

Cutting forces analysis in orthogonal milling through inverse simulation.

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SUMMARY

This article intends, of a summary form, to tell the study work developed in the cutting forces analysis in orthogonal milling, using techniques of inverse simulation.

This technique takes advantage from the simulation but in a counter way. In this case it is used not to obtain an estimation of the forces involved in the cutting process, which will be the normal result of a process simulation but to help in orthogonal milling process characterization.

Key words: *Orthogonal Cutting; Simulation; Forces Measurement; FEA.*

1. Introduction.

The inverse simulation methodology simultaneously combines measurements of the involved forces in the cut process and methods of simulation through the modeling of the joint part-tool with resource to specialized software applications of Finite Elements Analysis (FEA).

The Finite Element Analysis techniques allow simulating cutting processes and extracting data as stresses and temperature distribution, force prediction and cutting conditions but with limitations once those are dynamic processes.

The results gotten in this study supply, on one hand, to a basic knowledge of the tool behavior during the cut process, while dynamic system where the applied loads play a extremely important role and for another one, given basic data that allows a realistic simulation of the milling process and complements the existing material characteristics.

2. Methodology.

During the works, measurements of the forces developed in the process of orthogonal cut are carried through, with parameters, materials and tools perfectly defined and using a rotating dynamometer Kistler® 9124A. The cut process characterization is made through the force analysis and the application of frequency analysis (San Juan and Montoya, 1998), taking in account the dynamic limitations of the measurement system (Tounsi and Otho, 2000).

At same time it is developed a three-dimensional model recurring to the experimental tests data – tool and materials characteristics, making the simulation the most faithful to the reality, as possible.

The previous characterization of the cut process allows simulation tests through the system modeling and posterior study in a computer application of finite elements analysis (FEA), using non-linear simulations. The simulation is done with lesser restrictions once it takes in account the calibrations derived from the experimental tests.

Through FEA cutting simulation it is possible to estimate the values of process variables that are not measurable or very difficult to measure by experiment (Yen et al, 2004). This way, with the force measurements in experimental tests and the process simulation, complementing each other, it will be possible to determine, in some cases, more accurate data related with the material characteristics and in other cases, complement the existing data extracted from materials tests. Other possibility is to let us know the tool behavior in the cutting process, stresses and temperature distribution, deformation and force prediction under a given set of cutting parameters. These capability results from the possibility of changing variables in one of the subsystems described – the experimental or the simulation system, which by complementing themselves and crossing data between them, produce significant changes in the other.

These interaction between experimental tests and simulation process, will lead to the change possibility of tool geometry allowing the study of non-orthogonal milling processes.

References

- San Juan, Manuel; Montoya, Felipe. (1998). “Estudio del proceso de corte en fresado mediante el análisis en frecuencia de las fuerzas de corte”. *Anales de Ingeniería Mecánica*, Año 12, vol. 3, 244-249.
- Tounsi, Najeh; Otho, Alain. (2000). “Dynamic cutting forces measuring”. *International Journal of Machine Tools and Manufacture*, vol. 40, n°8, 1157-1170.
- Yen, Yung-Chang; Jain, Anurag; Altan, Taylan. (2004). “A finite element analysis of orthogonal machining using different tool edge geometries”. *Journal of Materials Processing Technology*, vol. 146, n°1, 72-81.