FOR APPLICATION, PLEASE CONTACT ADVISOR(S) BY EMAIL WITH COPY TO:
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Research Topic for the ParisTech/CSC PhD Program

Field: Materials Science, Mechanics, Fluids

Subfield: Mechanical Engineering

Title: Experimental full-field strain and temperature measurement under extreme conditions using digital image correlation and an IR camera. Application to the machining process of titanium alloys.
ParisTech School: ENSAM (Angers).

Advisor(s): Idriss TIBA (idriss.tiba@ensam.eu), Guénaël GERMAIN (guenael.germain@ensam.eu)

Lab.: Laboratoire Angevin de Mécanique, Procédés et innovation (LAMPA, http://lampa.ensam.eu)

Short description of possible research topics for a PhD: (10-15 lines in English + optional figure)
Improving our understanding of the thermal and mechanical phenomena involved during material deformation under extreme conditions is a major scientific challenge, especially for the study of manufacturing processes. This knowledge leads to better modeling of what is a highly nonlinear problem and, consequently, increases the quality of numerical simulations. The latter provides predictions of the strain and temperature fields in order to improve the cutting parameters (cutting speed and cutting angles, tool shape, etc.). However, most of the experiments can only measure global or average values.
The objective of this PhD work is to develop an experimental protocol to measure the full strain and temperature fields under thermomechanical conditions representative of machining operations (pure shear deformation and high strain rates). The measurement of the mechanical fields will be performed by Digital Image Correlation using a high-speed camera (cf. figure 1) and the temperature evolution will be measured by IR cameras/thermocouples. Thereby, a specific instrumentation for the measurement of the coupled mechanical and thermal fields will be required in this work.

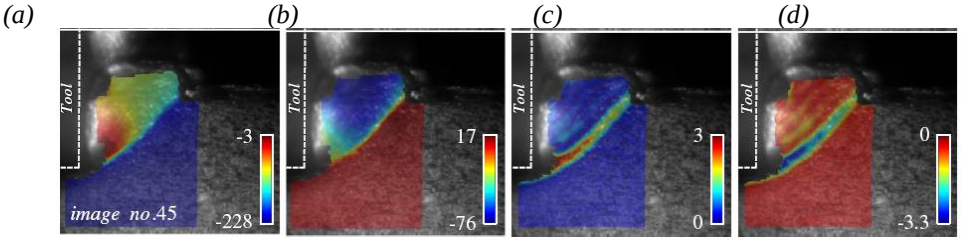

Figure 1 : (a) Horizontal displacement (in μm). (b) Vertical displacement (in μm). (c) Major strain. (d) Minor strain during the machining of the titanium alloys Ti64 (ap = 0.25 mm ; Vc = 6 m/min) [1]

Required background of the student: (Which should be the main field of study of the applicant before applying)
The student must have very good knowledge of continuous solid mechanics and instrumentation (optics).

A list of 5 (max.) representative publications of the group: (Related to the research topic)
[1] T. Pottier, G. Germain, M. Calamaz, A. Morel, D. Coupard, 2014. Sub-Millimeter measurement of finite strains at cutting tool tip vicinity, Experimental Mechanics, Vol. 54, Is. 6, pp. 1031-1042.
[2] M. Harzallah, T. Pottier, R. Gilblas, Y. Landon, M. Mousseigne, J. Senatore, 2018. A coupled in-situ measurement of temperature and kinematic fields in Ti-6Al-4V serrated chip formation at micro-scale, International Journal of Machine Tools and Manufacture, 130–131, 20–35.
[3] M. Harzallah , T. Pottier, J. Senatore, M. Mousseigne, G. Germain, Y. Landon, 2017. Numerical and experimental investigations of Ti-6Al-4V chip generation and thermo-mechanical couplings in orthogonal cutting. International Journal of Mechanical Sciences 134, 189–202.
[4] C. Badulescu, M. Grédiac, H. Haddadi, J.-D. Mathias, X. Balandraud, H.-S. Tran, 2011. Applying the grid method and infrared thermography to investigate plastic deformation in aluminium multicrystal, Mechanics of Materials, Vol. 43, Is. 1, pp. 36-53.