. Among other things the automation of flat cable routing and connection as well as completely automated assembly of vehicle modules which contain flat cable components, have been tested.



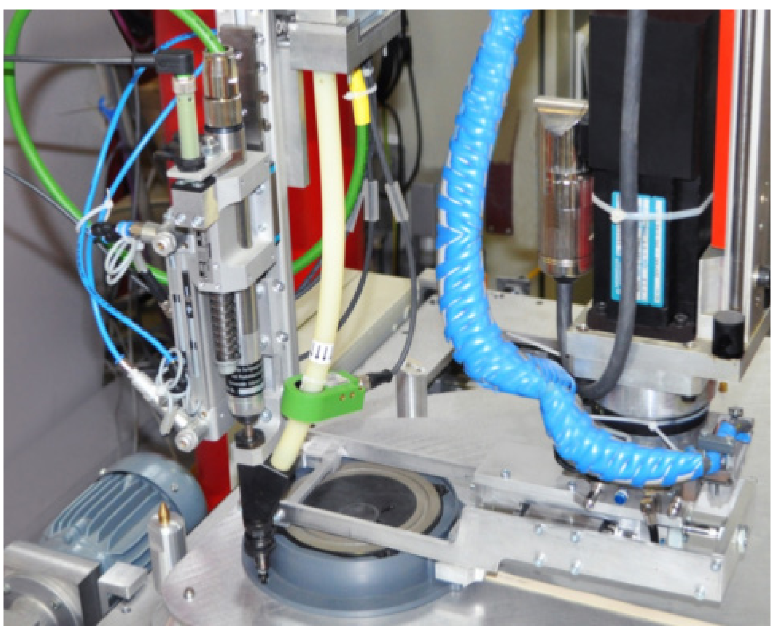
As an example of the Direct Contact Spring Clip to flat cable assembly, one of the production cells employs two robots. In this case a loudspeaker is assembled to a vehicle door panel. Two linear robots - Reis Robotics RL16, are positioned so that they share a common working area. In order to extend the working range of the robotic actuators, the work-piece/assembly is mounted to an automated hexapod which allows additional positioning movements. Feeding of materials within the cell is managed by a dual belt transfer system. The Gripper units of the robotic assembly cell have access to various tools. A sophisticated screw-driving system with screw feeding as well as a special Direct Contact Spring Clip gripper is in use to connect the electrics of the loud speaker with the flat cable to be mounted into the vehicle door panel.

Whilst the gripper was specifically developed for this task by the researchers at the institute, the team led by Dipl.-Inf. Markus Michl have relied on the screwdriving spindles, feeding systems and screwdriving controller technology from the specialists in screwdriving and automation, DEPRAG SCHULZ GMBH & CO from Bavaria, Germany. The main component of the screwdriving system is a DEPRAG programmable screwdriver MINIMAT®-E 320E27-0042 with a torque range of 0.7 to 4.2 Nm suitable for the application. Project leader Dipl.-Inf. Markus Michl: "Due to its small size and low weight this device proved to be the best suited screwdriving -spindle for the robot end-effector".

In order to automatically feed the 4 M4 x 12 mm screws, required for the application, to the MINIMAT®-E EC screwdriver FAPS used a screwdriving system available from DEPRAG's standard program. Based on vibratory feeding technology, the screw feeding system is distinguished by its highly reliable feeding performance. It consists of a vibrator drive, a single spiral vibratory feed bowl and a screw separator. The screws are automatically fed through a feed hose before every screw assembly cycle. The screw is blow fed to the mouthpiece and nosepiece and accurately positioned ready for assembly. The robot positions the combination of screwdriver, mouthpiece and nosepiece over the screw location. With the help of a linear bearing slide the screwdriver moves downwards. The bit descends through the mouthpiece and nosepiece onto the head of the screw. After the start signal from the main controller the screw is tightened.

The screws are assembled in a two-step process: First the screw is threaded in at a slow speed and then tightened to a preset torque (minimum 1.2 Nm / maximum 1.8 Nm). Once torque has been reached the screwdriver stops automatically. The screw is seated securely every time at the same torque with a maximum standard deviation of 3%. The screw is assembled in 1.3 seconds. This process is monitored and controlled by the DEPRAG screwdriver controller AST10 which is integrated with the Central control system of the assembly cell.

Bernd März, Head of the DEPRAG Mechatronic Development Centre describes the versatile application options of the AST10: "Our AST10 sequence controller is not only used in fully automated assembly systems but also in handheld stations." It serves as a screwdriving controller for brushless electric motors, remote operation, control and monitoring of screwdriving processes, for central data collection and retrieval, to compare data with external databases and for worldwide access to processing data. The advantages are seen in the high precision, sophisticated software ergonomics, the http-interface and the integrated web server.



Dipl.-Inf. Markus Michl chose the DEPRAG AST10 as the screwdriving controller for this project "because of its ease of integration into our control-system". The central controller component of the prototype FAPS assembly system is a PC, which is connected via several interfaces to the individual controllers such as the AST10 and which can, if required, be controlled by the PC. Connection is guaranteed between the central computer and both industrial robot machine controllers via the Ethernet, over which the data packages with guidance instructions in XML format can be set externally.

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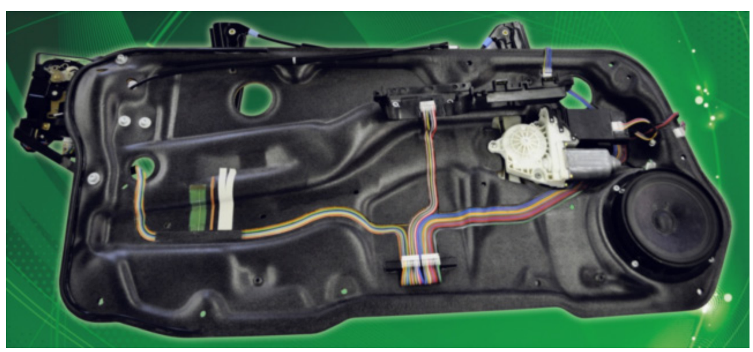
There is also an Ethernet-based communication connection to the hexapod. Via USB interfaces two more IO-Warriors (microcontrollers for process monitoring) are attached, and these allow the typical PLC tasks to be carried out, such as the setting and processing of digital input and outputs. Actuators (solenoid valves for pneumatic control) and sensors (to control the screw assembly, recognition of the feed position of the linear unit) are connected via the "IO-Warrior" to coordinate the work of the vibratory feeder and the feeding components with the Central computer.

The DEPRAG screwdriving controller AST10 is linked to the IO-Warrior via the PLC port. The AST10 controller screwdriving program is selected via this communication interface (binary signals); it also processes the start signal for screwdriving as well as any messages from the screwdriving controller (system OK/NOT OK, screw assembly OK/NOT OK). In addition there are serial and Ethernet interfaces to the screwdriving controller designed to process detailed information about the screw assembly procedure via data interface.

Data strings, which contain e.g. information about the final tightening torque of the screws or error codes, are communicated via the serial connection. The content of these data strings can be configured in advance via the web-based configuration interface of the AST10 controller. A detailed data record of the screw assembly procedure can be called up via an http-request for processing analysis and documentation. In this way for example torque, angle and number of the current screw phase are available in milliseconds for analysis in case of error and for processing administration.



Such data technical connections are the optimum prerequisites for Dipl.-Inf. Markus Michl for operator friendly central coordination of the entire assembly cell. In order to make this as simple as possible for the user, elementary functions such as robot or Hexapod actions, the feeding of screws or the design of screwdriving programs are integrated into a sequence controller in the object oriented script language Python.

In this way a great burden is lifted from the operator: There is no need to create a sequence program, a job which is time consuming and susceptible to errors. The operator's task is simply to specify the working instructions to the device in a preset data format. The chosen data scheme always contains five elements according to the scheme "contract name/pre-condition/machine name/command/parameter".

And so the cables in the door module are assembled via a completely automated process: The door module with attached flat cables as well as the loud speaker to be assembled is fed via the internal transfer system. The door as

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a basic component is fixed onto a palette which is clamped onto the hexapod. Next the robot which is equipped with a gripper takes hold of the loudspeaker and places it onto its predetermined assembly position. The contact between the flat cable and loudspeaker has already been produced. The main object at this point is that the robot must maintain its position long enough for the loudspeaker to be fixed with the joining elements and fastened securely.

This is the task of the second robot which handles the screwdriving tool. The robotic Screwdriver moves to each joint where a screw is applied and the screw is assembled to torque. This process is repeated for all screw positions. Then the robots return to their starting positions and the assembled door module exits the cell.

Dipl.-Inf. Markus Michl emphasizes the success of the research equipment: "Due to the flexible software framework which has been developed, the testing of complex procedures with several components to be connected on the door module is feasible without problems". Also the production of other module units as well as the use of modified contact- technology can easily be put into practice. Before general use of these new technologies in the automotive industry however, further tests must be carried out. The researchers want to perform long term tests in order to analyze the reliability of these and alternative options in regard to types of cabling and contacting parts.

Institute for Production Automation and Production Systems

The Institute for Production Automation and Production Systems (FAPS) is a part of the Friedrich-Alexander-University Erlangen-Nuremberg, the centre of scientific research and education in the region of Nuremberg. Around 24,000 students in 11 faculties have a wide range of studying facilities. Under the leadership of Prof. Jörg Franke around 20 employees at the FAPS-Institute research various topics concerning processing and systems design in the areas of handling and assembly technology, electronic production as well as planning and simulation. Numerous research and cooperation projects (BMBF, BFS, DFG, AiF, EU) have been successfully completed. Furthermore the institute is part of in a specialist research program of the German Research Community.

Dipl.-Inf. Markus Michl, born in 1980, has been an employee since 2006 and focuses on the development of monitoring and diagnosis systems for production equipment.

Dipl.-Ing. Christian Ziegler, born in 1979, has also been at the institute since 2006 and works in the field of handling and assembly technology.

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