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PREDICTION OF MILLING-INDUCED VIBRATIONS IN MACHINING COMPLEX PARTS: NUMERICAL AND EXPERIMENTAL INVESTIGATION.

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ABSTRACT

Avoiding vibrations during machining is an important issue for industry. When dealing with chatter prediction with a numerical approach, several models are required: dynamical models of the workpiece and tool, cutting interaction law and surface representation. The resulting model is a trade-off between the complexity of the above-mentioned ingredients in the context of given solution strategy of equations of motion. Classically, one or two of the above mentioned modelling triad are kept rather rudimentary. These simplifications are often justified depending on the relative importance of phenomena at stake in concrete system. Nevertheless, there are cases when neglecting one of these aspects can lead to considerable alteration in the results (dynamical behaviour and resulting machined surface). In the present work, an integrated approach is proposed in order to combine the use of relatively advanced developments along each modelling aspect: a reduced finite element model (using a basis of modes) of the part and tool for the dynamics, segment-wise analytical cutting laws on discretized matter-erasing cutting edges for tool/workpiece interaction, and at last dexel-based geometrical model for the surface evolution. The present work is concerned with a face milling operation of an automobile exhaust collector. Due to the complexity of the geometry of machined surface, this operation takes place under continuously varying conditions in terms of length of tooth path, of number of engaged teeth and of local workpiece dynamic stiffness. Observations of final surface on actual parts include several zones with considerable vibration-induced defects. Different levels of detail levels are applied in order to appreciate the impacts of different phenomena, such as workpiece or tool compliance, static deformations caused by the part clamping. The results show that the flexibility of the part or of the tool would impact the resulting defect distribution and severity and that only when all these flexibilities are accounted for, the surface defects are close to the reality. Finally, sensitivity to other parameters, such as damping or cutting is also investigated.