Acta Technica *62* (2017), No. 4A, 505–512

Influence of cutting parameters on residual stress during hard dry cutting

Tang Dewen[2,4], Peng Cong[3], Zhao Ruilan[3], Zhang Jiayu[3]

Abstract. Dry cutting technology is a kind of machining method, shall not apply to the coolant is a kind of green cutting technology. This paper mainly studies the cutting speed and cutting depth on surface residual stress and the effect of residual stress in the surface of the forecast and control to improve the machining quality and machining efficiency is of great significance. The indentation method is adapted to measure with the result of the experiment results show that: due to the increase of cutting speed, increase thequantity of heat, heat source movement speed also corresponding increase at the same time, but is passed to the workpiece surface heat is limited, and the effect of thermal stress. If increasing the cutting depth at this time, the metal deformation increases, the effect of mechanical stress play, surface residual tensile stress decreases. At the same time under the high cutting speed, feed less effect on the machining surface residual stress changes.

Key words. Dry cutting, fem, residual stress; indentation method.

1. Introduction

Manufacturing engineering is one of the important content of the 21^{st}-century environment clean green manufacturing technology, dry cutting technology as a kindof efficient,environmentally of efficient, environmentally friendly processing methods, widely used in aerospace, mold parts processing, automobile and other fields.But in the dry cutting process, due to lack of cooling liquid lubrication cooling effect, friction between tool and chip and workpiece, produce a large amount of cutting heat.Lead to thecutting tool and the workpiece surface machining surface temperature has risen

[1]Acknowledgement - The authors gratefully acknowledge the funding by the Natural Science Foundation of Hunan Province with the project number 2015JJ5023; Hunan Provincial Innovation Foundation For Postgraduate with the project numberCX2017B525;Outstanding Young Scientist Project In Hunan Province Department Of Education with the project number 15B206.

[2]Workshop 1 - Cooperative innovation center for nuclear fuel cycle technology & equipment, Hengyang, Hunan, China

[3]Workshop 2 - School of Mechanical Engineering, University of South China, Hengyang, Hunan, China

[4]Corresponding author:Tang Dewen ; e-mail: will998@163.com

sharply, processing surface residual stress are more likely to produce.At the same time, thehigh cutting temperature will speed up the tool wear, further improve the cutting temperature and cutting force, resulting in processing surface residual stress is more difficult to predict [1].

Yang Wenming et al. [2] are found that suitable for dry cutting under the condition of large feed, low cutting speed, especially under the condition of feeding large, dry cutting tool life and wet cutting tool life is quite, and heat release and heat transfer also increases, the machining temperature will decrease, and the roughness of the workpiece remain unchanged. However, with the increase of cutting speed, cutting the temperature will rise, chip form more easily, leading to reduce the cutting force, tool life can also be as reduced.Wang Baobao et al. [3] discovered that the greatest influence on the milling force is turning back, followed by feeding, influence is the least cutting speed.Improve the cutting speed can be effective to shorten the time of heat producing and heat into the workpiece and reduce the cutting depth can reduce

surface contact between the tool and the heat source and the load can be reduced while cutting.But in smaller cutting depth, feed larger ultra-high speed machining, due to the very short contact time between the cutter and workpiece, the cutting heat can be processed for more than 90%.Sun Yazhouet al. [4] and others to study the effects of cutting parameters on surface residual stress. For most of the material, the surface residual stress is the biggest impact of the cutting speed, followed by feed and cutting depth. Improve the cutting speed, surface residual stress will increase accordingly, the thickness of the surface residual stress layer will increase. Within a certain range, the increase of feed can cause deep residual compressive stress increases, and the increase of cutting depth will cause processing surface residual tensile stress and the increase of the depth of residual stress layer.R.S. Pawade et al. [5] are found that Inconel 718 processing surface residual stress, it is concluded that impact on the cutting parameters on surface residual stress.

2. Experimental conditions and methods

2.1. Experimentalpreparation

This experiment selects the45 hardened steel for dry cutting, the size is 330mm $\times$60mm$\times$10mm (as shown in figure 1), the 10 pieces of each piece of workpiece processing area, processing area adjacent interval of 10mm in order to prevent the mutual influence, 30 mm area set aside for workpiece each side so that the clamping.Choose TiAlN coating hard alloy cutter knives, cutting tool parameters for 4F-D10$\times$25C$\times$10$\times$75L. The experiment used machine tools for CNC machining center V600. Machining residual stress measurement by indentation method, models for TST3822 measuring instrument.

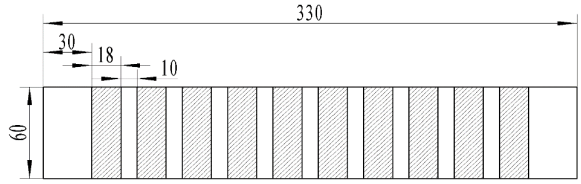

Fig. 1. Workpiece shape

Fig. 2. The milling test scene

2.2. Experimental method

On CNC machining center V600 with integrated 45 hardened steel cutting experiment, the cutting speed is from 50 m / min to 200 m / min, the feed is from 0.02 mm / z to 0.08 mm / z, and the cutting depth is from 0.2 mm to 0.8 mm, Cutting layer width Ae = 8mm, to facilitate processing residual stress measurement, the workpiece cutting area of 60mm×18mm size.

In-plane stress field, the materials produced by pressure into the spherical indentation creep relaxation deformation can cause stress, the tensile stress area the size of the material to shorten the size of the material elongation, compressive stress area.At the same time, produced by indentation elastic and plastic zone and the surrounding stress and strain in under the action of residual stress will produce corresponding change.This strain produced by thesuperposition of two deformation modes of variation can be called superposition strain increment (Hereinafter referred to as the strain increment). Using spherical indentation induced strain increment of solving method of residual stress is called indentation strain gauge.

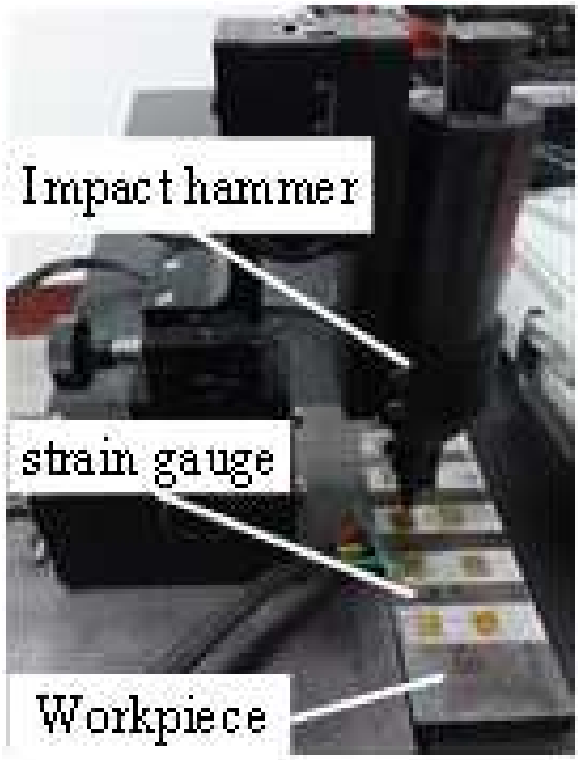

Fig. 3. Residual stress impact device Figure.4 Residual stress measurement of the scene

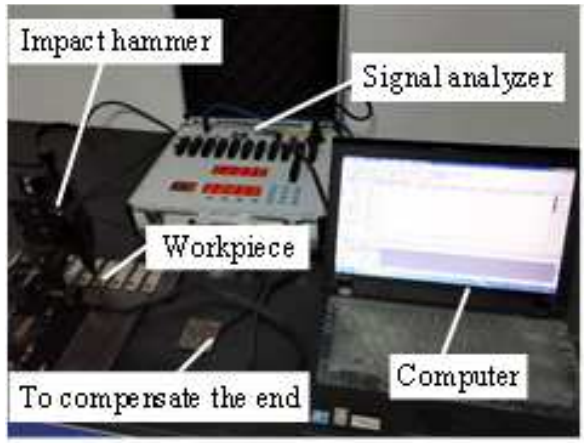

Fig. 4. Residual stress measurement of the scene

3. Experimental results and analysis

3.1. Cutting speed - feed on the influence of surface residual stress

To study the effect of feeding on surface residual stress and the cutting depth remains the same.The figure 5 shows that with the increase of feed, the residual stress of cutting surface of 45 # first decreases and then increases, the change curve in U.For the same cutting speed, Reduce the cutting speed from 0.06 mm/z to 0.02 mm/z, metal removal rate increases, the surface of metal deformation and mechanical stress effect is enhanced, the distribution of residual stress in depth, thus machining surface residual stress decreases as a whole.But as the feeding increases to 0.08 mm/z, anincrease of metal removal efficiency, increase in the number of calories per unit time, dominate the action of thermal stress at this point, surface residual stress increase rapidly. The lower the cutting speed, the greater the residual stress changes in the degree of curvature of thecurve.The reasons for this phenomenon is:In the case of lower cutting speed (v = 50 m/min), heat source movement speed slower, heat cutting have plenty of time to the workpiece machining on the surface, leading to the surface of the workpiece cutting temperature rise, thus caused by the feeding effect of mechanical stress and thermal stress at the same time. To be specific, When feeding is low (f = 0.02 mm/z ˜ 0.06 mm/z), the mechanical stress is the main role, processing residual stress decreases. When higher feeding (f = 0.06 mm/z ˜ 0.08 mm/z), the thermal stress effect began to play a major role, therapid increase in the surface residual stress. When the cutting speed is higher (v>150m/min), thermal efficiency increases, but the heat source moving speed, thereby reducing the heat transfer time.At the same time, due to the low thermal conductivity of 45 #, so less cutting on the surface of the heat transfer to the processing, thermal stress effects play a role, thus machining surface residual stress vary with feed is smaller.

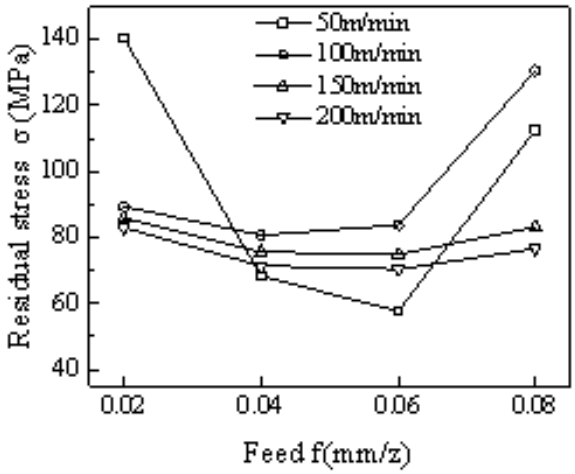

Fig. 5. Cutting speed - feed on the influence of surface residual stress (Ap=0.4mm, Ae=8mm)

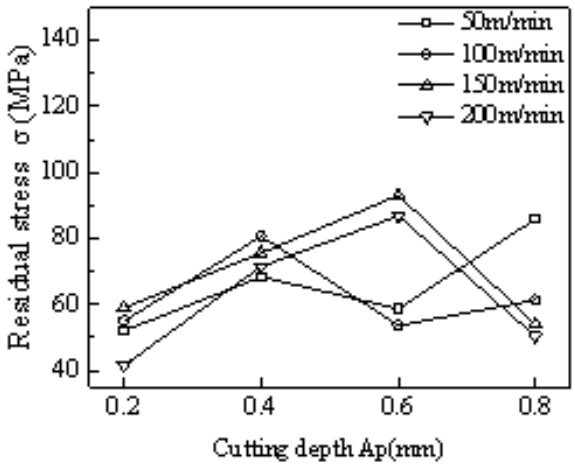

Fig. 6. Cutting speed - cutting depth on the influence of residual stress(f=0.04mm/z, Ae=8mm)

Figure 6 shows that in low speed down (v = 50 m/min, 100 m/min), with the increase of cutting depth, 45 # processing surface residual stress increases first, then decrease and then increase, change curve shows fluctuation. However, under the condition of high speed (v = 150 m/min, 200 m/min), with the increase of cutting depth, 45 # processing surface residual stress first increases and then decreases.The reasons for this phenomenon is: Under the condition of high speed, because of the increase in cutting depth heat production rate of heat increase, transfer heat to the surface increases, the surface temperature rise and thermal stress effect, so lead to surface residual tensile stress increased. Increase along with the cutting depth, the effect of thermal stress leveled off gradually, but metal plastic deformation continues to increase, lead to the workpiece machining surface residual tensile stress due to the effect of mechanical stress to strengthen gradually decreased. Under the condition of low speed, the increase of cutting depth can lead to the effect of thermal stress and mechanical stress effect at the same time, thus the surface residual stress fluctuation change.

4. Conclusion

Under the condition of different cutting speed, feed and cutting depth on the influence of the residual stress is different. In low-speed cutting (v = 50 m/min, 100 m/min), with the increase of feed, surface residual stress decrease then increase first, and with the increase of cutting depth, surface residual stress increases gradually, the change tendency is obvious. In high-speed cutting (n = 150 m/min, 200 m/min), with the increase of feed, surface residual stress change is not obvious. But with the increase of cutting depth, surface residual stress showed the change trend of increase with the decrease of again then.

In short, when the dry cutting 45 #, due to the increase of cutting speed, increase

thequantity of heat, heat source movement speed also corresponding increase at the same time, but is passed to the workpiece surface heat is limited, and the effect of thermal stress. If increasing the cutting depth at this time, the metal deformation increases, the effect of mechanical stress play, surface residual tensile stress decreases. At the same time under the high cutting speed, feed less effect on the machining surface residual stress changes.

References

[1] W. Jomaa, V. Songmene, P. Bocher: *Surface finish and residual stresses induced by orthogonal dry machining of AA7075-T651.* Materials *7* (2017), No. 3, 1603–1624.

[2] W. M. YANG: *Selection and Applicationof Dry Cutting Parameters of Cutting.* Equipment Manufacturing Technology *233* (2014), No. 5, 64–65.

[3] B. B. Wang, H. Shen, W. J. Wei: *Force Research in Interrupted Dry Cutting Hardened Steel Cr12MoV by PCBN Tool.* Tool Engineering *47* (2013), No. 11, 19–21.

[4] R. P. Singh, S. K. Jain: *Finite Element Simulation and Experimental Research of Residual Stresses in the Cutting Based on the Coupled Thermo-mechanical Model.* Journal of Mechanical Engineering *47* (2011), No. 1, 187–193.

[5] M. N. Gaikwad, K. C. Deshmukh: *Effect of machining parameters and cutting edge geometry on surface integrity of high-speed turned Inconel 718.* International Journal of Machine Tools & Manufacture *48* (2008), No. 1, 15–28.

Received November 16, 2016