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3D FEM Simulations of Milling On a 304L Stainless Steel

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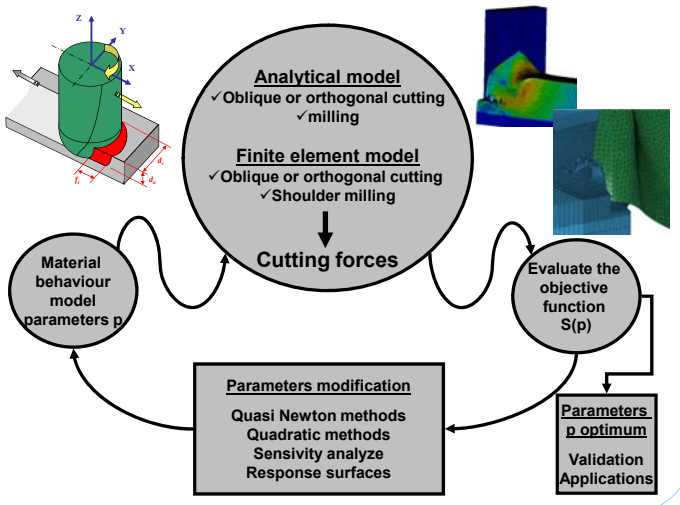
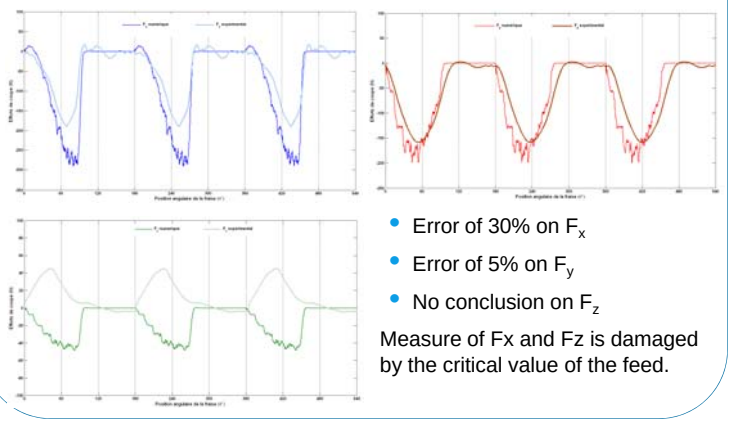
Objectives

The purpose is here to simulate the milling process with the commercial software Ls-Dyna and to make a confrontation with the experimental cutting test. The final aim consists to be able to obtain numerical cutting forces to lead on an identification procedure of the material behaviour law parameters. The method have been tested with the analytical model of milling and very good results have been obtained. This work try to extend this methodology with a commercial software using finite element methods.



Experimental validation

The experimental validation have been lead on a micro milling machine KERN and the measure of the cutting forces have been conducted with a Kistler dynamometer.



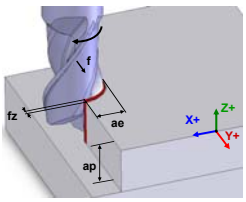
- Error of 30% on F_x
- Error of 5% on F_y
- No conclusion on F_z

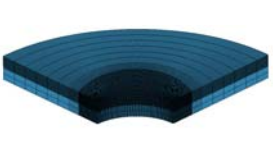
Measure of Fx and Fz is damaged by the critical value of the feed.

Numerical developments and results

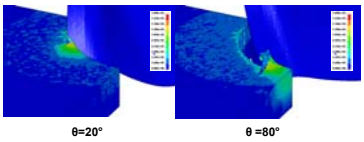
The numerical investigation make a simulation of a shoulder milling operation of a 304L stainless steel with a *Φ4mm end mill*. The cutting conditions used are a feed of *0.2mm.tooth^{-1} and a cutting speed of 250* m.min^{-1}. The 304L stainless steel behaviour is modeled by a classical Johnson Cook Law, in first approximation in order to reduce the calculation time the thermal effects have been neglected.

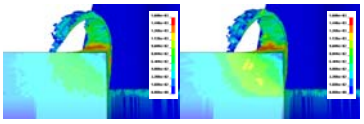
$$\sigma = \left[A + B\left(\varepsilon^{p}\right)^{n}\right]\left[1 + C\ln\left(\frac{\dot{\varepsilon}^{p}}{\dot{\varepsilon}_{0}}\right)\right]\left[1 - \left(\frac{T - T_{ref}}{T_{melt} - T_{ref}}\right)^{m}\right]$$

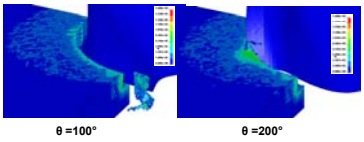


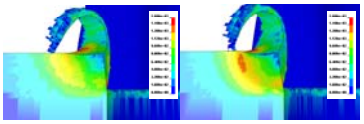


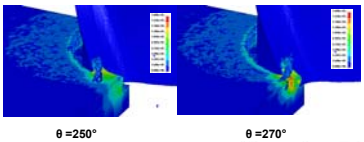
The results of the calculation are the von Mises stress contours obtained during the chip formation with the tool and the numerical cutting forces. The calculation time for three tooth path is about 5 days in parallel on a computer equipped with 8 processors and 64Go RAM.

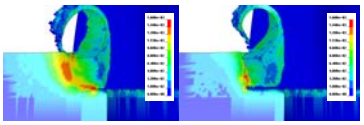




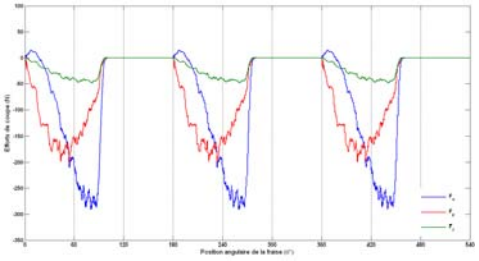








Numerical Cutting Forces obtained at the end of the simulation for three tooth path in shoulder milling. The result is conform to the rigid case modeled.



Prospects

The numerical developments permit to create the chip and to obtain the cutting forces, the improvements consist to create a simulation of an industrial case. The main difficulties induced by the process geometry and the finite element method, could be resolved with the new mesh less methods.

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