Review of Orthogonal Metal Cutting using Finite Element Method

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Abstract: **Metal cutting is very impotent role in industry. Finite element method of simulation of this process has fully developed to give a chance to understand something of this process and, sometimes, good accordance with experiment. Nevertheless, due to the critical nature of the metal cutting process in industry, FEA of metal cutting is not straight. In this literature reviews the concepts of the FEA of metal cutting. Comparisons of mathematical, theoretical validation of FEA. It also cover some important growth reported done. Conclusions and statements on recent and future research are also created. In this paper give by share to begin complete knowledge about the FEA of metal cutting.**

Key words: **ALE, damage, FEA, metal cutting models.**

I. INTRODUCTION

In any manufacturing industry its very important in metal cutting process for producing final required shape of products and using latest technology to developments in materials. The final required shapes of most engineering components are procure by a number of industrial operations, like forging and rolling, are mostly followed by a number of metal cutting operations with different parts and suitable , dimensions, and quality of surface finish.

In this research has been dedicated to appreciation the mechanics of this process. The uses of simulation of metal cutting is to predict variables such as stress, forces, temperature for a suitable geometry of workpiece and tool parameters with cutting conditions, materials properties. To attain experimental and analytical techniques are used. In present days still, with the flow in computational capacity, the concentrate has turned to numerical simulation of the procedure along finite element methods. Number of simulations have included in the literature[1-3] and proceedings of conferences, wokshops. All precision engineering centres to manufacture in metal cutting products with suitable precision, engineering ranging from machine tool error problems to error reduction through either physical way and indirect ways, from tool dynamics structural using FEA testing. In this recently has extended research deeply into finite element analysis of a cutting process. In this paper has selected final research literature review in this section. Which is not comparable competence of computational plasticity and its application of cooling of tool using coolant (model testing and CFD and FEA.FEM) in engineering. It will concentrate on to the fundamental concept issues to be presented in the application of finite element analysis of metal cutting. This paper present to large views on the body of computational plasticity and some practical and theory characteristics about metal cutting simulation.

II. MAIN ASPECTS OF METAL CUTTING

In computational method point of view very important role in this aspects.

1. Strain rate is higher(10^5 s^{-1} and higher)
2. Complicated conditions of friction between tool, chip and wok piece contact complicated conditions.
3. Complecated analysis in thermo coupled with high temperature above 1000°C.
4. Large vibration and wear tool in actual machining process.
5. Chip separation with continuous and discontinuous growing.

This metal cutting process the stress, strain rate and temperature will all the dependent on the cutting parameters of feed rate ,cutting speed, rake angle and nose radius. In FEA point of view, metal cutting process is very important a thermocouple elastic-viscoplastic problem. Frequently simplified and a rigid visco elastic material model is used replace-it gives better equivalent accuracy for chip shape and size. Chip separation very difficult this problem in further aspects. Hence FEM is a selected choice in this development the authors awareness in finite element technique has been inspired in different applications and mean while benefited from the input and output of numerical with mathematical understand.[4] R.F. Brito et al. a numerical simulation of the thermal effect of the coated and uncoated tools during cutting process. To analysze the thermal and geometrical parameters of the coated tools. [5] Amol Thakare predict steady state temperature distribution in the case of tool with flank land.[6] The Finite element modelling of the cutting tool prior to fracture is investigated in different zones.

III. FINITE ELEMENT METHOD

It is used for metal cutting analysis with different operations. In this analysis mainly used Lagrangian approach, Eulerian and Adaptive Lagrangian approach.

The Lagrangian approach used for mechanics applications like structural problems. In this approach finite element mesh consists of material elements and grid deforms with the material (workpiece and or tool), unconstrained material flow as the finite element mesh presents the material boundaries. The Eulerian approach is used for fluid-flow problems. Mesh is fixed grids and the material properties are find at fixed spatial locations as the material flows through the mesh. The Arbitrary Lagrangian-Eulerian (ALE) approach has applied to the metal cutting process presently [7]. This development is inspired mainly by the realisation of the strength of the combination of the Lagrangian and Eulerian methods in modelling some of the aspects of the machining process. The thermo-mechanical problems within the cutting process can be modeled and then simulated by means of the Finite-Element method (FEM) [8].

IV. BASIC OF MATERIAL BEHAVIOUR AND FLOW STRESS

Mostly materials behaviour shell be expert to outline the main behaviour under strain, strain rate, thermal effects, various methods have been introduced in particular research application. In very important known Johnson-Cook mathematical relation is used. The flow stress of this equation is

$$\sigma = (A + B \in^{B})^{n} \left[1 + c ln(\frac{\in}{\in_o})\right]\left[1 - \frac{T - T_{amb}}{T_{melt} - T_{amb}}\right]^{m}$$

V. INTERFACE BETWEEN CHIP AND TOOL FRICTION

Stress distribution in rake face in different places of mathematically presented

$$\sigma_f = \mu\sigma_n \quad \text{when } \sigma_f \le \sigma_s$$

$$\sigma_f = \sigma_s \quad \text{when } \sigma_f \ge \sigma_s$$

Where σ_f is the frictional stress, σ_n is the normal stress, μ is the coefficient of friction, and is σ_s the shear stress of the chip material. Work completed in specified journal in [9] proposed a different model and its effects on residual stress.

VI. DAMAGE WITH CHIP TEMPERATURE RELATION

Number of papers have been proposed in the literature, very complex fracture of mechanics in the form of a strain and geometrical criteria. Physical justification of chip shape and size what critical value should be created. This area further research will be justify.however, suitable to practical application of finite element simulation of the cutting process with software, it has been reported that the Johnson-Cook failure mode has been used with ABQUS Explicit. The strain at failure is assumed to

$$\in_f = \left[\boldsymbol{d_1 + d_2 e^{d_3 \frac{p}{q}}}\right]\left[\boldsymbol{1 + d_4 ln \frac{\in}{\in_o}}\right]\left[\boldsymbol{1 + d_5 \left(\frac{T - T_{trans}}{T_{melt} - T_{trans}}\right)}\right]$$

$\boldsymbol{d_1}$ **,** $\boldsymbol{d_2}$ **,** $\boldsymbol{d_3}$ **,** $\boldsymbol{d_4}$ **,and** $\boldsymbol{d_5}$ **,**are the failure constants to be determined by Experiment. Failure of damage parameter it reaches to unity

VII. SOFTWARE'S USING METAL CUTTING APPLICATIONS

Different software has been details to be able to simulated the metal cutting process. They are: ABAQUSI Explicit/implicit ,Marc, DEFORM 2D and 3D, FLUENT, LS DYNA, ANSYS, ADVANTAGE

VIII. RECENT APPLICATIONS OF ABAQUS

Abaqus is special software committed to metalworking processes (metal forming and machining). [10] Recently, models for finding of dynamic temperature source energy distribution, kinetics of phase transformation, diagrams, implemented in additional subroutines used in Abaqus finite element analysis allowed numerical and mathematical simulation of progressive hardening process remarkable elevation and its applications have been generated.

IX. CONCLUSION

Finite element analysis is very new trend research work to analyze metal cutting processes. Outstanding advances has been achieved in both simulation, theoretical and experimental. Good simulation results compared to experiment have been reported. In metal cutting processes has gained reasonable success, somewhat fundamental problems addresses by the research community. This problems to develop under implementation of more advanced plasticity theory and damage model for chip separation.

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