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AN OVERVIEW ON COMMMERCIAL SOFTWARE'S IN FEM ANALYSIS MACHINING

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ABSTRACT: *Nowadays, the choice of finite element software for machining analysis is an important aspect in determining the quality and scope of analysis that can be performed. The purpose of this study is to present an overview on commercial software's in FEM (Finite element method) analysis machining. Finally, a case study on FEM analysis of machining of an aluminium alloy (7075) using Advantedge^{TM} software is presented.*
KEYWORDS: *FEM (Finite element method), machining, commercial software's*

INTRODUCTION

Nowadays, the choice of finite element software for machining analysis is an important aspect in determining the quality and scope of analysis that can be performed. Three of the most common software for FEM analysis machining are presented and well described by Gardner et al [1]: Deform^{TM}, Abaqus^{TM} and AdvantEdge^{TM}. Given the complexity of the finite element method, the choice of package is very important for the type of analysis that can be performed and quality of the results as well.

The type of analysis that can be performed as well as the quality of the results are software dependent because different packages have different capabilities and it is critical to select the package with the appropriate feature set. Furthermore, the assumptions and solver techniques used in the package have far reaching consequences in the results obtained from the simulations.

Deform^{TM} (Design Environment for Forming), is a commercially available FEM solver that can be applied to several manufacturing processes. Deform^{TM} original area of specialty was in metal forming operations like forging. It has since expanded to include modules that support machining operations. As an advantage, Deform^{TM} machining modules can be used to quickly set up standard machining processes like turning, milling and drilling. The user has to supply the workpiece and tool geometry as well as the process parameters. The solver then uses a standard solver configuration and finds the solution. Alternatively, the user has the ability to adjust solver parameters like mesh-size, nodal boundary conditions, and tool-workpiece interaction properties, for example. Given that many of these parameters remain constant from one simulation to the next, the pre-programmed modules can work very effectively. Deform also has an extensive material library containing models of several common materials and alloys. The program also has the capability of defining new materials based on stress/strain data and other key material properties. This contributes to the usability of the program to simulate actual process conditions and increases its applicability. Adaptive meshing controls accommodate high workpiece deformations that are very common in machining. As for Deform^{TM} disadvantages, workpiece tends to demand more and more elements as the simulation progresses, which causes the simulation to run slower with time. In addition, the simulation will stop periodically and the mesh size needs to be adjusted by the user. There are several fine points which accompany the learning curve for Deform^{TM} [1].

Abaqus^{TM} is a general purpose FEM program that can solve a variety of problems. Abaqus^{TM} does not have any modules/packages for machining simulations, and hence the user has to explicitly define the tool and the workpiece, the process parameters and the simulation controls (including boundary conditions and mesh geometry.) As for advantages, Abaqus^{TM} comes with two solvers (Standard and Explicit) which can be used to run a variety of simulations. Simulations are setup in Abaqus^{TM} by using keywords that define the functioning of the simulation. The user is free to model the machining operation using specific axioms, thus providing a good deal of control over the simulation. Though Abaqus^{TM} has no support for any materials, it allows users to configure the materials using a variety of models. The user also has very fine control over the meshing and the element types used in the model.

Perhaps the biggest advantage of Abaqus™ is that is allows modelling at a high level of detail. The user is able to setup a very detailed model describing various kinds of behaviour, as well as a "bare-bones" model that provides general information. Moreover, the software is command-line accessible and supports scripting functionality. As for disadvantages, the open-ended nature of the program presents a steep learning curve. Also, it takes a lot of time to "setup" simulations using the software as the user has to manually set many of the simulation parameters. This is especially true in the case of mesh optimization [1].

AdvantEdge™ is a machining specific FEM package. It has pre-programmed modules for both 2D and 3D machining operations including turning and milling and is very intuitive. In figure 1, a scheme on how FEM packages work is presented. As shown, in order to obtain results, several software inputs are required. In other words, a pre-programmed module has several fields that need to be specified before the simulation takes place. In this case, where machining operations are the objective, the inputs are based in machining parameters. Among these inputs, the friction coefficient and the material flow stress need special attention like already mentioned.

FEM software demands several input values to predict the thermo mechanical behaviour of the machining operation. The inputs can be geometric like tool rake angle, cutting edge radius, etc. Cutting parameters like cutting speed, feed rate or depth of cut are also crucial as an input in the software. The number of nodes and the mesh also have weight in the FEM results. It is worth noting that although every input is important and if the cutting conditions are kept the same, the material flow stress and the friction coefficient, among all inputs, are the most representative in the simulations reliability.

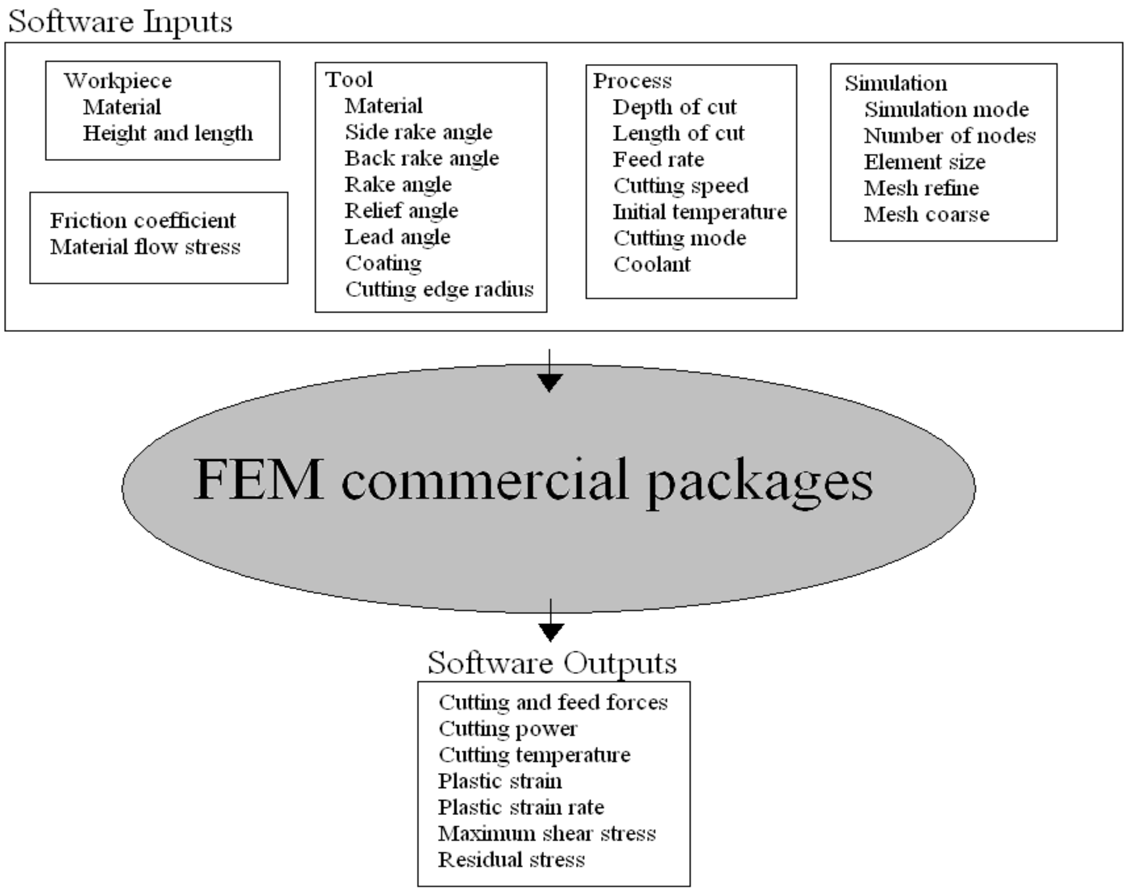

Figure 1: Typical FEM machining software inputs and outputs

CASE STUDY- FEM ANALYSIS MACHINING AN ALUMINIUM ALLOY

In order to perform a comprehensive study on FEM analysis in machining, cutting parameters such as feed rate as well as cutting tool materials were simulated to evaluation of thermomechanical behaviour in machining an aluminium alloy 7075 [2]. Advantedge™ software was used in this study. In this research, aluminium alloy (7075) was used. The tool materials used to machining the workpiece were a cemented carbide K10 and polycrystalline diamond (PCD). The friction coefficient was obtained using a Coulomb model based in experimental tests. Figure 2 shows temperature distribution in the *workpiece, tool, chip and burr with Vc = 1000 m/min, f = 0.12 mm/rev and a_p = 2mm (dry) for both cutting tool materials. Von Mises stress distribution in the workpiece, tool, chip and burr with Vc = 1000 m/min, f = 0.12 mm/rev and a_p = 2mm (dry) for both cutting tool materials are shown in Figure 3.*

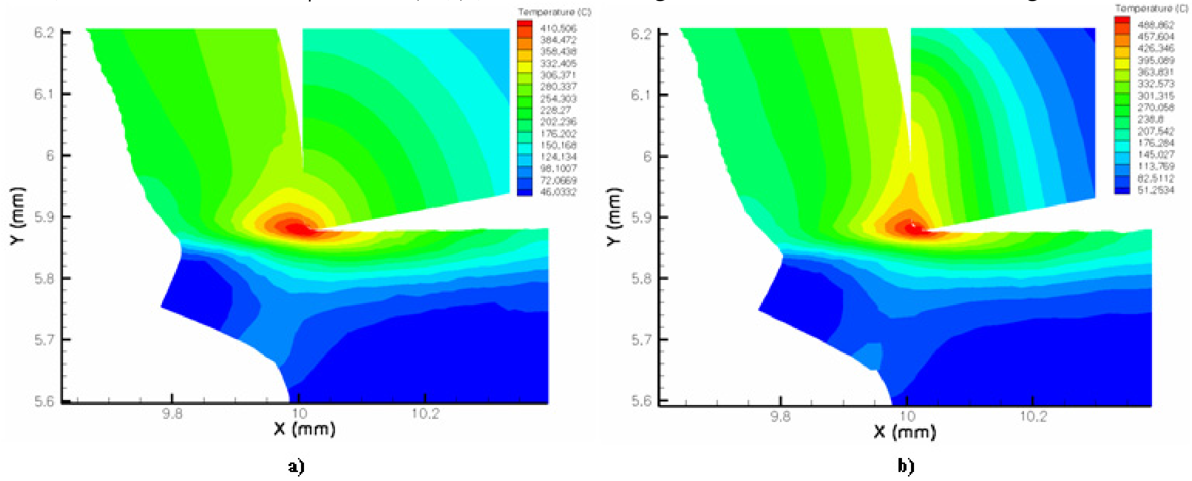

Figure 2. Temperature distribution in the workpiece, tool, chip and burr with Vc = 1000 m/min, f = 0.12 mm/rev and a_p = 2mm (dry) a) Polycrystalline diamond PCD b) Uncoated cemented carbide K10

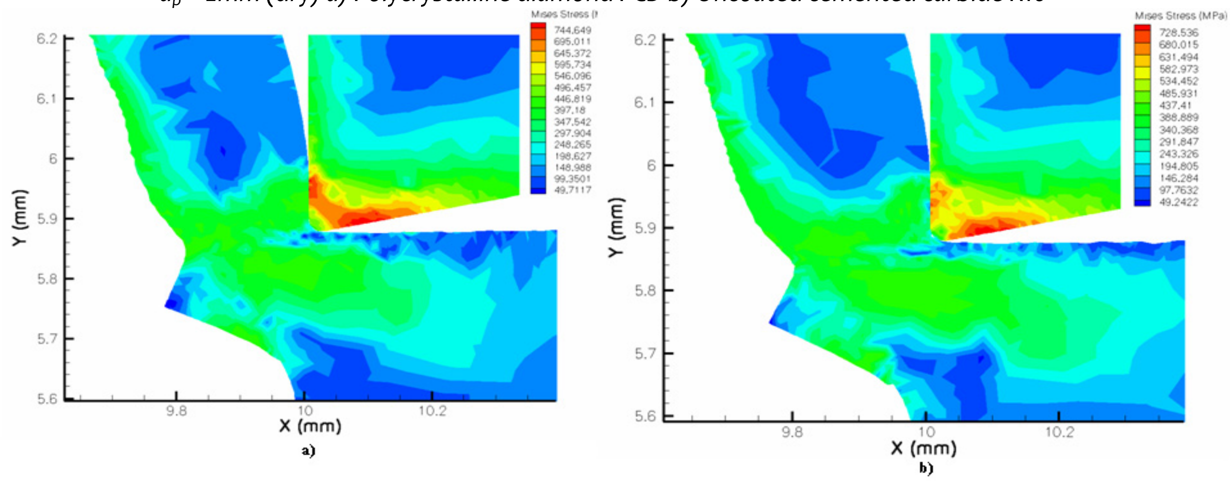

Figure 3. Von Mises stress distribution in the workpiece, tool, chip and burr with Vc = 1000 m/min, f = 0.12 mm/rev and a_p = 2mm (dry) a) Polycrystalline diamond PCD b) Uncoated cemented carbide K10

CONCLUSIONS

This short article reported some important aspects of current use of commercial software´s in FEM analysis machining. Advantedge™ software used in the case study of the article was built with metal cutting operations in mind, allowing the simulation of turning, drilling, milling, micromachining, etc. It uses adaptive meshing to improve the quality and precision of the output results and it also supports a wide range of workpiece material libraries.

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