Cutting force integration at the CAM stage in the high-speed milling of complex surfaces

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High-speed milling (HSM) technology has been rapidly absorbed by the die and mould manufacturing industry and by the aeronautical sector. The new cutting tools can withstand much higher machining conditions than 10 years ago. Last-generation, high-speed machining centres are equipped with high-frequency spindles with hybrid ball bearings, leading to rotational speeds over 18 000 r/min. Multiaxis machining can be effectively carried out in five-axis machining centres of different architecture. These new and advanced machining processes are much more complex and provide the final component with a higher added value. However, the reliability of the whole process must be reconsidered, since collisions, tool breakage and dynamic problems can result in expensive machine repairs and some parts may be impossible to recover.

In order both to minimize the above problems and increase machining performance, a new machining approach based on two ideas has been developed. First, virtual verification of the NC programs, avoiding collisions or tool–machine interferences that may arise during the machining of complex surfaces. Second, toolpath optimization in the machining of complex surfaces. For this purpose a utility to estimate the cutting forces before machining has been integrated in the computer-aided manufacturing (CAM) planning process stage.

The estimation of cutting force uses a semi-empirical approach, in which the pair tool/material is characterized by six specific cutting force coefficients. The force model introduces the effect of part slope in calculations, just with tool geometry, cutting conditions, and material. The value of cutting force is used as an estimator for selecting the best cutting toolpaths for a complex surface. In this way a more accurate, better-finished surface is machined, and a reduced tool wear is withstood.

The global CAM process is applied to three examples that are discussed. They are representative of a highly efficient high-speed process, without any risks of tool collisions, surface machined errors and low cutting forces.

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