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ON NUMERICAL STRATEGY FOR TOOL WEAR MODELLING DURING AISI 4140 CUTTING

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1 Introduction

The quality of machined products is strongly related to the machining conditions especially the tool wear evolution. The latter is among the most important problems encountered by manufacturers. In fact, the complexity of dealing with tool wear is due to the diversity of its origins (abrasion, diffusion, adhesion...) and the limits of models to predict it.

For that, the majority of studies were based on experimental works to find laws linking tool wear to several cutting conditions [1, 2]. These estimations are limited to specific cutting conditions far from the industrial context. Some researchers resort to Finite Element (FE) Method to simulate cutting tool wear since it can help to investigate it finely than via experiment's procedure [3, 4].

The aim of this study is to develop a numerical model to simulate cutting tool wear via the FE software ABAQUS®. It is focused on the modeling of the machining of AISI 4140 steel by an uncoated tungsten carbide tool in an orthogonal cutting configuration.

2 Numerical model

In this study, the modelling of tool wear is based on a multi-parts model in order to have a more optimized contact management during simulations. Commonly, tool wear occurs after several minutes of machining and a lot of developed orthogonal cutting simulations last only few milliseconds [5]. Consequently, a new strategy named “VERTical Modeling of CUTting” (VEMCUT) (Fig.1) that aims to increase the machining time simulated, is developed [6].

To take into account cutting tool wear, the Abaqus UMESHMOTION subroutine is adapted to the current model. It is illustrating the Archard wear law and consists in calculating wear rate for each node on the tool surface.

The Archard law is presented as following:

$$w = K * V_s * P(1)$$

Where w is the wear rate [m/s], K is the wear coefficient [Pa^{-1}], P is contact pressure [Pa] and V_s is the sliding velocity [m/s].

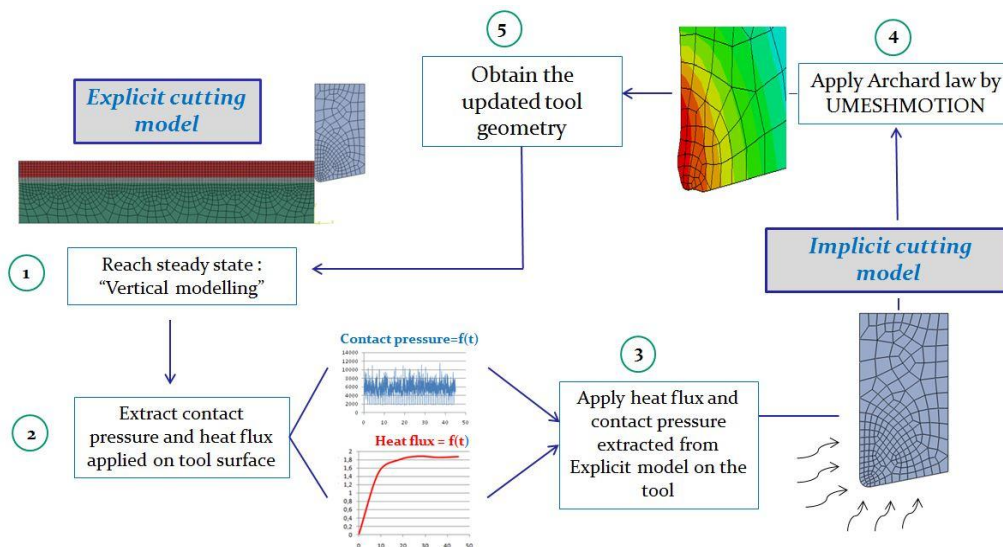


Figure 1: Explicit-Implicit strategy for tool wear modelling

The tool geometry is updated by applying an adaptive mesh procedure. To define the steady state corresponding to the new tool geometry, the developed EXPLICIT model is used again. This procedure is repeated several times until the cutting tool is estimated worn enough (Figure 1).

Conclusion

A multi-part model is developed to simulate tool wear in orthogonal cutting machining of AISI 4140 steel by an uncoated tungsten carbide tool. A new procedure helping to develop tool wear is implemented via Archard Law. The simulation results are validated by experimental tests.

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