AUSTRALIAN JOURNAL OF BASIC AND APPLIED SCIENCES

ISSN:1991-8178 EISSN: 2309-8414
Journal home page: www.ajbasweb.com

Effect Of Machining Parameters On Residuel Stresses Distribution

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ARTICLE INFO

Article history:
Received 18 January 2017
Accepted 28 April 2017
Available online 25 April 2017

Keywords:
Numerical model ,machining,residual stresses, Cutting parameters

ABSTRACT

The high level of strain imposed by machining changethe structural state of materials, this change appear by the birth of residual stress field caused by the incompatibility of plastic strain between the different layers of the material beneath the finished surface. A number of questions remain about the causes and mechanisms of generation of residual stresses during machining and how these residual stresses can be controlled to achieve a desired distribution. The aim of this work is to create a numerical model using Abaqus software to verify residual stresses induced by machining in aluminum alloy 2024- T3 for different cutting parameters (cutting speed, feed rate and cutting angle). The effect of each cutting parameter used on the distribution of residual stresses induced by machining has been shown.

INTRODUCTION

Most of the materials used in the engineering industry must undergo a machining operation o achieve their final form. The cut is a common way of shaping metals. From a mechanical point of view is a very complex process that the details are still poorly understood (Che-Jaron , Mater.,2001) (Jang , et al 1996).The material of the workpiece is subjected to very high strain level, which causes a considerable elevation of temperature and formation of a chip.

The problems that may caused by cutting operations are:

The residual stresses in the finishing work piece (Bannantine et al. 1990) (ELAJRAMI 2007

Wear and fatigue of tool.

Too long chips and irregularities in the finished cutting surface.

The aim of this work is to create a numerical model using Abaqus software to verify residual stresses induced by machining in aluminum alloy 2024- T3 for different cutting parameters (cutting speed, feed rate and cutting angle)

MATERIAL AND METHOD

Material choice:

The material used in this study is an aluminum alloy AERO TL 2024-T3. The mechanical properties of this alloy are given in table 1. The chemical composition is shown in table 2.

To Cite This Article: FayçalYounes EL-HASSAR, Mohamed ELAJRAMI, Houcine Milouki and Abdelkader MEGUENI., Effect Of Machining Parameters On Residuel Stresses Distribution. ***Aust. J. Basic & Appl. Sci.,*** *11(5): 196-201, 2017*

Australian Journal of Basic and Applied Sciences, 11(5) April 2017, Pages: 196-201

Table 1: Mechanical properties of aluminum alloy 2024-T3

Ultimate strength	476	MPa
Yield strength	378	MPa
Displacement	18.1	%
Elastic Modulus	72.22	GPa
Poisson's ratio	0.33	

Table 2: Chemical composition of aluminum alloy 2024-T3

Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	V	Zr	Other
0.09	0.27	4.45	0.61	1.34	0.02	0.17	0.02	0.01	0.00	0.05

Method:

Our work consists in developing a 2D numerical model of the material removal machining (trucking) in order to deduce the field from the resulting residual stresses.

The effect of the variation of the cutting speed, the speed of advance of the tool and the angle of cut on the variation of the residual stresses will be illustrated.

I- Finite element modeling with Abaqus:

Many of the researcher, (Özel, T. and Zeren, E., 2005) (Özel, T. and Altan, T., 2000), have used predefine chip geometry to the orthogonal machining using Eulerian,Lagrangian and ALE formulation. As it is quite unrealistic to use pre-define chip geometry in the model. So in this study Modelling is done using ALE-remeshing technique with purely Lagrangian boundary condition, in which mesh follows the work material. by doing this we can get rid from the pre-define chip geometry problem to make the model more realistic.

A. Tool geometry and boundary conditions:

The tool is modeled using360 elements522nodes.This mesh consists of isoparametric quadratic elements and will be refined at the tip (Figure 1).

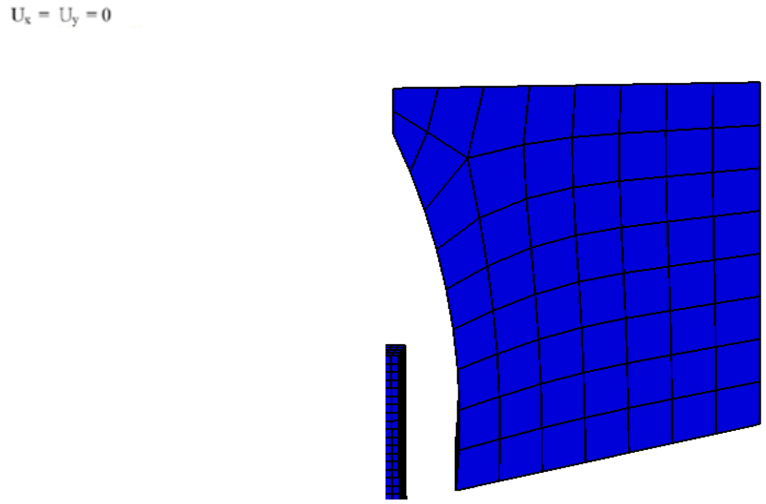

Fig. 1: Tool geometry

In the Figure 2 is shown the 2D finte element simulation model for ALE formulation. The workpiece is a cylindrical rod, the simulation consist to considered a planar member of small dimensions of 5 mm length and 2 mm in width. The model of the workpiece has 4200 isoparametric elements and 8844 nodes. At the machined area, the mesh will be refined.

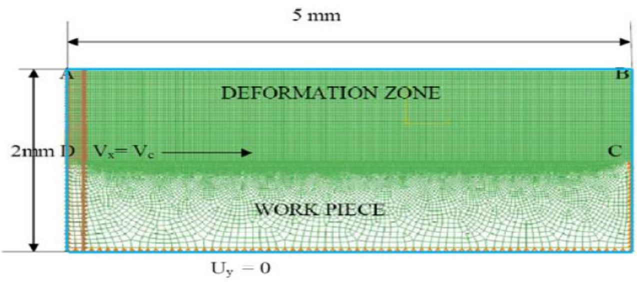

Fig. 2: 2D finite element simulation model

Figure 3 explain how residual stresses are measured

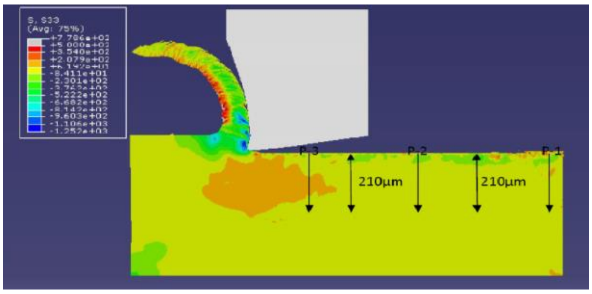

Fig. 3: Technic of residual stresses measurment

RESULTS AND DISCUSSION

Table 1 groups the different cutting parameters used in this work.

Table 3: Cutting parameters used

Cutting speed (m/min)	*200*	*300*	*400*
Feed rate (mm)	*0.2*	*0.4*	*0.8*
Cut angle (°)	*+6*	*0*	*-6*

B. Effect of feed rate variation:

In a first step, a choice of a constant cutting speed of 300 m / min and a constant angle of cutting was done at 6 degree with a change in feed rate (0.2, 0.4 and 0.8 mm). Figures 4 to 9 shows the obtained results.

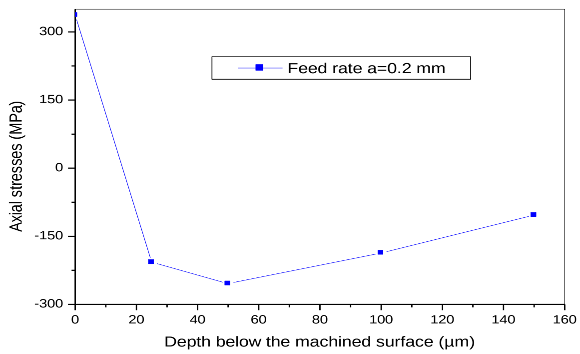

Fig. 4: Axial stresses (a=0.2 mm)

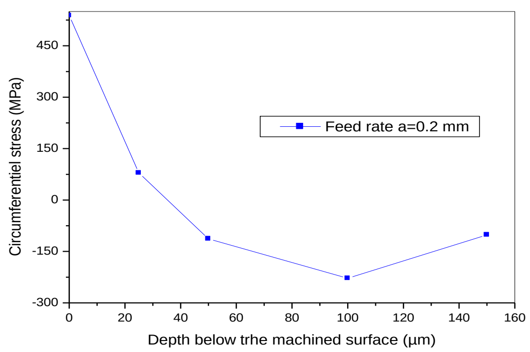

Fig. 5: Circumferential stress (a=0.2 mm)

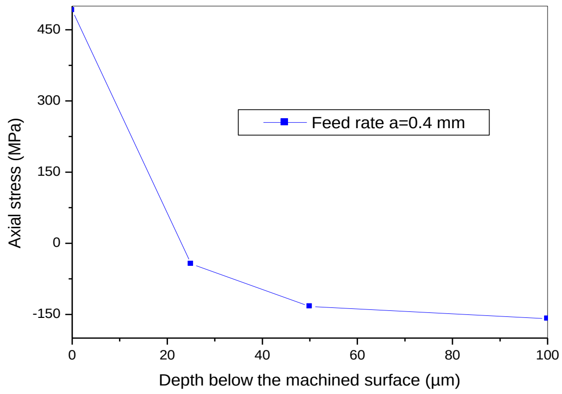

Fig. 6: Axial stresses (a=0.4mm)

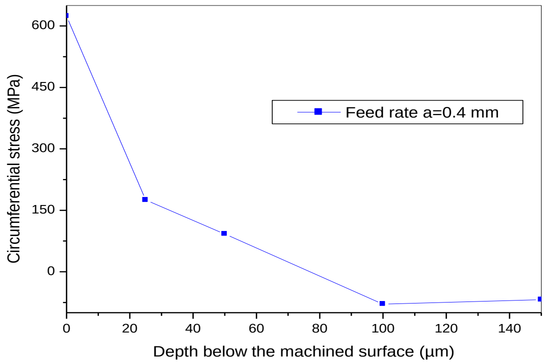

Fig. 7: Circumferential stress (a=0.4 mm)

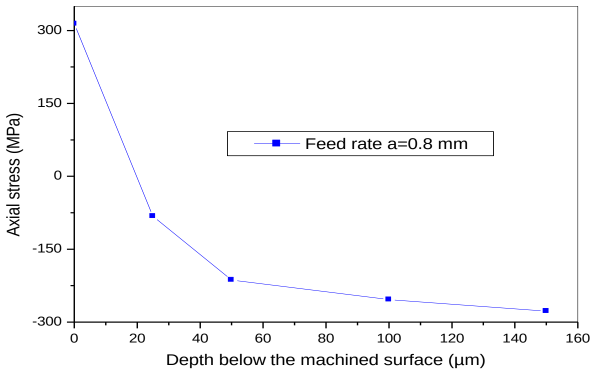

Fig. 8: Axial stresses (a=0.8 mm)

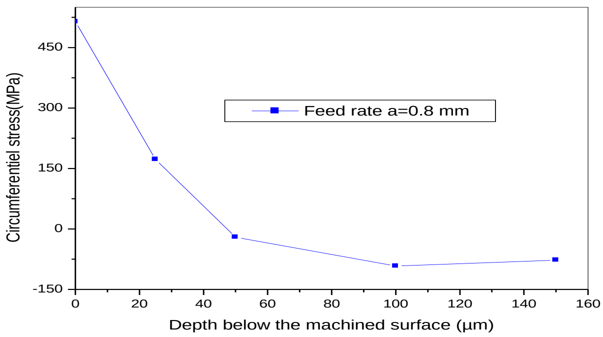

Fig. 9: Circumferential stress (a=0.8 mm)

We observed a region of very high strain and high stress area near the tip of the cutting tool. On the other hand, the results show that the residual stresses caused by machining increases with increases of feed rate. The difference of residual stress values for two different values of feed rate 200MPa.

C. Effect of cutting speed variation:

In a second step we choice constant feed rate (a = 0.2mm) and a constant angle of 6 ° with variation of cutting speed.

It has been observed in figure 10that the increase in cutting speed leads to an increase in residual stress values. So to avoid such constraints, choose relatively low cutting speeds, but in this case the finished part surface state will be affected. On the other hand, it is found that the variation of the residual stress is not significant through the depth.

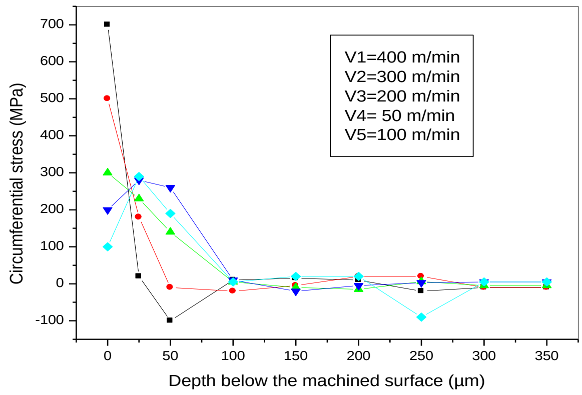

Fig. 10: Residual stresses for different cutting speed

D. Effect of cutting angle:

In a third step we choice constant cutting speed of 300 m / min and a feed rate of 0.2mm with variation of the cutting angle. The obtained results show that residual stresses vary proportionally with the variation of the cutting angle. In a region of 50 micrometers, this variation is very significant where the residual stresses range from -30 MPa to -400 MPa.

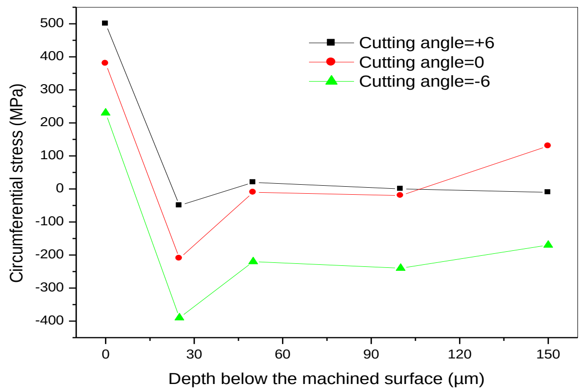

Fig. 11: Effect of the cutting angle

Conclusion:

Through the computer code Abaqus, a 2D numerical model was developed. The influence of the variation of three cutting parameters on the variation of the residual stress has been illustrated It is noteworthy that the great difficulty that arises during machining simulation is the mending of cut elements, to solve this problem, an arbitrary Lagrangian Eulerian method was used with adaptive meshing capability. The expected results are mainly focused on the prediction of residual stresses. These stresses are caused by the plastic deformation of the incompatibility between the different layers of material beneath the finished surface. Because of the shear layers of the material below the cut plane generated by the cutting tool, plastic incompatibility will be more severe in the cutting direction.

The results allowed us to conclude that:

- This incompatibility is severe in the cutting direction
- Close to the tip of the tool, is an area of very large values of strain and very high stresses.
- Increasing feed rate causes an increase of the residual stress values induced by machining.
- The difference in residual stress values with depth is not significant.
- The strain rate has a direct and significant impact on the residual stresses.
- An increase in strain rate implies higher values of residual stress.
- The strain rate varies proportionally with feed rate.
- Cutting forces vary proportionally with advance.
- 20 % difference was recorded between the results of a very refined numerical model and a standard model.
- The residual stresses vary proportionally with the variation of cutting speed.
- The cutting angle affects the residual stress field resulting from the machining
- To a depth of 50 micrometers, the variation of the residual stress due to the variation of the cutting angle was very significant (-30 MPa to 400 MPa).

Finally, it should be emphasized that the results of the numerical model needs to be validated by experimental tests.

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