40th Leeds-Lyon Symposium on Tribology & Tribochemistry Forum 2013
September 4-6, 2013, Lyon, France

Modeling of the abrasive tool wear in metal cutting: Influence of the sliding-sticking contact zones.

F. Halila[1*], C. Czarnota[2], M. Nouari[1]

[1)] Laboratoire d'Energétique et de Mécanique Théorique et Appliquée, LEMTA CNRS-UMR 7563, Ecole des Mines de Nancy, Mines d'Albi, GIP-InSIC, France
[2)] Laboratoire d'Etude des Microstructures et de Mécanique des Matériaux, LEM3 CNRS-UMR 7239, Université de Lorraine, France

[*]Corresponding author for faycel.halila@insic.fr

Tool wear and tool failure are some of the main critical problems in industrial manufacturing fields since they affect the quality of the machined part and raise the production costs. Improving our knowledge of wear mechanisms and capabilities of wear prediction are therefore of great importance in the machining process. Abrasion, adhesion and diffusion modes are usually identified as the three main wear modes that occur at the tool/chip and tool/workpiece interfaces. (see Fig.1)

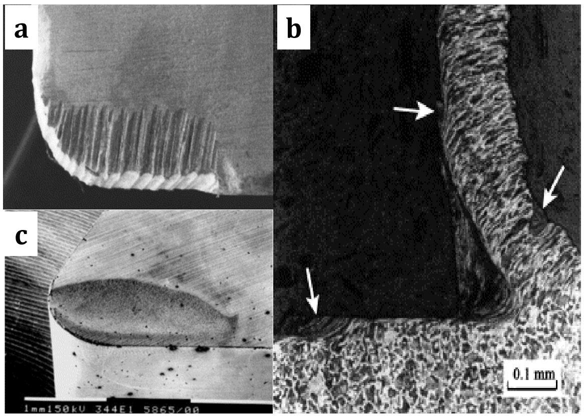

Fig. 1 (a) Abrasive tool wear located at the tool rake face after machining titanium alloys, [1]. (b) The white arrows show deposition of material left on the workpiece after the removal of the built-up edge (white arrows) in the case of orthogonal cutting of steel with cutting speed *V=0,5 m/s* and feed *t1=0,2 mm*, [2].(c) Crater formed by diffusion process on a WC insert used for the machining of AISI 1020 steel with cutting speed *V= 300m/min*, [3].

From an experimental point of view, the analysis of mechanisms that govern the wear process is still difficult to conduct due to the confinement of the tool-work material contact and the high thermomechanical loading in this area (see Fig. 2). The objective of this research work is to develop predictive wear modeling taking into account only the abrasive wear mode. The latter is assumed to be closely linked to the microstructure of the materials and caused by hard conical particles trapped into the contact between the cutting tool and chip. The proposed model is based on an analytical approach including a stochastical description governing the distribution of particles with conical shape embedded in the contact area. The volume of the removed material per unit time was chosen in this study as the main parameter to describe the abrasive wear mode. The sliding–sticking zones at the tool–chip interface depend on the evolution of the local conditions of stress, velocity and sliding friction coefficient.

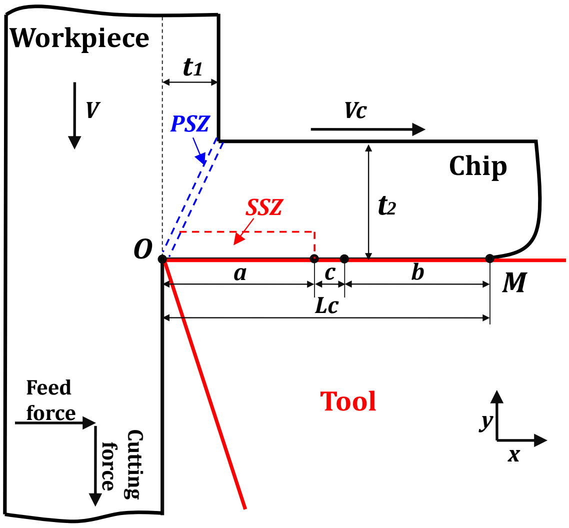

Fig. 2 Schematic presentation of the contact tool/chip during machining process. Parameters *a*: sticking contact, *b*: sliding contact, *c*: transition zone, *Lc*: total contact length, *O*: Tip of the tool, *M*: end of the contact, t_1: feed, t_2: chip thickness, *Vc*: chip sliding velocity, *V*: cutting speed, *PSZ*: Primary Shear Zone, *SSZ*: Secondary Shear Zone,

Finally, a wear criteria has been proposed to estimate the tool life in order to address the concerns of industries. An extensive parametric study was also conducted to highlight, for a given tool-material couple, the influence of cutting conditions on productivity

References

[1] S. Lo Casto, E. Lo Valvo, E. Lucchini, S. Maschio, M. Piacentini, V.F. Ruisi « Ceramic materials wear mechanisms when cutting nickel-based alloys», Wear, 225–229, 1999, 227–233.

[2] S.P.F.C. Jaspers, J.H. Dautzenberg « Material Behaviour in Metal Cutting: Strains, Strain Rates and Temperatures in Chip Formation », J. Mater. Proc. Technol., 12, 2002, 123-135.

[3] H.O. Gekonde, S.V. Subramanian « Tribology of tool–chip interface and tool wear mechanisms », Surf. Coat. Technol. , 149, 2002, 151-160.