Evaluation of brazed joints in automotive heat exchangers using artificial neural networks

Abstract

The paper discusses the test results of brazed joints in automotive heat exchangers, as well as the procedure of predicting their quality using artificial neural networks. The analysis was preceded by a review of the state of knowledge (chapter 1). It was found that heat exchangers are important products of the automotive industry, and the technological assembly process determines their quality. Brazed joints must meet a wide range of requirements, including tightness, mechanical strength and corrosion resistance, which are influenced by the properties of the joined materials and the solder binder, as well as technology and brazing parameters. The assessment of complex processes and products, in conditions of having incomplete information, requires the use of decision support tools that complement the knowledge and experience of employees. The main objective of the work is therefore to develop a procedure for the prediction of the quality of brazed joints using artificial neural networks (chapter 2). Brazed joints made of aluminum alloy AA3003 and AA4343 were chosen for further tests, made in a radiation-convection oven under a nitrogen atmosphere, according to CAB technology (Controlled Atmosphere Brazing) (chapter 3).

The experimental part include results of (chapter 4): 1) macro- and microstructured metallographic microscopy (light microscopy and scanning electron microscopy), 2) chemical composition and profile of concentration changes of elements (x-ray spectroscopy with EDS energy dispersion), 3) basic mechanical properties, including Vickers microhardness, Young's modulus, plastic deformation (nanointendance), 4) corrosion resistance (potentiodynamic electrochemical polarization and salt spray fogging), 5) geometrical dimensions and possible defects (coordinate measuring technique, three-dimensional optical scanning, X-ray computed tomography, 6) tightness, 7) resistance to burst, thermal shocks and pressure pulsation, and 8) resistance to thermal shocks. In order to assess the stability of the heat exchangers production process, a normality test for the distribution - chi-square, as well as histograms approximated by normal distribution was performed, the results of the measurements were presented on the theoretical distribution of the normal distribution. The indicators of the qualitative capacity of the Cp and Cpk process were also calculated. The collected experimental material allowed to present a comprehensive description of brazed joints, as well as to prepare the most important assumptions of the author's assessment procedure using artificial neural networks (chapter 5). In order to select the most effective networks, their structure and parameters were experimentally changed,

including: 1) learning algorithms (Levenberg-Marquardt, Bayesian regularization, conjugated scaling gradient and Broyden-Fletcher-Goldfarb-Shanno), 2) number of hidden neurons (6-30), 3) activation functions (linear, logistic, hyperbolic tangent and exponential). The possibility of using developed networks in industrial conditions was also discussed.