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Understanding the Effect of Material and Deformation Conditions on the "Wear Mode Diagram": A Numerical Study

Authors : A. Mostaani, M. P. Pereira, B. F. Rolfe

Abstract : The increasing application of Advanced High Strength Steel (AHSS) in the automotive industry to fulfill crash requirements has introduced higher levels of wear in stamping dies and parts. Therefore, understanding wear behaviour in sheet metal forming is of great importance as it can help to reduce the high costs currently associated with tool wear. At the contact between the die and the sheet, the tips of hard tool asperities interact with the softer sheet material. Understanding the deformation that occurs during this interaction is important for our overall understanding of the wear mechanisms. For these reasons, the scratching of a perfectly plastic material by a rigid indenter has been widely examined in the literature; with finite element modelling (FEM) used in recent years to further understand the behaviour. The 'wear mode diagram' has been commonly used to classify the deformation regime of the soft work-piece during scratching, into three modes: ploughing, wedge formation, and cutting. This diagram, which is based on 2D slip line theory and upper bound method for perfectly plastic work-piece and rigid indenter, relates different wear modes to attack angle and interfacial strength. This diagram has been the basis for many wear studies and wear models to date. Additionally, it has been concluded that galling is most likely to occur during the wedge formation mode. However, there has been little analysis in the literature of how the material behaviour and deformation conditions associated with metal forming processes influence the wear behaviour. Therefore, the first aim of this work is first to use a commercial FEM package (Abaqus/Explicit) to build a 3D model to capture wear modes during scratching with indenters with different attack angles and different interfacial strengths. The second goal is to utilise the developed model to understand how wear modes might change in the presence of bulk deformation of the work-piece material as a result of the metal forming operation. Finally, the effect of the work-piece material properties, including strain hardening, will be examined to understand how these influence the wear modes and wear behaviour. The results show that both strain hardening and substrate deformation can change the critical attack angle at which the wedge formation regime is activated.

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