TOOL WEAR SUPERVISING APPLYING VIBRATION MODAL ANALYSIS

Piotr Wolszczak[*], Marcin Bednarz[**] and Grzegorz Litak[*]

[*] *Lublin University of Technology, Faculty of Mechanical Engineering, Department of Automation, Lublin, Poland*

[**] *Zamość Academy, Zamość, Poland,*

Abstract. Application of modal analysis of tool vibration signal during cutting allows the separation of components caused by phenomena associated with the drive system and components generated in the cutting zone. However, the interpretation of these results is difficult. The article presents ways of using modal analysis in relation to signals observed during drilling or milling. The tool vibration signal was recorded using vibroacoustic sensors and then subjected to empirical decomposition. An additional frequency analysis of the extracted component signals was carried out in order to identify their sources and select the components generated in the cutting zone. In this way, vibrations related to the spindle speed and the number of tool blades were filtered out. Comparing the results of the physical experiment with the results of numerical simulations, it was possible to distinguish the components related to the deflection of the tool shank and the work of the blades. The applied method is illustrated by examples of comparisons of the operation of tools with changed geometry, the influence of machining parameters and the monitoring of the initial lapping phase of the blades. The presented method of optimizing machining parameters is especially important when machining difficult-to-machine materials.

Introduction

One of the ways of wear of cutting tools is chipping and chipping of the edges of the cutting blades. They are formed as a result of the action of cutting forces on the rake surface [1, 2]. Self-excited vibrations are generated during the detachment of the material layer. Accumulating vibrations contribute to chipping of the blades by changing the nature and increasing the value of the cutting forces, which remain undispersed, and by material fatigue. In the case of carbide materials, the method of initial lapping of the tools can be significant for the further usefulness of the tool. In the workshop, initial wear is observed by the machine operator's hearing and by visual inspection of the tools and machined surface after the first few passes. Instruments used so far in laboratory tests are used more and more often in workshop conditions [3]. Manufacturers of cutting tools use electronic devices to determine the operating characteristics of their products and to select the optimal operating parameters [4].

Results and discussion

Vibration sensors connected to the registration, processing and visualization system are used to measure the forces generated in the cutting zone. In the case of rotating tools, the sensors are placed on machine components or material. Based on the values of the recorded accelerations, it is concluded about the variability of the forces acting on the tool. The use of such a form of monitoring involves the need to develop a measurement method and measurement procedures in order to avoid various types of systematic errors, e.g. related to changing the location of sensors.

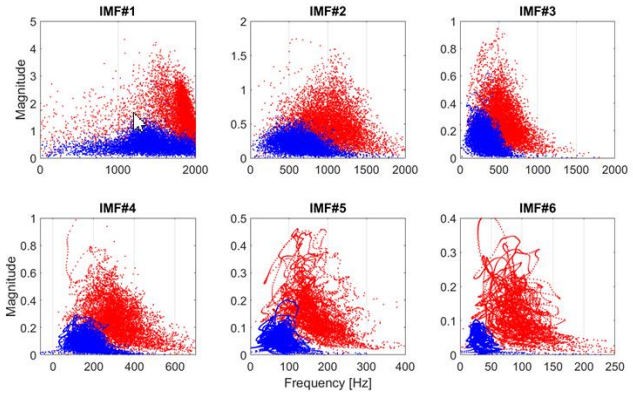

Figure 1: Example results of dependences amplitude and frequency modes of decomposition empirical Hilbert-Huang sample runs of the tool type “Hi-Feed” in the course of: red - cutting operation, and blue - tool linear movement [5].

References

[1] Sarhan A. et al. (2001) Interrelationships between cutting force variation and tool wear in end-milling. *Journal of Materials Processing Technology* **109:** 229-235.

[2] Choudhury S.K., Rath S. (2000) In-process tool wear estimation in milling using cutting force model. *Journal of Materials Processing Technology*.**99**: 113-119.

[3] Dimla E. i Dimla Snr. (2000) Sensor signals for tool-wear monitoring in metal cutting operations—a review of methods. International *Journal of Machine Tools and Manufacture*. **40**: 1073-1098.

[4] Ghani J.A., et al. (2011) Monitoring online cutting tool wear using low-cost technique and user-friendly GUI. *Wear*. **271**: 2619-2624.

[5] Wolszczak P., Litak G., Łygas K. (2017) Monitoring of cutting conditions with the empirical mode decomposition. *Adv. Sci. Technol. Res. J.* **11**:96–103.