Microstructure, tribological properties and thermal stability of surfaces created by sliding-based surface thermomechanical treatments

G. Kermouche[1] , G. Smagghe[1], D. Tumbajoy[1], C. Courbon[2], J. Rech[2], Y.Y. Zhang[3], R. Chromik[3]

1.1University of Lyon, Ecole des Mines de Saint-Etienne, LGF UMR5307 CNRS, Saint-Etienne, France
2.University of Lyon, ENISE, LTDS UMR5513 CNRS, Saint-Etienne, France
3.McGill University, Department of Mining and Materials Engineering, Montreal QC, Canada

MOTS CLES

Surface Mechanical Treatment, Friction, Grain refinement, Microstructure gradient, Recrystallisation, Severe plastic deformation, Wear resistance, Thermal stability

ABSTRACT

The surface treatment notion is usually connected to the modification of surface properties by various actions of physical, chemical, thermal or metallurgical origin (quenching, nitriding, ...). However mechanical loadings alone result in modifications that engineers find of particular interest such as the creation of compressive residual stress fields [1] or sub-surface grain refinement [2] without any thermal or chemical phenomena. It is often named as "Surface Mechanical Treatments (SMT)". The most known SMTs are those based on impact loadings, such as shot peening process [1] for compressive residual stress concerns or such as SMAT [2] for its ability to create a nano-structured top layer. Sliding-based surface treatment can also be used to generate such interesting surface modifications [3-4]. In the past ten years, strong research efforts have been devoted to investigate the effect of sliding-based treatment on surface grain refinement. Firstly this phenomenon was related to the brittle "white layer" induced by machining operations and was viewed as an issue to overcome. Then it has been tried to optimize sliding loadings to create a better-controlled grain-refined layer [5]. It led to the development of the "so-called" Surface Mechanical Grinding Treatment (SMGT). Note that SMGT requires specific attentions, i.e. liquid nitrogen temperature to avoid recrystallization phenomena on copper for instance, to obtain the desired nano-structured layer.

In this paper, consequences of a sliding-based surface mechanical treatment close to the SMGT process are investigated. The main difference lies in the absence of cooling during the treatment in order to enhance dynamic recrystallization phenomena as well as grain refinement by severe plastic deformation. Moreover these conditions are closer to what happen during machining operations. Jacquet et al [3] have shown recently that the sliding speed may be chosen to tailor the induced gradient of mechanical properties in single pass high speed sliding experiments on a pure copper (Fig 1). In this paper the effect of a lower speed combined with a lower feed is investigated. The improvement of wear resistance of the resulting surfaces is studied as well as the thermal stability of the microstructure.

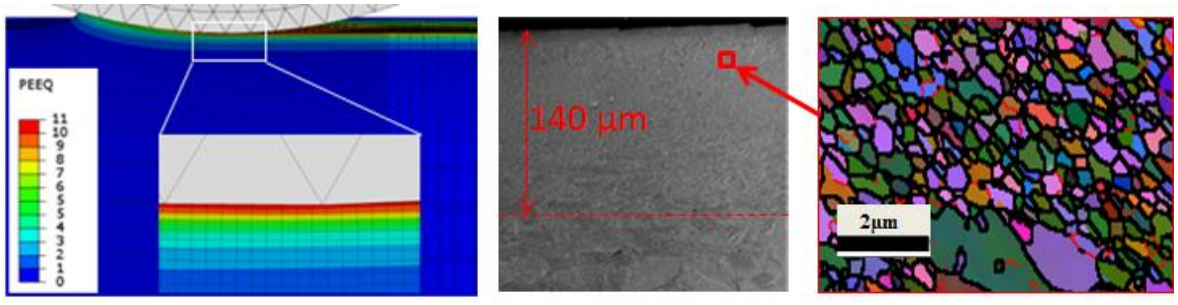

Figure 1 :Effect of a scratch-based surface treatments [3] on sub-surface microstructural evolution of a pure copper (a 100 µm thick layer composed of nanograins with a mean radius of 300 nm is shown on the left-side).

Références

[1] T. Hong, J.Y. Ooi, B. Shaw, A numerical simulation to relate the shot peening parameters to the induced residual stresses, Eng. Fail. An. 8 (2008) pp 1097-1110
[2] K. Lu, J. Lu, Nanostructured surface layer on metallic materials induced by surface mechanical attrition treatment, Materials Science and Engineering A 375-377 (2004), pp 38-45
[3] G. Jacquet, G. Kermouche, C. Courbon, D. Tumbajoy, J. Rech, Effect of sliding velocity on microstructural evolution induced in Copper during friction test, Materials Science and Engineering, IOP Conference Series, 63 (2014), 012039
[4] G. Kermouche, "Scratch-based residual stress-field by scratch-based surface mechanical treatments (superfinishing, polishing, roller burnishing), in Modelisation and simulation of manufacturing processes, J.M. Bergheau, ed., Hermes, 2014, pp. 305- 320
[5] W.L. Li, N.R. Tao, K.Lu, Fabrication of a gradient nano-microstructured surface layer on bulk copper by means of a surface mechanical grinding treatment,ScriptaMaterialia 59 (2008), pp 546-549