Support for Micro-Tolerancing Through the Feedback of Existing Quality-Related Data to Product Developers

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Abstract

This paper presents a new approach for the Micro Product Engineering Process (µPEP), in which manufacturing data from previously designed and manufactured microsystems is used to aid the tolerancing of new design projects. An existing database of historical production data from the SFB499 was thus adapted to grant *tolerance-oriented* instead of *part-oriented* production knowledge access. The new approach was then applied on development of a micro gas turbine.

1 Introduction

In order to downsize mechanical systems, technological restrictions specific to an applied manufacturing process, e.g. micro-milling, micro powder injection molding, etc., have to be considered. Nominal dimensions can be miniaturized, but the realizable process deviations cannot be scaled down in the same way. While designing micro-systems, these effects have to be considered and thus analyzed and evaluated very early in the design process. This can be achieved through the feedback of manufacturing process deviations in the factory to the development team. Unfortunately, information about necessary tolerances and obtainable manufacturing process deviations is difficult to procure and maintain. However a comprehensive approach to gather and store feasible deviations in the manufacturing process and provide this information during system design could lead to considerable quality improvements and accelerate the µPEP. This paper presents an approach to accelerate and improve the development and tolerancing of micro-mechanical systems through the feedback of existing quality-related data.

2 "Tolerancing" in the µPEP

In the macro-PEP, components are designed and appropriate function-related tolerances are allocated, which must then be adhered to by the production. Depending on the tolerances' size, adequate production processes with sufficiently small process deviations are utilized, so that the process deviation does not exceed the tolerance limits. The size of the tolerances, thus, influences the overall production costs of a component. Since the µPEP is limited by the capabilities of available manufacturing processes, tolerances cannot be assigned to components solely based on functional criteria. Tolerance assignment must be oriented on the abilities of the production technologies used. In micro manufacturing, these are already the leading edge of technology and therefore the limitations of these processes must be considered. In contrast to macro-tolerancing, it is not a question of cost but of manufacturability.

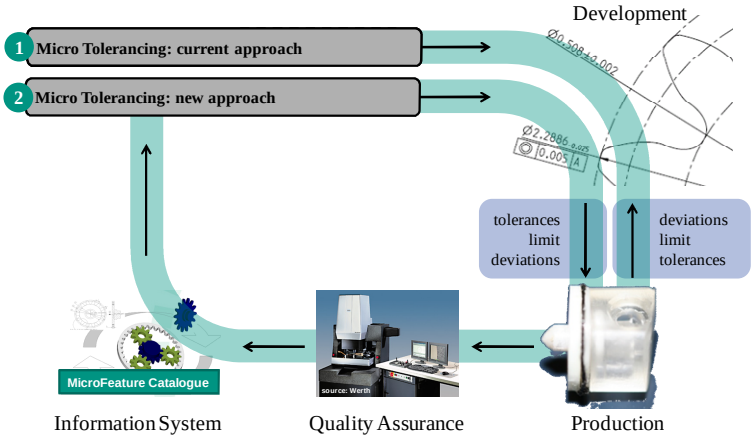

Figure 1: New tolerancing approach for µPEPs: Through the feedback of production knowledge using the MicroFeature Catalog, the µPEP is closed

For micro-tolerancing, the microsystem's designer needs support adapted to these differing conditions. Information on producible tolerances (dimensional-, positional- and shape tolerances) for features like plains, holes, etc. in correlation to the feature's dimensions must be provided. Access to this information would ideally be granted on the specific kind of tolerance needed. Through the feedback of knowledge from the production and quality assurance, a better integration of production and development can be achieved, see Figure 1.

3 MicroFeature Catalogue

The presented approach was developed within the research project SFB499 at the Karlsruhe Institute of Technology (KIT). The project work is completed by a team of multiple, individual institutes at KIT. In order to successfully transfer knowledge obtained by the individual team members between each other, an internet-based database was developed to store part data at each stage of the product development process, i.e. design, manufacturing and quality assurance [1]. Included in the database are the nominal and actual values of manufactured parts as well as the parameters of the utilized manufacturing processes. From this data, information about the manufacturing process deviations can be determined and analyzed. However, the current set-up of the database only allows part-oriented access to information about the achieved manufacturing process deviations. If the designer would like to estimate the achievable process deviations for his current design, he has to select a specific part, which has already been created, and scan the part's features for analogies to the current design. If certain features of the two parts correlate to a large enough extent, the previously realized manufacturing deviations can provide useful information for assigning tolerances to the features of the new part. Since identical parts do not have to be developed multiple times, this part-oriented access to information in the database is not practical. Instead, tolerance-specific access would be more suitable. Ideally, a developer could search in the database for a specific geometric element (e.g. a cylinder shaft, borehole, etc.) with given parameters (e.g. diameter, depth, etc.) and obtain information on achievable deviations in the manufacturing process to the nominal values as well as information about form deviations (e.g. cylindricity, roundness, etc.). To allow direct access to this kind of information, the aforementioned database was adapted.

4 Application on development of a micro gas turbine

Currently, a micro gas turbine is being developed within the scope of the SFB 499, see Figure 2 [2]. A main problem is the tolerancing of the gas turbine components. For example, the bush bearings supporting both sides of rotor need several tolerances at once. Here, cylindricity, rectangularity and coaxial alignment are of paramount importance. For the best performance of the rotor, these tolerances needed to be as small as possible while maintaining their manufacturability.

Using the database, production knowledge on realized process deviations was fed back from previous design projects into the current design project. Here, tolerance proposals for the cylindricity were obtained from a previously manufactured micro air pressure turbine, see Figure 2 [3].

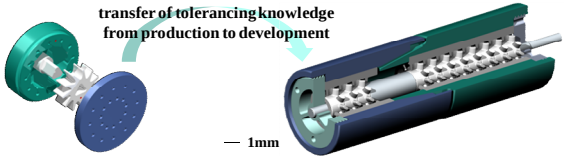

Figure 2: Feedback of manufacturing data from previously designed project (left) eased tolerancing of currently developed system “micro gas turbine” (right)

5 Summary and Outlook

In contrast to macro-tolerancing, micro-tolerancing is not a question of cost but of manufacturability. A new tolerancing approach for µPEPs was presented in which manufacturing data from previously designed and manufactured microsystems is used to aid the tolerancing of new design projects. An existing database of historical production data from the SFB499 was thus adapted to grant *tolerance-oriented* instead of *part-oriented* production knowledge access. Future work will focus on gathering additional micro-production data for further kinds of tolerances.

Acknowledgments

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