Research on grinding wheel characteristic

Pawan kumar Sharma [1], Rajesh Singh[2]

Scholar Department of Mechanical Engineering, Faculty of Engineering, Moradabad

Scholar Department of Mechanical Engineering, Faculty of Engineering, Moradabad

***Abstract*— Grinding of metals is a complex material removal operation. Research on cutting process of a single abrasive grain is the basis of further understanding of grinding mechanism. In this investigation, the simulation and analysis for the non-uniform thermo-mechanical coupling intense stress fields in cutting zones of a single abrasive with negative rake are conducted by means of the FEM techniques. The cutting forces, the cutting temperature distribution and the strain rate in cutting zone are numerically demonstrated. Grinding mechanics are analyzed from microscopic view according to the simulation results. Research results facilitate a better understanding on the mechanics of grinding.**

Keywords- Cutting simulation; FEM; Grinding mechanism, cutting speed

Introduction

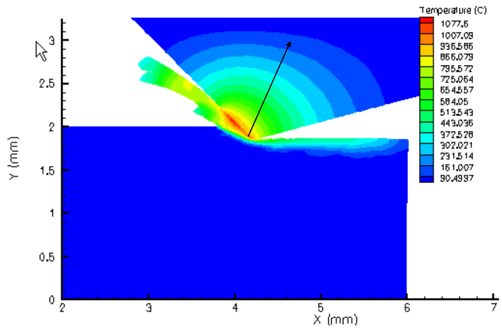
Grinding is a very complex material removal operation. Compared to conventional machining, grinding differs in many ways, including the use of high wheel speeds, fine depths of cut, a large number of multiple cutting points of unknown geometry which varies continuously with time, the high negative rake angles presented by the abrasive grains. As a simplified model of the grinding, the grinding technique with a single abrasive grain is an effective way to explore the mechanism of the complex grinding. Komanduri[1] investigated machining with high negative rake angles to simulate grinding and made an attempt to provide an alternate explanation for some of the anomalies, such as the force ratio, specific energy, subsurface deformation by comparing grinding with machining with high negative rake angle tools. Research on cutting process of single abrasive is the basis of further understanding of grinding mechanism.Experimental research on grinding with single abrasive grain is difficult to conduct because of the non-uniform thermo-mechanical coupling intense stress fields in cutting zones of single abrasive with negative rake. With the development of computer technology, the finite element method(FEM) was widely used in machining simulations. In recent years, the finite element method has particularly become the main tool for simulating metal cutting processes[2]. The finite element models are widely used for calculating the stress, strain, strain-rate and temperature distributions in the primary, secondary and tertiary sub-cutting zones. In consequence, temperatures in tool, chip and workpiece, as well as cutting forces, plastic deformation(shear angles and chip thickness) , chip formation and possibly its breaking can be determined faster than using costly and time consuming experiments. At the same time, the ability to characterize the mode of material removal through simulations provides an alternative approach to understanding the effect of varying machining parameters such as rake angle, cutting-edge radius, and depth of cut. In this paper, machining simulations of a single abrasive with negative rake are conducted on the basis of the thermo-elastic-plastic deformation theory and FEM techniques, which contribute to a better understanding of grinding mechanism.

Cutting temperature and power

The influence of rake angle on the cutting temperature and power is summarized in Fig.4. It could be seen that both cutting temperature and power increased as the rake angle decrease and reach the maximum value for -45º case.

High negative rake angle will cause great shear strain, which has been proved by research results[1]. Rapid adiabatic shearing phenomenon will occurs in the cutting deformation zone when cutting with abrasive of high negative rake angle. In that case, the cutting temperature is very high because that the material deformation time is very short and the vast majority of plastic deformation power/friction power has no time to dissimilar property of grinding wheel Cutting force/cutting temperature and power, From Fig.5, we can see that both the cutting temperature and power increase with the cutting speed increasing, which conforms to the general cutting principle. The cutting temperature distribution was showed in Fig.6, from which we can see the temperature change in work piece and chip clearly and the highest temperature appeared in the tool tip or zone of rake face close to the second deformation zone. In cutting case with tool of -45° rake angle, with cutting speed increasing from 60m/min to 240m/min, the highest temperature in the tool tip increase from 1078ºC to 1467ºC. When V 300m/min, maximum cutting temperature reaches 1539°C, which is close to the temperature value of abrasive point measured in the experiment[4] and reaches the melting temperature of TC4 alloy(about 1600°C).

The cutting temperature distribution with the distance from original point is showed in Fig.7, from which shows that temperature gradient are mainly concentrated in the range of 0.5mm from the tool tip, and the work piece surface temperature gradually dropped with distance from tool tip increasing.



(a) V=60m/min T_{max}=1078°C

(b) *v*=240m/min T_{max}=1467°C

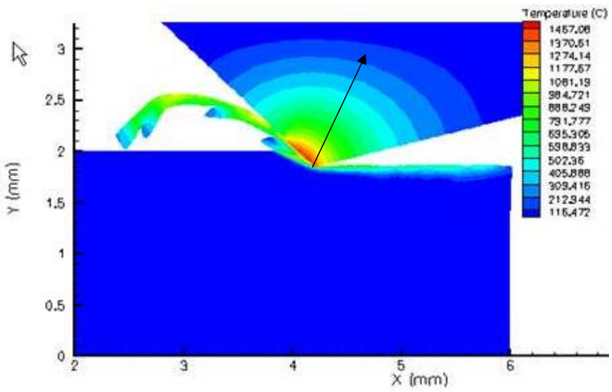


Fig.6 The cutting temperature distribution for different cutting speed

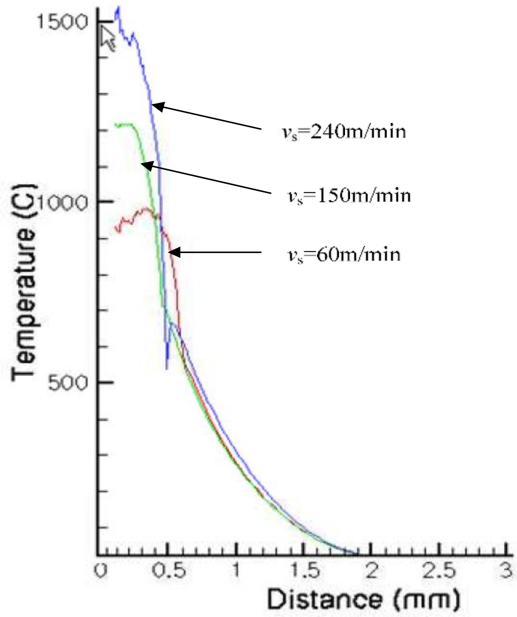


Fig.7 The cutting temperature gradient for different cutting speed

Influence of the cutting speed on strain rate-
Fig.8 presents some strain rate values of different cutting speed, from which we can see that the increase of cutting speed leads to strain rate declines dramatically. That is because the abrasives interacts with the work piece at extreme high speed in grinding process, which lead to severe plastic deformation of the material in contact zone. Therefore the material strain rate in the grinding exceeds that of the cutting process significantly, and the strain rate hardening effect is enhanced greatly.

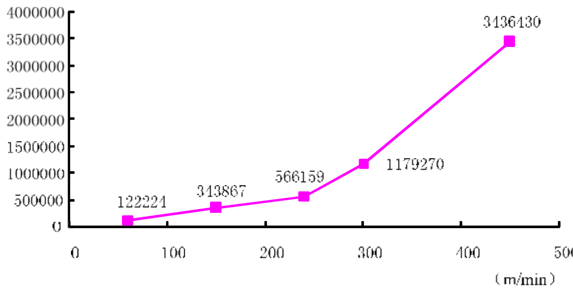


Fig.8 Strain rate for different cutting speed

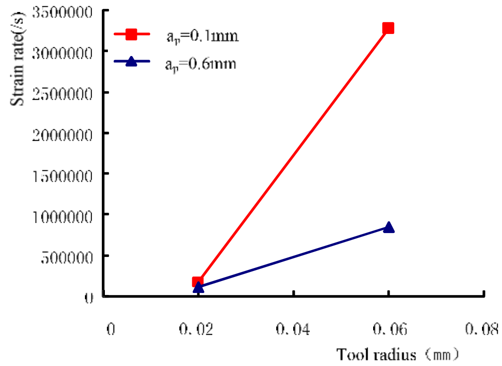


Fig.9 Strain rate for different tool radius

Cutting simulation results of different tool radius-
According to the characteristics that the abrasive grain has a larger cutting-edge radius, cutting simulations of different tool radius are conduct. As showed in Fig.9, with tool radius increasing, the cutting temperature rises and strain rate declines dramatically. The influences of the cutter radius variation on grinding process are made more significant with the reduction of cutting depth, and it is especially obvious when the cutting depth is close to the cutter radius.

Conclusion

With the value of negative rake angle increasing, the cutting forces/ the ratio of thrust force to cutting force/the cutting temperature and power consumed increase at the same time.Both the cutting temperature and power increase with the cutting speed increasing. When Vic=300m/min, maximum cutting temperature is close to the temperature value of abrasive point measured in the experiment and approaches the melting temperature of TC4 alloy.The increase of cutting speed leads to strain rate declines dramatically. The abrasives interact with the work piece at extreme high speed in grinding process, which leads to severe plastic deformation of the material in contact zone. Therefore the material strain rate in the grinding exceeds that of the cutting process significantly, and the strain rate hardening effect is enhanced greatly. With tool radius increasing, the cutting temperature rises and strain rate declines dramatically. The influences of the cutter radius variation on grinding process are made more significant with the reduction of cutting depth.

References

[1] R. Komanduri. Some aspects of machining with negative rake angles simulating grinding[J]. Int.J Mach. Tool. Des. Res. 1971, Vol. 11:223-233
[2] F.Kloke, T.Beck, S.Hoppe, T.Krieg. Examples of FEM application in manufacturing technology,J.Mater.Process.Technol.120(2002):450-457
[3] Hou Z B, Komanduri R. On a thermo-mechanical model of shear instability in maching[J].Annals of the CIRP, 1995, 44(1):69-72
[4] Zhang Hongxia, Chen Wuyi, Chen Zhitong. Temperature Measurement in Grinding Titanium Alloys[C]. Proceeding of the Eighth International Conference on Progress of Machining Technology, 2006,