A Finite Element Analysis of the Influences of Ultrasonic Welding Parameters on Temperature Rise at Interfaces of Aluminum Strands in Wire Bonding Process

Shimaalsadat Mostafavi, Bernd Markert

Institute of General Mechanics (IAM)
RWTH Aachen University
Templergraben 64, 52062 Aachen, Germany
e-mail: mostafavi@iam.rwth-aachen.de, markert@iam.rwth-aachen.de

web page: http://www.iam.rwth-aachen.de/

ABSTRACT

Wire bonding is an unavoidable step in automotive industry. Multi-strand aluminum cables are used as battery cables inside an appropriate contact system in automobiles. These are for instance used for connection of different electronic components and electrical centers in automobiles. As an alternative for crimping technology in wire bonding, ultrasonic welding (USW) is applied, which is counted as a rapid manufacturing process in order to create solid state joints between thin materials at low temperature and low energy consumption compared to other common welding processes, such as oxy-fuel welding and arc welding. Ultrasonic welding of metals is a joining technique as a combination of applying pressure and frictional vibrations within the range of ultrasonic frequencies. In automotive industry, ultrasonic welding is often used for wired connections. An ultrasonic welding machine consists of different parts, such as pneumatic cylinder, piezoelectric converter, booster, sonotrode and anvil. Despite of the simplicity of the USW process, choosing the right machine and process parameters is a tricky and complicated task in order to obtain an adequate bond.

Thermo-structural analysis of ultrasonic wire bonding has been performed by means of the 3D finite element method by Ding and Kim [1]. Thermomechanical analyses of ultrasonic welding of aluminium alloy have been performed by Siddiq and Ghassemieh [2].

The present work investigates the USW of a bundle of wires and focuses on the influence of some of the ultrasonic welding parameters, such as applied pressure on the wire bundle and vibrational amplitude of the sonotrode, on the temperature rise at the interfaces of each two strands in contact as well as the temperature distribution across the wire bundle.

Microsections obtained during experimental investigations done in the present study show the softening of aluminum strands at some bonding parts within the wire bundle. This phenomenon can be an interpretation of a local temperature rise close to the melting point of aluminum. The obvious difference in microsections from different weld samples was a motivation for this study to further investigate the thermomechanical aspects of the problem by use of FEM simulations. The represented model is a simplification of the real case and is intended to investigate the temperature rise between strands in connection during ultrasonic welding.

REFERENCES

[1] Ding, Y. and Kim, J. Numerical analysis of ultrasonic wire bonding: Part2. Effects of bonding parameters on temperature rise. *Microelectron. Reliab.* (2008) **48**:149-157.

[2] Siddiq, A. and Ghassemieh, E. Thermomechanical analyses of ultrasonic welding process using thermal and acoustic softening effects. *Mech. Mater.* (2008) **40**:982-1000.