

The influence of cutting speed on the residual stresses after machining

¹H. Miguélez, ²R. Zaera, ³A. Molinari, ¹A. Muñoz

¹*Department of Mechanical Engineering, Universidad Carlos III de Madrid, Spain*

²*Department of Continuum Mechanics and Structural Analysis, Universidad Carlos III de Madrid, Spain
Avda. Universidad 30, Leganés 28911, Madrid, Spain*

³*Laboratory of Physics and Mechanics of Materials, UMR CNRS 75-54, University of Metz, Ile du Saulcy,
57045 Metz cedex, France*

Abstract.

The residual stress field in a machined surface is one of the most important factors influencing the surface quality and consequently, the workpiece material behaviour during service loading [1]. Residual stresses are produced by mechanical and thermal phenomena associated with the process of chip formation. Both mechanical and thermal effects are coupled. Despite of the abundant literature devoted to residual stresses in machining, it seems that more work is desirable in view of isolating and explaining the effects of the main influencing parameters. In a previous work [2] a numerical analysis of the influence of tool rake angle, cutting edge radius, friction and thermal expansion on the residual stresses was carried out. It has been shown in this paper that in machining operations, mechanical effects can also contribute to the development of tensile residual stresses. Indeed it was demonstrated that tensile residual stresses could be generated near the machined surface even in the absence of thermal expansion effects. Certainly, the level of tensile stresses is higher when thermal expansion is taken into account.

The main objective of present work is the analysis, through numerical simulation, of the influence of cutting speed (2, 4, 8 m/s) in the residual stresses after machining. The interest of numerical simulation is to offer the possibility of modifying freely the parameters of the model, thus allowing the study of their influence separately, which is in general not feasible in experiments. An Arbitrary Lagrangian Eulerian (ALE) model of orthogonal cutting is developed with the commercial finite element code ABAQUS/Explicit, and the study is focused on steel AISI 316 L. Tool rake angle was -6° and feed was 0.1 mm. The details of the model are shown in [3].

The influence of cutting speed in the residual stresses in cutting direction is shown in figure 1, including simulations performed with or without friction and thermal expansion. Accordingly to the previous work of the authors [2], tensile residual stresses can be generated in absence of thermal expansion. The level of the stress decreases with cutting speed, when no expansion is taken into account. This effect could be related with thermal softening and with the rate sensitivity of the material response, including the indirect effect of the heat conduction.

On the other hand residual stresses when thermal expansion is taken into account increases with cutting speed, in accordance with experimental data in literature [4]. Temperature is increased when cutting speed increases (see figure 2), this effect seems to be dominant when thermal expansion is taken into account, resulting in a significant increment of residual stress with cutting speed.

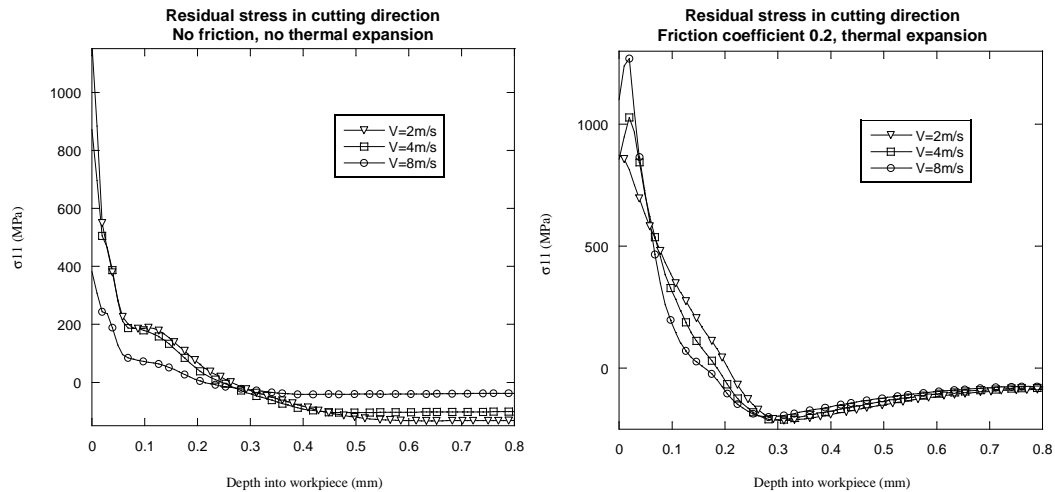


Figure 1. Influence of cutting speed in the profile of residual stresses. Left: without friction nor thermal expansion. Right: with friction and thermal expansion.

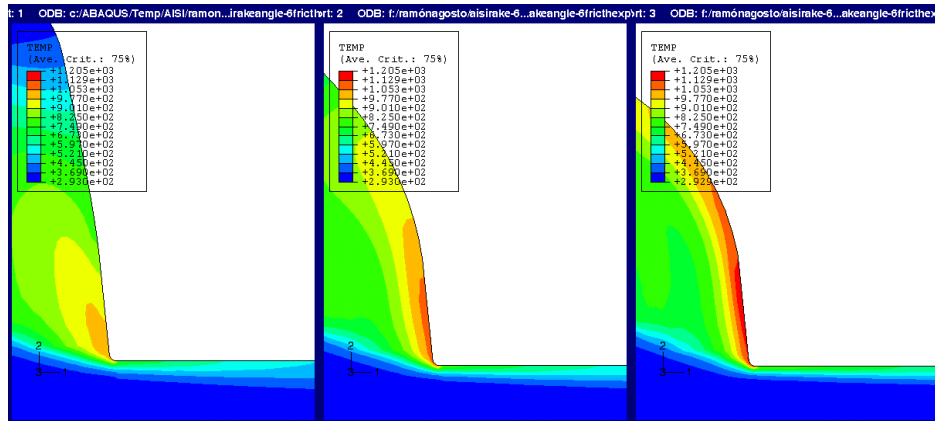


Figure 2. Temperature (K) in the chip during cutting, considering thermal expansion and friction coefficient equal to 0.2. From left to right, cutting speed 2, 4, 8 m/s.

References:

- [1] K. Okushima, Y. Kakino, A study on the residual stress produced by metal cutting, *Memoirs of the Faculty of Engineering, Kuyoto* 34 (1972) 234±248.
- [2] M.H. Miguélez, R. Zaera, A. Molinari, R. Cheriguene, A. Rusinek, residual stresses in orthogonal cutting of metals: the effect of thermo-mechanical coupling parameters and of friction, *I.J. Thermal Stresses* (submitted, April 2008)
- [3] Miguélez, H., Zaera, R., Cheriguene, R., Rusinek, A., Moufki, A., Molinari, A., Modelización numérica del corte ortogonal utilizando una formulación ALE, *VIII Congreso Iberoamericano de Ingeniería Mecánica*. Cuzco Perú, ISBN 978-9972-2885-3-1, 2007.
- [4] R. M'Saoubi, J.C. Outeiro, B. Changeux, J.L. Lebrun, A. Morão Dias, Residual stress analysis in orthogonal machining of standard and resulfurized AISI 316L steels, *Journal of Materials Processing Technology* 96 (1999) 225±233

E-mail address: mhmiguel@ing.uc3m.es

Tel.: +34-91-856 12 22 ; fax: +34-91-624 94 30