Virtual Advanced Manufacturing – Capabilities and Challenges of Process Simulations

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Abstract

Due to increasing demands on the industrial production, for example, in form of a high variety of complex components and a reduced time to market, virtual manufacturing becomes more and more important. Using process simulations, e.g. to analyze the NC machining of turbine blades or blisks in the aerospace industry, too high process forces or the occurrence of chatter resulting from the dynamic behavior of the tool, workpiece or machine tool can be predicted. This way, time- and cost-intensive running-in phases as well as iterative optimization processes can be reduced.

The development of such simulation systems is a highly interdisciplinary task. A deep knowledge in the area of machining as well as mathematics, mechanics and computer science is necessary to analyze the machining processes and to develop appropriate simulation models. Additionally, the influence of the machine tools or robots being used as well as the influence of the machine controller on the manufacturing process can be considered in the simulation system.

Due to increasing demands, for example, in the medical or aerospace industry, new and often difficult-to-machine materials are developed. In order to take the material behavior in the simulation into account, the “effects of manufacturing processes on the material properties” (c.f. the presentation “Superior Surface Integrity to Knowledge-based Manufacturing” given by Daniel Meyer) and the material properties on the machining process have to be analyzed. For this purpose, an intensive collaboration between production engineering and materials science becomes more and more important.

In order to optimize the machining process and, for example, the resulting surfaces, it is often not sufficient to model only the machining process itself, but the influence of the process chain has to be taken into account as well. For this purpose, collaboration between experts from different manufacturing fields, e.g., forming, coating or additive manufacturing is reasonable.

Especially in the era of “Industry 4.0” also a coupling between sensor systems – for example integrated into the machine tool – for analyzing the current machining and process simulations for the prediction of the process behavior is required in order to optimize the machining process. The applicability of simulation systems for this purpose is especially limited since in general they are not real-time capable and, therefore, the development of efficient models is necessary.

In this presentation, capabilities and challenges of process simulations will be discussed by showing different examples – from the simulation-based design of processes to “intelligent” manufacturing.

Short bio

Petra Wiederkehr (née Kersting) received her diploma in Computer Science from the University of Dortmund (Germany). She finished her doctoral thesis in Mechanical Engineering under the supervision of Prof. D. Biermann at the TU Dortmund University in 2010. Afterwards, she became head of the division “Simulation and Optimization” at the Institute of Machining Technology (ISF), she was research visitor for short durations at the University of British Columbia, Canada and at the University College Dublin, Ireland, and since 2012 she holds the Junior professorship in the field of “Modeling methods for machining processes”. During the academic year 2014/2015, she was Dorothea-Erxleben guest professor at the Otto-von-Guericke-University Magdeburg. Since 2014, she is Chair of the Research Affiliates of the International Academy for Production Engineering (CIRP). For her research work, she received the Hans-Uhde and Rudolf-Chaudoire Awards as well as the Otto-Kienzle Medal. Her research work is especially focused on modelling, analyzing and optimizing NC machining processes.