# Finite element analysis of different chipbreaker types for turning tool process

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## Abstract

This paper used rigid-plastic finite element DEFORM™ 3D software, studying on 6061 aluminum alloy cutting plastic deformation behavior. The main design including a variety of different types of turning tools chipbreakers that under the same conditions, chipbreakers including without chipbreaker design, square chipbreaker design and an elliptical chipbreaker design, in order to analyze the effective stress after cutting, the effective strain after cutting, tool temperature, tool wear analysis in different chipbreaker types. The results of simulation analysis hoped to confirm the applicability of finite element method for cutting 6061 aluminum alloy.

**Keywords:** Turning tool, Chipbreakers design, 6061 aluminum alloy.

## Introduction

Cutting is an important method for forming a metal material, in order to improve processing efficiency and product surface quality, together with co industry stringent requirements. Must examine cutting inherent principle, since the metal cutting technology is quite complex and involves many factors. It used analytical methods are difficult to accurately describe the chip formation process, and funding for purely experimental study required a lot of investment and time. The finite element analysis techniques aided design as an effective tool to the workpiece material properties such as temperature, strain and strain rate functions for the interaction between the various machining parameters.

Includes regarding the mechanical processing research: [Toru et al. (2014)] research the cutting tool hot-working, transfers heat from heated up cutting tool, the work piece carries on the simulation analysis, the cutting experiment showed that the cutting tool heated up the pattern to improve the cutting process capability. [Stepan et al. (2014)] confirmed for calculating the stability of fixed milling, surveys in the working conditions carries on the confirmation the general numerical algorithm, its can forecast that the cylindrical milling cutter geometric form carries on the milling process the stability condition. [Gandjar et al. (2014)] described five axis milling, during using an analysis method to define the CWE half fine mill ring-like and plane face cutter in the carving part. [Totis et al. (2014)] research cutting tool shape optimization. It has carried on the optimization to the design of module through the use finite element analysis method, the dynamic mathematical model of common sensor having. Through conducting modal analysis and cutting test. The experimental result has proven the new equipment outstanding characteristics. [Jaroslava and Zdenk et al. (2014)] studied the cutting blade and cutter life of cutting blade radius, the process steam turbine outer covering division.

## Finite element analysis

In metal shaping process, because comes under influence of the plastic deformation, creates the production of flaw mostly is caused for the material ductile fracture by processing. The brittle failure of metallic material among crystallizing cleavage surfaces, the atom unifies to destroy for the focus micro phenomenon mutually, namely breaks out the destruction, and before the material destroys. The strain capacity does not have minimum even the plastic deformation, and formation

destruction of non-early warning. The DEFORM$^{TM}$ software according to the design system and processing process, because of the analysis pattern that the two-dimensional or three-dimensional flow distorts, can simulate the metallic material in the die forming, after ductile fracture value and distortion, temperature and plastic flow speed, stress and strain of distributed situation.

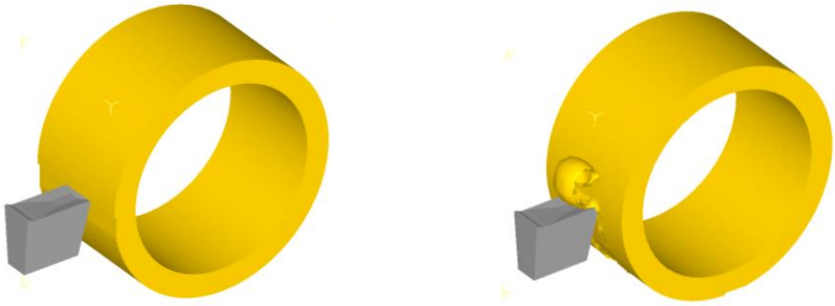
**Simulation and parameter setting**

Table 1 illustrated the different tools chipbreakers cutting simulation parameters of 6061 aluminum alloy, including fixed parameters include: speed 200 rpm, tool temperature 200 $^{o}$C, friction factor 0.7.

**Table 1. Different tools chipbreakers cutting simulation parameters of 6061aluminum alloy**

| turning tools chipbreakers types | Rotational speed (rpm) | Tool Temperature ($^{o}$C) | friction factor |
|---|---|---|---|
| without chipbreaker | 200 | 20 | 0.7 |
| square chipbreaker | | | |
| elliptical chipbreaker | | | |

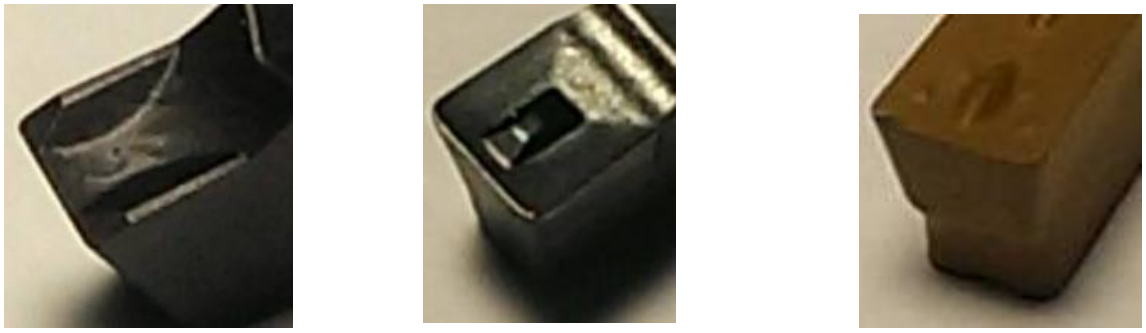
Figure 1 (a) and (b) show simulation diagram for an 6061 aluminum alloy chipbreaker turning cutting before forming and after forming .



(a) before cutting (b) after cutting

**Figure 1. 6061 aluminum alloy chipbreaker turning cutting**

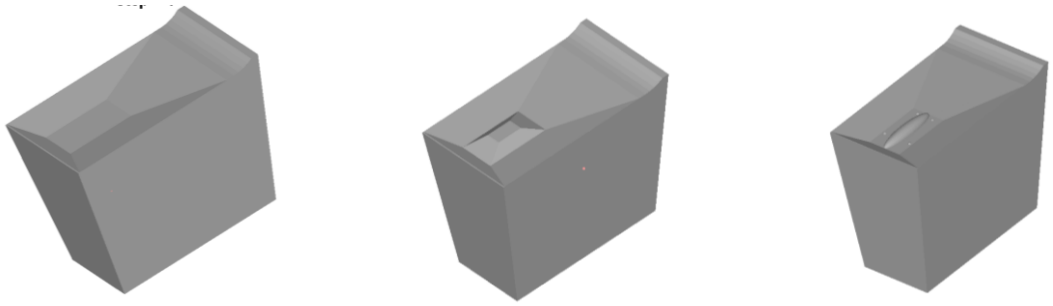
Figure 2 shows 6061 aluminum alloy turning chipbreaker entity diagram, which (a) without chipbreaker, (b) square chipbreaker and (c) elliptical chipbreaker.



(a) without chipbreaker (b) square chipbreaker (c) elliptical chipbreaker

**Figure 2. Entity diagram of 6061 aluminum alloy chipbreaker turning cutting**

Figure 3 shows simulation diagram of 6061 aluminum alloy turning chipbreaker, which (a) without chipbreaker, (b) square chipbreaker and (c) elliptical chipbreaker.



(a) without chipbreaker (b) square chipbreaker (c) elliptical chipbreaker

**Figure 3. Simulation diagram of 6061 aluminum alloy 6061 chipbreaker turning cutting**

## Results and discussion

Figure 4 shows effective stress diagram for different chipbreaker, the maximum value at 0.1 second for an elliptical chipbreaker. Moreover stress producing is 841MPa, square chipbreakers stress arising is smallest value 790MPa. Stress arising from 0.02-0.05 seconds is no difference. Figure 5 shows effective stress diagram of without chipbreaker tool. It can be seen that the maximum effective stress generated in the tool and billet contact.

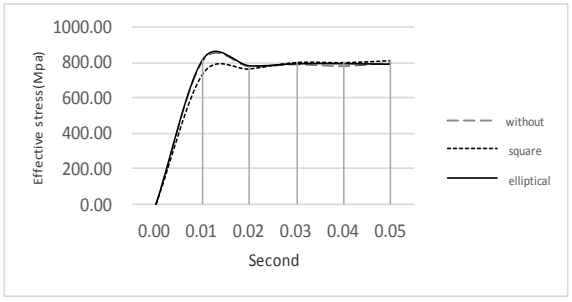



**Figure 4. Different chipbreaker effective stress diagram**

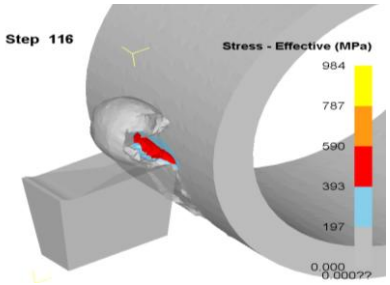



**Figure 5. Effective stress of without chipbreaker**

Figure 6 shows effective strain diagram for different chipbreaker. The without chipbreaker produce the greatest strain 16(mm / mm) at 0.2 seconds. The square chipbreakers is arising smallest effective strain 7.5(mm/mm). Strain The elliptical chipbreakers is arising largest effective strain at 0.4 seconds. Figure 7 shows strain- effective diagram for without chipbreaker. It can be seen that the maximum effective strain generated in the chip curler.

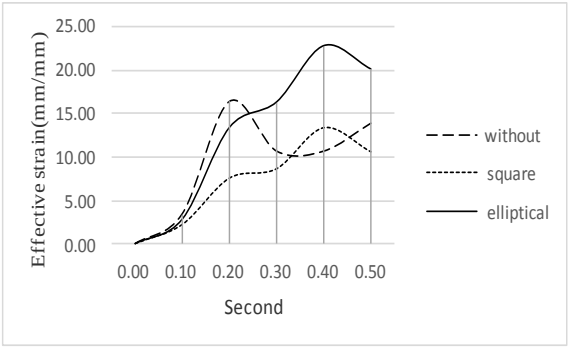



**Figure 6. Different chipbreaker effective strain diagram**

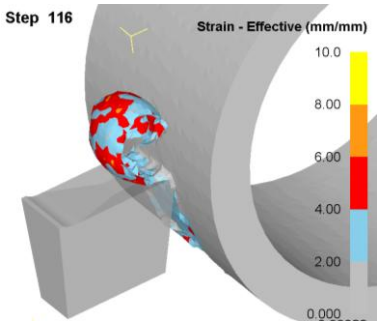



**Figure 7. Effeive strain of without chipbreaker**

Figure 8 shows different chipbreaker temperature diagram, the square chipbreaker produced maximum value at 0-0.5 seconds, the temperature is 141$^{o}$C. Figure 9 shows without chipbreaker

temperature diagram. It can be seen that the maximum temperature generated in the tool and billet contact.

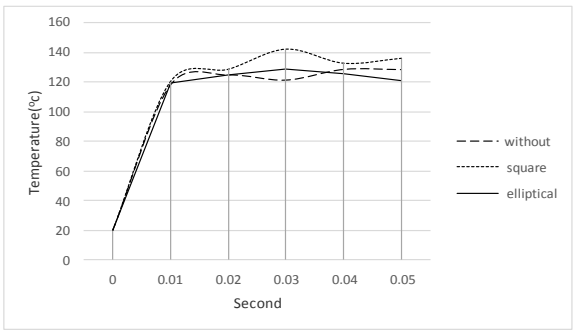



**Figure 8. The temperature of different chipbreaker**

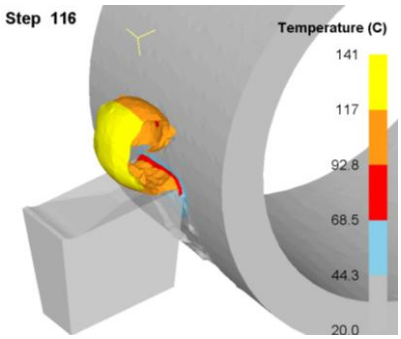
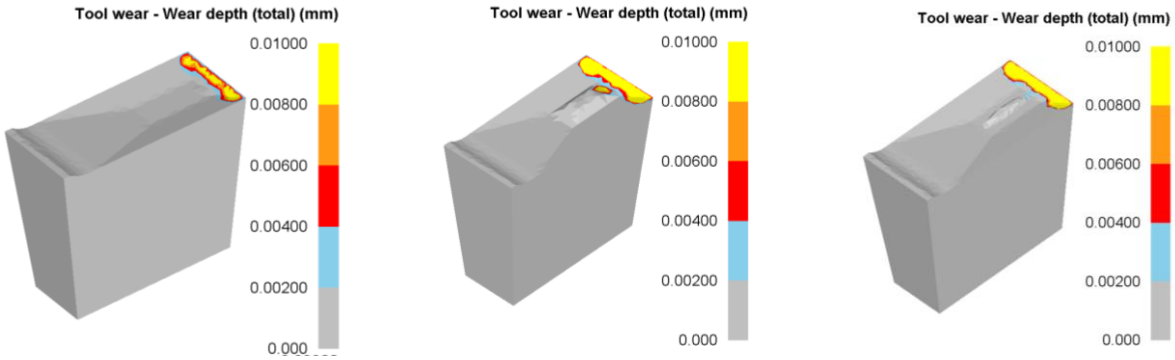



**Figure 9. The temperature of without chipbreaker**

Figure 10 shows wear simulation diagram for different chipbreakers, (a) the wear is homogeneous at the tip for without chipbreakers, (b) square type chipbreaker generate maximum wear in the chipbreaker area and (c) elliptic chipbreaker induced homogeneous wear at the tip area.




(a) without chipbreaker (b) square chipbreaker (c) elliptical chipbreaker

**Figure 10. Wear simulation diagram of different chipbreakers**

## Conclusions

This article in view of the aluminum alloy 6061 materials, has built the finite element model of description cutting process for without chipbreaker design, square chipbreaker design and an elliptical chipbreaker design. The results have shown that: (1) square chipbreakers stress arising is smallest value 790MPa; (2) the maximum effective strain generated in the chip curler; and (3) square type chipbreaker generate maximum wear in the chipbreaker area.

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