Towards Increased Reliability of Resistance Welded Joints for Aircraft Assembly

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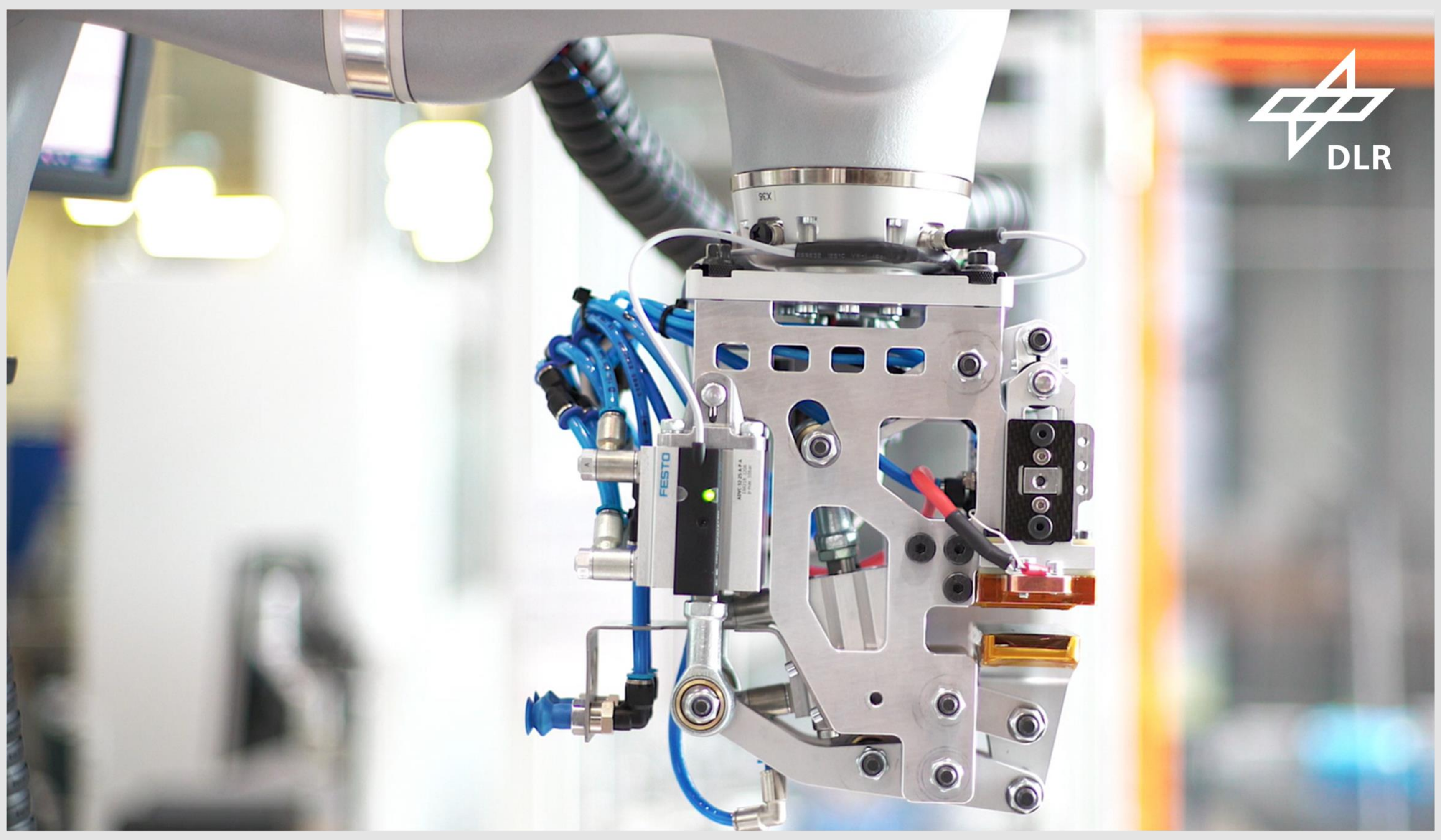


Custom-made end-effector for automated resistance welding of thermoplastic clips

Resistance Welding in Application

Introduction

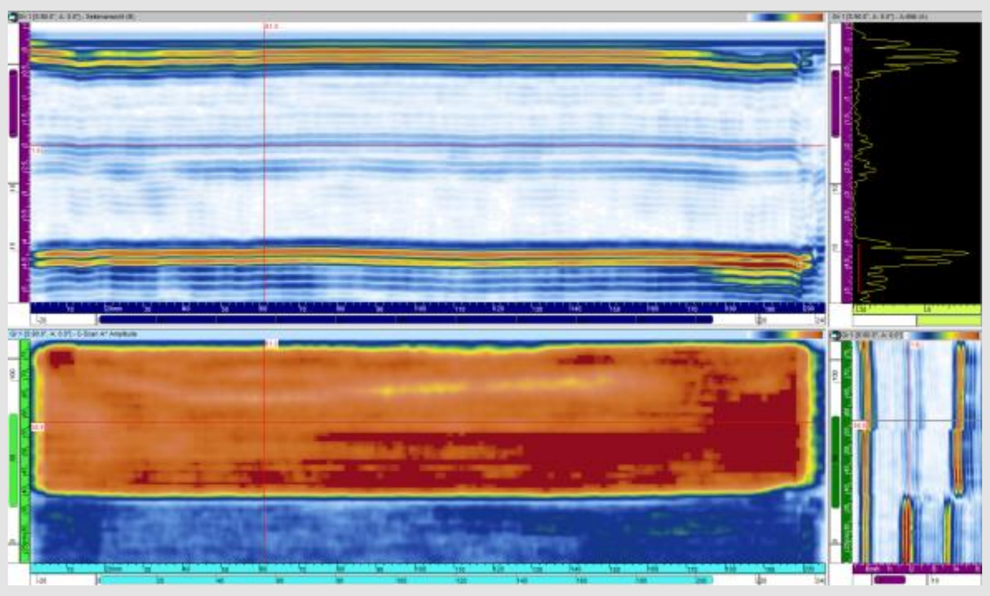
Carbonfiber-reinforced thermoplastics are currently in focus due to their advantageous characteristics in processing and especially in assembly. The weldability of thermoplastics offers new possibilities for a dustless assembly and allows a reorganization of assembly processes. The Center for Lightweight Production Technology Augsburg and its project partners AIRBUS, Premium AEROTEC and Aernnova are involved in the European Clean Sky 2 Large Passenger Aircraft (LPA) project and face the challenges of producing an 8 meter long thermoplastic upper shell segment of an aircraft fuselage.

The skin of the Multifunctional Fuselage Demonstrators (MFFD) upper shell will be manufactured in an in-situ tape laying process. While the stringers will be integrated by continuous ultrasonic welding, the residual stiffening elements like frames, frame couplings and cleats will be integrated by electrical resistance welding. This study focuses on the opportunities and challenges applying the static resistance welding process to a full-scale upper shell fuselage demonstrator

Resistance welding principle and opportunities

In resistance welding, the required fusion heat is generated in the welding zone by Joule heating of a current-carrying conductor. In order to sufficiently consolidate the thermoplastic matrix and generate an assembly free of voids, an external pressure must be applied to the welding zone during processing.

One of the advantages of the resistance welding process discussed in this study is the possibility to produce homogeneous welds with a defined weld seam in order to achieve a closed joint with reduced stress concentration at the edges. Phased array ultrasonic testing is used to check the full-surface closure of the test specimens during welding process development



Fully-closed welding connection validated by an ultrasonic scan of a 200mm x 40 mm CF/PPS weld specimen

Furthermore, the weld performance validated in destructive testing with welding factors around 0.8 and the applicability of static resistance welding for different matrix systems are described. By using an electrical conductor in the welding zone, conclusions about the current welding temperature can be drawn via a resistance-temperature correlation. Processing data like welding temperature, voltage, current, power, energy input, as well as the pressure levels in the contacting and welding can be tracked and digitally stored.

Resistance welding challenges

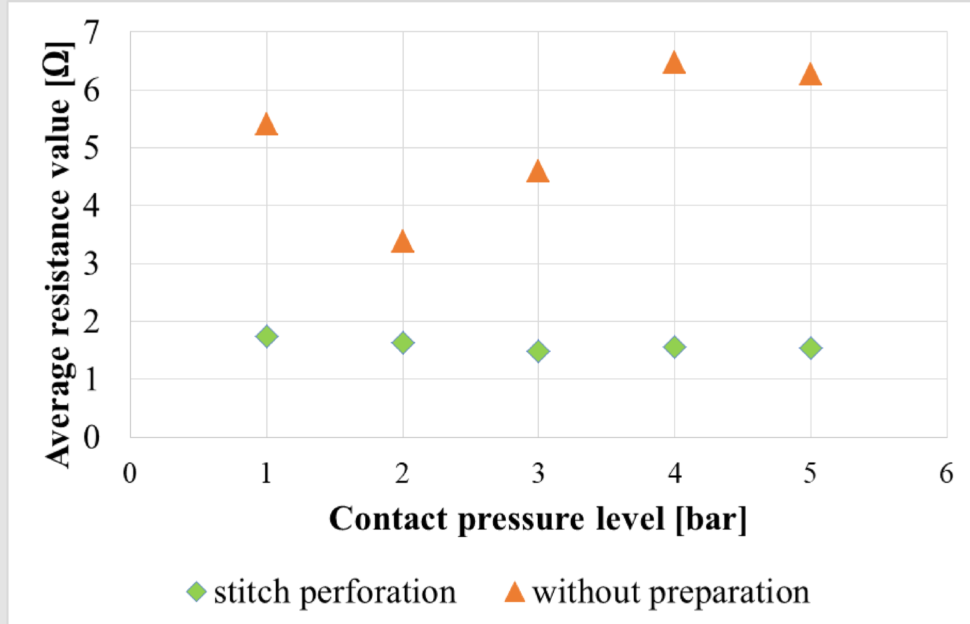
Well known phenomena of the resistance welding process like current leakage and edge effect must be prevented and automation approaches have to overcome with challenges like part and assembly tolerances. Resistance welding is known as low flow welding technology with limited possibilities for tolerance compensation that makes early consideration in the design phase inevitable.

One sided accessibility for electrical contacting at manufacturing of the MFFD demonstrator requires a robust method for pressure independent generation of a constantly low contact resistance value. Aspects of easy and proper assembly, such as the reduction of the variety of parts and the accessibility of the components, must be taken into account, especially in resistance welding due to the comparatively complex tools.

Approaches to increase reliability

A three-step approach to increase the process reliability in the production of the demonstrator is carried out..

The first stage describes an increase in reliability through modifications at process level. The aforementioned dependency of the contact resistance value on contact pressure is reduced by modifications of the welding conductor by stitch perforation.



Improvement of contact quality by stitch perforation of the electrical conductor

The second level contains aspects for intelligent tooling design where the proven kinematic concept of the clip welding end-effector is partly translated to the MFFD for frame, frame coupling and cleat integration.

In the third stage, inline quality assurance measures are taken to ensure reliable process execution. For example, the welding current can be released automatically before the welding process by evaluating the contact resistance.

Summary and outlook

This work presents an outlook of the welding activities for the upper shell Multifunctional Fuselage Demonstrator. The resistance welding process is described followed by its opportunities and challenges that occur during manufacturing of a full scale structure. Welding strength values and possibilities for process control are highlighted to be an opportunity of this process. Tolerance management, a high variety of parts and their accessibility are described as the biggest challenges during demonstrator assembly.

Furthermore process modifications to assure a homogenous heating of the welding element are described. An intelligent design of the welding toolings already confirmed its increase of reliability in the past and was transferred to the MFFD tooling. Finally, integrated quality assurance was named as a necessary part of the process itself. It provides direct information about process control, increases reliability and strengthens confidence in the welding process.

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