Matrix-Based Systematic Approach for Self-Adjusting CNC Manufacturing Processes

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Computer Numerical Control (CNC) machines automate the process of machining high-precision metal parts. However, tools attrition, combined with thermal expansion, results in fluctuations of the physical dimensions of manufactured parts. Thus, CNC machine operators must continuously adjust tools positions according to the differences between the measurements of the parts and the specifications. Nevertheless, important fluctuations are continuously observed. Using the Octave Scientific Programming Language, a novel approach and software were designed in order to automatically determine tool positioning. Together, this allows: (1) modeling of the combinatorial relations that exist between the tools and the finished part dimensions; (2) use of matrix–based computations to analyze the system of linear equations; (3) automatic determination of corrections to be made to tools positions, without machinist intervention. After successful theoretical validation, an experiment was carried out in a real machine shop. Control quality data from 210 parts produced using the novel approach were compared to 360 parts produced using the traditional CNC approach. Parts produced with the novel approach were on average 34.4 % closer to the nominal target/specifications. Computer simulations showed that an improved algorithm using linear optimization and redundant data could lead to additional improvement. The developed approach allows automating and stabilizing a complex process. Milling companies adopting this system would significantly reduce their setup time while improving production quality, stability of the process and robustness of the whole production system.

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