Rzeszów University of Technology
The Faculty of Mechanical Engineering and Aeronautics
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Abstract of Doctor's Thesis

Title: Expert system, based on fuzzy logic, supporting ADT gearbox casings production of PW1000G engine, with CNC machining centers

Abstract The thesis present the issue of quality control of accessory drive train (ADT) housings under production line conditions. In the case of the most responsible elements of aircraft engine construction, such as engine cases and transmission housings, all manufactured pieces are subjected to dimensional inspection. Due to the required accuracy of workpieces, dimensional and shape characteristics are obtained using coordinate measuring machines (CMM). The biggest drawback of this type of approach is the high cost of purchasing and maintaining CMMs and long measurement time.

This thesis presents an alternative method for final control of bearing seats deviation, by replacing the coordinate measuring machine (CMM) with a numerically controlled machine (CNC) equipped with a set of measurement probes and an Adaptive Neuro-Fuzzy Inference System. This approach coincides with the company's "Industry 4.0" concept and the Closed Door Technology (CDT) processing concept implemented at the corporate level.

As part of the work done, a test detail was developed for the machine. The CNC machining center was equipped by appropriately configured tensometric touch probes. Experiments studies were conducted using three different measuring probes. Measurements were made according to four sequences of increasing complexity and then the quality of the measurements was evaluated based on R&R and SPC tools. For housings in quantity 97 pieces, measurement data were collected, both on CNC and CMM, for bearing seats position deviation. Next, the method for creating synthetic data was developed, synthetic data sets were created and subjected to the evaluation process. Two types of neuro-fuzzy systems have been developed for holes position prediction on the CMM. Both of them use CNC measurements. The first one use calibration measurement on the CMM, the second based solely on CNC measurements. Learning, testing and validation data for ANFIS models were prepared and then neural-fuzzy models were developed for each characteristic and for the two types of measurement schemes. Indicators for qualitative evaluation of the prediction of the tested neural-fuzzy models were selected. A study was conducted to select the optimal configuration of each model. The optimal configuration of the ANFIS model for each of the key characteristics was selected.

The study proves that the proposed final quality control of product in terms of measuring the key features of ADT housings, implemented on the basis of CNC measurements and a neuro-fuzzy system, is possible and can be an alternative to measuring on the CMM. In addition to this, the technological process of housings manufacturing is fully automated and implemented entirely on the production line.

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