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Effect of Cooling Parameters on Cutting Vibration of Milling GH4169

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Abstract: Nickel base superalloy is a typical difficult to machine material. With the development of social demand, more and more attention has been paid to the research of green manufacturing technology. Reducing the emission of cutting fluid is of great significance to achieve green manufacturing. Low temperature quantity cooling (MQCL) is a kind of green manufacturing technology. In this paper, the experiments of milling superalloy GH4169 under MQCL were carried out to study the influence of cooling parameters on cutting vibration and its mechanism.

Keywords: MQCL, Cutting vibration, Cooling parameters.

1. Introduction

In the process of milling nickel base superalloys, high heat will be generated in the tool workpiece contact area. Higher milling temperature is likely to cause surface burns and changes in surface microstructure of the workpiece, as well as fracture and violent vibration of the tool, which will shorten the service life of the tool. In order to solve this problem, the traditional machining method often uses pouring cutting, that is, a large number of cutting fluids are used to cool and lubricate the workpiece. Extensive research shows that MQL technology is difficult to be used for hard cutting materials such as titanium alloys and superalloys due to its limitations in cooling effect (Liu et al, 2019). MQCL technology is developed on the basis of MQL, and scholars at home and abroad believe that it is more conducive to improving the cooling effect and playing a role in lubrication.

2. Experimental plan

This experiment adopts the combination of orthogonal experiment method and single factor experiment method. The single factor experiment is used to analyze the influence trend of cooling parameters on surface roughness and vibration. According to the results of multiple milling experiments, and considering factors such as surface roughness, tool wear and tool vibration, the milling parameters such as cutting speed, milling depth, and feed per tooth are set as fixed values. The specific milling experiment parameters are shown in Table 1. Cooling parameters are the focus of this experimental study. The cooling parameters are divided into three factors and four levels. The specific parameter gradient is shown in Table 2. The numbers 1, 2, 3 and 4 in the table represent the gradient number of each parameter. According to the actual situation, the parameters of the single factor experimental group are set as the experimental data shown in Table 3-3, which includes 12 groups of experiments in total. After removing the experimental groups that overlap with the orthogonal experiment, there are 9 groups of experiments, in which 1, 2, 3, and 4 represent the level of each factor respectively. According to the Taguchi experiment method, the orthogonal experiment is designed as the number of experimental groups shown in Table 3-4, including 16 groups of experiments. In the process of single factor experiment and orthogonal experiment, in order to obtain accurate experimental results, each group of experiments is conducted three times, collecting tool vibration signals, measuring workpiece surface roughness and hardness, and collecting experimental chips to number experimental groups for analysis and observation, and finally taking the average value of their experimental measurement results

Table 1. Milling Experimental Parameters

Milling parameters	Value/method
Milling method	Face milling
Milling speed *v* (m/min)	60
Feed per tooth *f* (mm/rev)	0.15
Milling depth a_p (mm)	0.3
Milling width a_f (mm)	5
Nozzle distance (mm)	20
Nozzle angle (°)	45

Table 2. Setting of Cooling Parameters

Level	Fluid flow (ml/h)	Wind speed (m/s)	Temperature (C°)
1	80	5.5	-20
2	140	7.0	-10
3	200	8.5	0
4	260	10.0	10

3. Experimental System and Equipment

In order to enhance the reliability of the experiment and improve the accuracy of processing, the design and layout of the system for building the low temperature micro lubrication experimental platform are shown in Figure 1. In the figure, (a) represents the milling machine processing system, (b) represents the vibration signal acquisition and processing system, and (c) represents the low temperature micro -lubrication processing system.

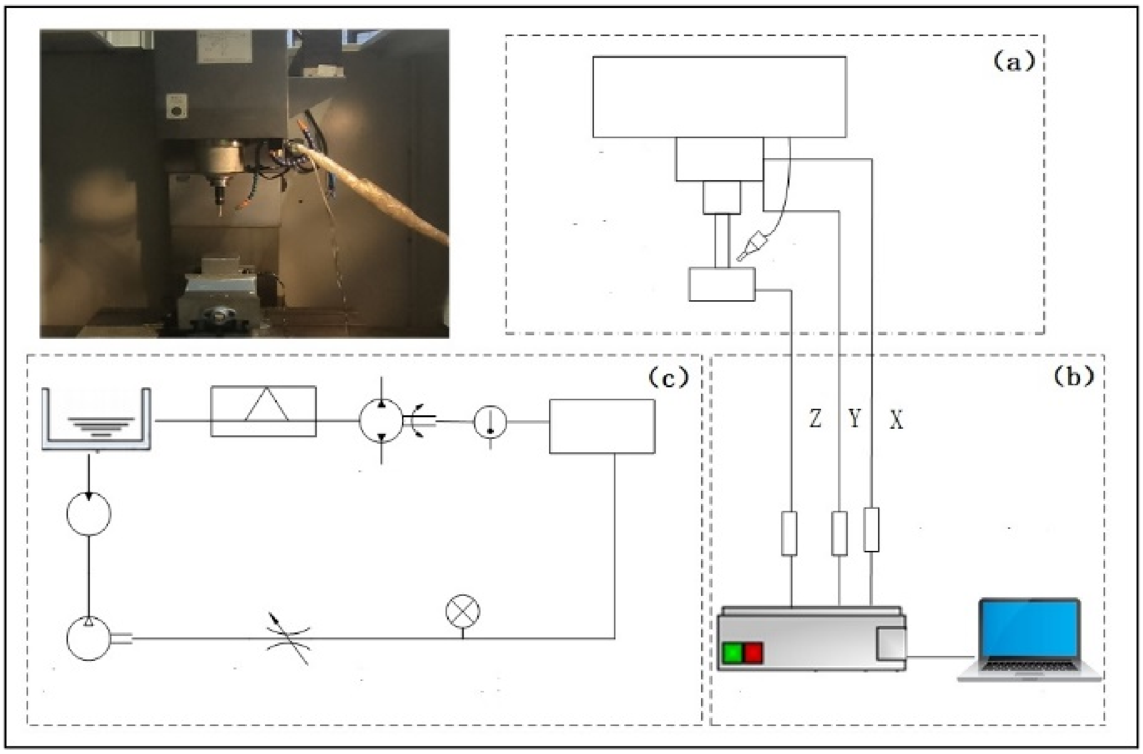

Figure 1. Design and layout of micro lubrication milling system

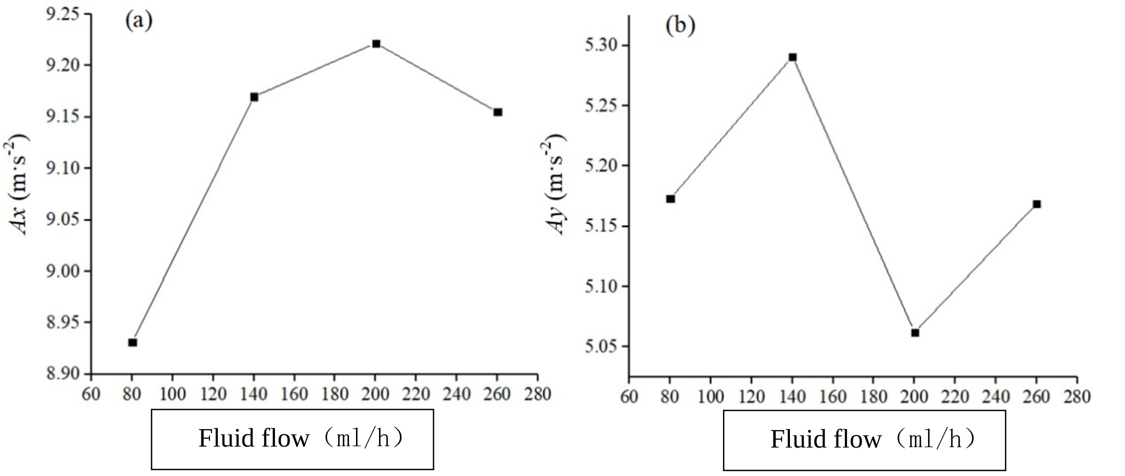

Figure 2. Cutting vibration acceleration under the change of oil flow: (a) axial vibration; (b) Radial vibration

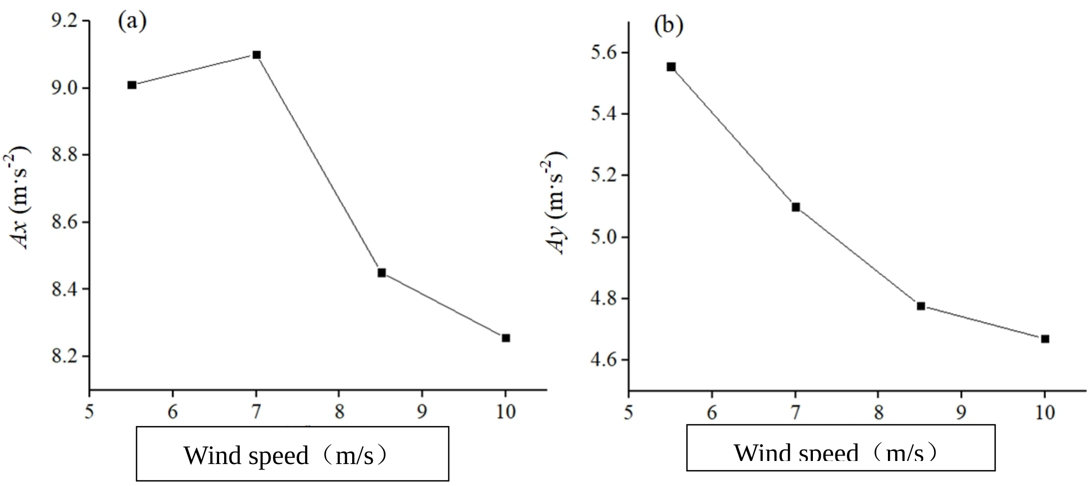

Figure 3. Cutting vibration acceleration under changing wind speed: (a) axial vibration; (b) Radial vibration

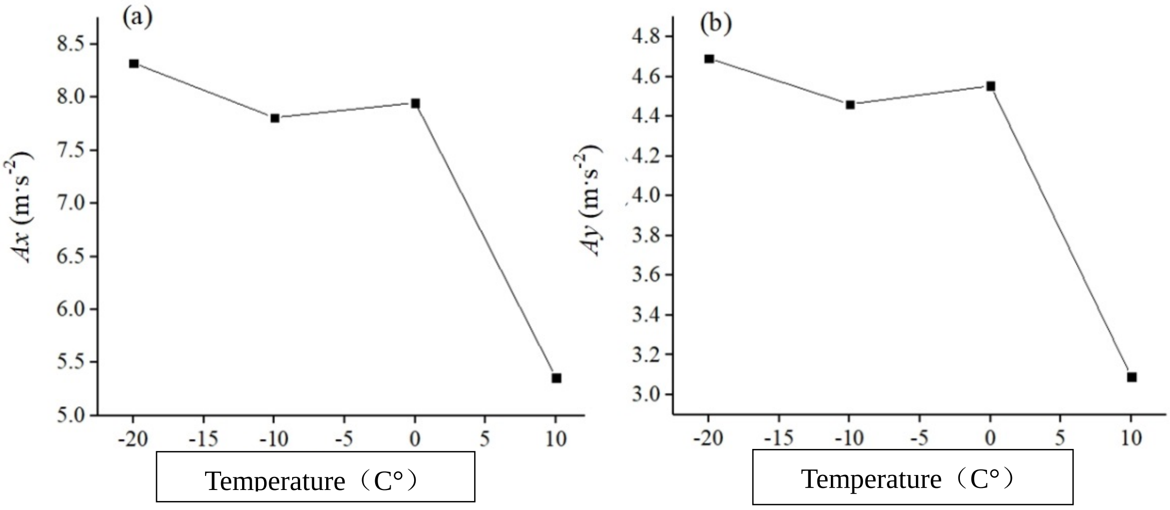

Figure 4. Cutting vibration acceleration under temperature change: (a) axial vibration; (b) Radial vibration

4. Study on the Influence of Cooling Parameters on Cutting Vibration in Milling GH4169

According to the experimental results, the result diagram is shown in Figure 2. The axial vibration amplitude is greater than the radial vibration amplitude, and the amplitude does not change linearly with the change of oil flow. Under the change of oil flow, the vibration trends of axial and radial vibration are different. When the oil flow is less than 140ml/h, the axial and radial vibrations increase with the increase of oil flow. When the oil flow rate is greater than 140ml/h and less than 200ml/h, the axial vibration amplitude gradually increases with the increase of oil flow rate, but the radial vibration amplitude starts to decrease, which may be due to the reduction of tool wear leading to the reduction of radial vibration; When the oil flow is greater than 200ml/h, the axial vibration amplitude is inversely proportional to the increase of oil flow, while the radial vibration is proportional to the increase of oil flow. In general, the oil flow has little influence on the radial vibration, and the axial vibration is more sensitive than the radial vibration. Proper oil flow can reduce the vibration generated by the system, so as to achieve the effect of stability and increase the tool life and the machining accuracy of parts.

The influence trend of wind speed on vibration is shown in Figure 3. In the whole experiment, the radial vibration is inversely proportional to the increase of wind speed, and the general amplitude change trend of axial vibration also decreases with the increase of wind speed. This shows that increasing the wind speed can reduce the vibration and improve the processing stability of the system. In general, the wind speed has a great influence on the radial vibration, and the radial vibration is more sensitive than the axial vibration amplitude change. Under the condition that the oil can be sufficient to cut the area, properly increasing the wind speed can reduce the vibration generated by the system, improve the surface roughness, and increase the tool life and machining accuracy of the parts.

According to the analysis of single factor experiment results in Table 3-7, the influence trend of temperature on vibration during the process of carbide tool milling superalloy GH4169 is shown in Figure 4. It can be seen from the figure that the vibration generated at - 20 ° C is higher than that at - 10 ° C. When the temperature is lower than - 10 ° C, the axial vibration and radial vibration decrease with the increase of temperature. When the temperature is between - 10 ° C and 0 ° C, the vibration amplitude has a slight increase trend. When the temperature is higher than 0 ° C, the axial vibration and radial vibration decrease with the increase of temperature. In general, the axial vibration is more sensitive to the change of temperature and has a large change range; The radial vibration increases with the decrease of temperature. The amplitude of radial vibration is small; When the temperature is - 10 ° C, the axial vibration and radial vibration suddenly decrease. This may be because the lubrication effect is improved and the tool wear is reduced at - 10 ° C, so that the vibration is reduced. The minimum vibration occurs at 10 ° C. This shows that increasing the temperature can reduce the vibration and improve the processing stability of the system, and the change of temperature has a great impact on the axial vibration. In actual processing, the lower the temperature is, the better the cooling effect is, but the lower the temperature is, the greater the vibration will be, resulting in strong system chatter and poor stability of the machine tool. Therefore, when selecting the cooling temperature, the cooling effect at - 10 ° C is better than that at - 20 ° C in low temperature, the stability of the machine tool is improved, and the tool wear is less.

5. Conclusion

In the direction of green manufacturing, MQCL milling nickel base superalloy GH4169 with fixed milling parameters is studied in this paper, and the influence of milling GH4169 with cooling parameters on cutting vibration is studied. It is concluded that temperature is the main factor affecting cutting vibration, and wind speed and oil flow rate have different degrees of influence according to different cutting vibration directions.

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