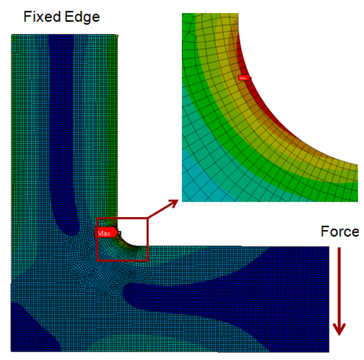
Lagrangian Finite Element Machining Model with Damage: a Question of Size

Francois.Ducobu@umons.ac.be

4th Researchers' Workshop of the Materials Research Institute

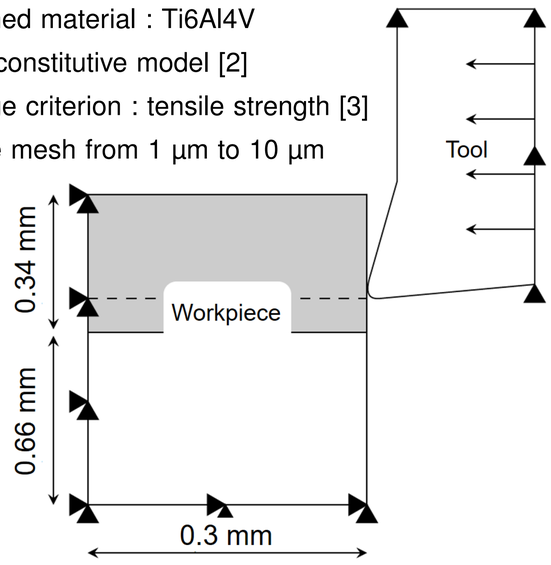
Context

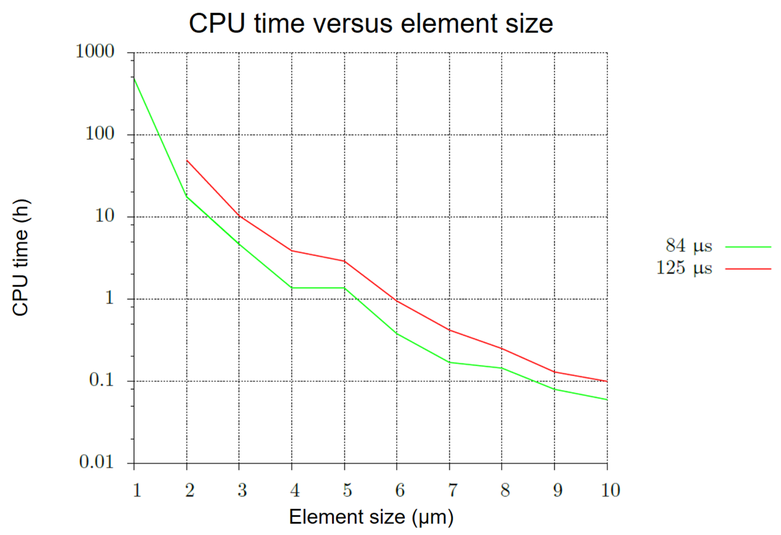
- ✦ Mesh dependence of the results of a finite element model = well known problem in many fields (Figure from [1])
- ✦ This problem is not much studied in the literature for machining modelling
- ✦ However, quality of the results and predictive aspect of the model heavily rely on it



Initial model

- ✦ Machined material : Ti6Al4V
- ✦ TANH constitutive model [2]
- ✦ Damage criterion : tensile strength [3]
- ✦ Square mesh from 1 µm to 10 µm



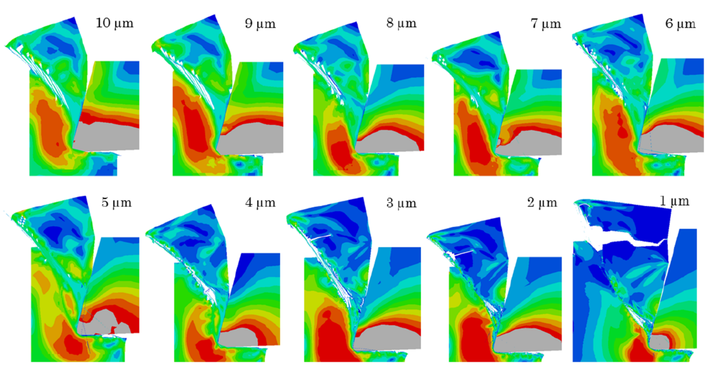


Experimental reference [4]

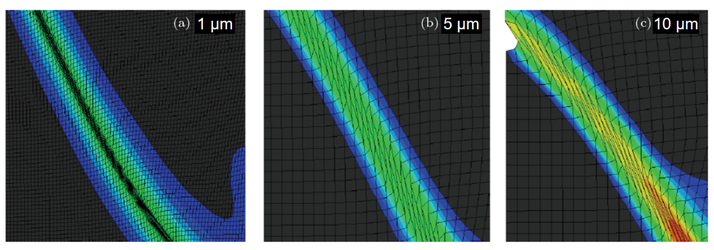
V_c = 75 m/min, h = 0.28 mm

Results of the initial model

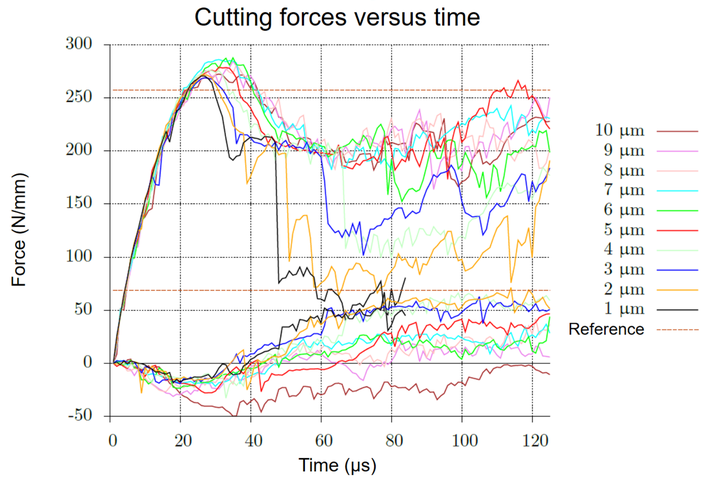
Chip morphology



Shear band width



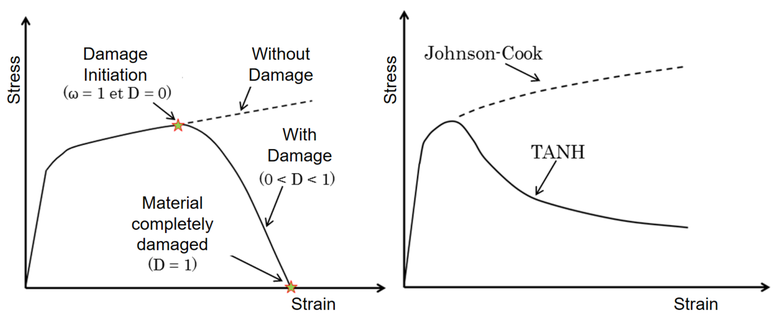
Cutting forces



Model with non-local damage criterion

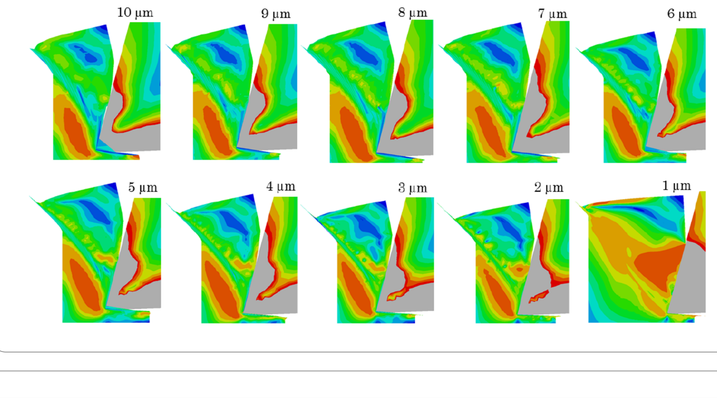
Constitutive model and non-local damage criterion

- ✦ Johnson-Cook constitutive model [5]
- ✦ Damage criterion : Johnson-Cook damage model [6]
- ✦ Initiation and propagation steps of damage

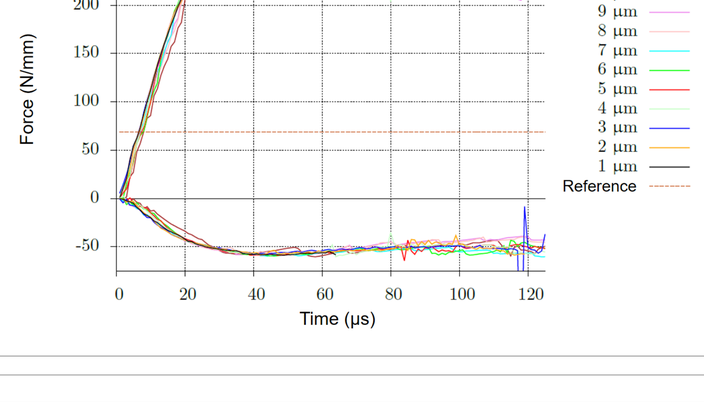


Results

Chip morphology



Cutting forces



Conclusions

- ✦ Dependence of the results to the size of the mesh is high with a Lagrangian formulation and a local damage criterion in machining
- ✦ The machined material and the cutting conditions increase that dependence
- ✦ The adopted non-local damage model reduces the mesh dependence
- ✦ Element size close to the grain size is recommended

References

[1] https ://caeai.com/sites/default/files/mesh2%204.png
[2] Calamaz M, Coupard D, Girot F. A new material model for 2D numerical simulation of serrated chip formation when machining titanium alloy Ti-6Al-4V. Int J Mach Tools Manuf 2008 ; 48 : 275–288.
[3] Lampman S. Wrought Titanium and titanium alloys, properties and selection : non ferrous alloys and special-purpose materials, vol.2. ASM Handbook, 1990.
[4] Sun S, Brandt M, Dargusch M. Characteristics of cutting forces and chip formation in machining of titanium alloys. Int J Mach Tools Manuf 2009 ; 49 : 561–568.
[5] Johnson G, Cook W. A constitutive model and data for metals subjected to large strains, high strain rates and high temperatures. In : Proceedings of the seventh international symposium on ballistics. The Hague, The Netherlands ; 1983. p.541–547.
[6] Johnson G. Strength and Fracture Characteristics of a Titanium Alloy (.06Al, .04V) Subjected to Various Strains, Strain Rates, Temperatures and Pressures. NSWC TR 86-144, Dahlgren, VA, 1985.