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A Method to Predict the Thermo-Elastic Behavior of Laser-Integrated Machine Tools

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Abstract : Additive manufacturing has emerged into a fast-growing section within the manufacturing technologies. Established machine tool manufacturers, such as DMG MORI, recently presented machine tools combining milling and laser welding. By this, machine tools can realize a higher degree of flexibility and a shorter production time. Still there are challenges that have to be accounted for in terms of maintaining the necessary machining accuracy - especially due to thermal effects arising through the use of high power laser processing units. To study the thermal behavior of laser-integrated machine tools, it is essential to analyze and simulate the thermal behavior of machine components, individual and assembled. This information will help to design a geometrically stable machine tool under the influence of high power laser processes. This paper presents an approach to decrease the loss of machining precision due to thermal impacts. Real effects of laser machining processes are considered and thus enable an optimized design of the machine tool, respective its components, in the early design phase. Core element of this approach is a matched FEM model considering all relevant variables arising, e.g. laser power, angle of laser beam, reflective coefficients and heat transfer coefficient. Hence, a systematic approach to obtain this matched FEM model is essential. Indicating the thermal behavior of structural components as well as predicting the laser beam path, to determine the relevant beam intensity on the structural components, there are the two constituent aspects of the method. To match the model both aspects of the method have to be combined and verified empirically. In this context, an essential machine component of a five axis machine tool, the turn-swivel table, serves as the demonstration object for the verification process. Therefore, a turn-swivel table test bench as well as an experimental set-up to measure the beam propagation were developed and are described in the paper. In addition to the empirical investigation, a simulative approach of the described types of experimental examination is presented. Concluding, it is shown that the method and a good understanding of the two core aspects, the thermo-elastic machine behavior and the laser beam path, as well as their combination helps designers to minimize the loss of precision in the early stages of the design phase.

Keywords : additive manufacturing, laser beam machining, machine tool, thermal effects
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