

PROJECT SUMMARY

Toolpath Optimization by Real-time Application of an Integrated Geometric/Mechanistic Model

The goal of this research is to improve the productivity of Numerically Controlled (NC) machine tools. If the research is successful it will fundamentally change the architecture of NC machine tools. Models of the cutting process will be integrated with the NC machine controller. Sensor feedback will be used to monitor the process and continuously improve the model accuracy through real-time self calibration. Machine tool productivity will be increased, but the associated improvements in the product development process may be of greater long term significance. Machine tool controllers which use these methods will be capable of using high level part descriptions for input as opposed to the low level "G-codes" that are currently in common usage; an attribute that should greatly decrease the overall time required to produce prototypes on NC machines.

Specific elements of the research include:

1. Development of an experimental test facility by retrofitting a 5 axis NC milling machine with an Open Architecture Controller (OAC).
2. Integrated geometric/mechanistic models of cutting on the OAC which are efficient enough to run in "real-time" mode. The models will be used to calculate optimal cutting conditions. Sensors on the machine tool will be used to perform continuous self-calibration of model parameters.
3. Continuous real-time comparison of actual and model-predicted cutting forces and the development of corrective actions to compensate for excessive differences.
4. Experimental comparisons between our methods and current "best practice" approaches. Complex sculptured surface programs developed by expert NC programmers at our industrial partner will be used.
5. Investigate trade-offs between model complexity, algorithm efficiency and quantifiable process improvements in machining time and part quality.

Different levels of algorithm complexity will be investigated. We intend to explore the use of two machining models: a simple volumetric model and a more exact integrated geometric/mechanistic model. We will also explore the use of four different strategies for using the models to optimize cutting conditions, ranging from a simple "chip-load leveling" approach to a very complex method which accounts for the effect of tool deflections on part dimensional tolerances. All of these methods can be implemented in either an "off-line" or "on-line" mode. In the "off-line" mode, cutting conditions are calculated prior to machining using "best guesses" for model coefficients. In the "on-line" mode, model coefficients are obtained from real-time measurement of cutting conditions. Experimental results will be used to quantify trade-offs between the complexity of the methods and the improvements in process efficiency.