Stability Analysis of High Speed in Micro Hole Drilling

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Abstract

The chatter phenomenon is a very strong relative between the micro-drill and the workpiece during metal cutting Vibration, the cause of its occurrence and the law of occurrence and development, the cutting process itself and the metal cutting machine State characteristics have inherent intrinsic links.This paper is to study the mechanism of the micro-hole drilling process, chatter diagnosis, modeling description, Stability analysis, and verify the feasibility of theoretical research results through experiments, analyze the variation of the limit feed rate with the spindle speed. During the research, comprehensive consideration of axial forces and twists on the main cutting edge and the chisel edge Moment, the expression of total cutting force is obtained, and the dynamic model of the cutting process is established on this basis. The dynamic differential equation is a parametric equation whose solution has a critical state between convergence and divergence. Finding the relational expression between the cutting parameters corresponding to this critical state, and then establish the feed-spindle Two-dimensional cutting stability limit diagram for determining the stable cutting zone and the unstable cutting zone for operation. Appropriate machine cutting parameters are recommended. The paper studies the cutting chatter behavior by comprehensively considering the high-speed micro-hole drilling, and improves the cutting. Cutting dynamic characteristics and processing ability, to achieve the recommended cutting amount, maximize machine performance, avoiding chattering causes damage to the tool and scrapping of the workpiece, improving production efficiency.

Keywords

High speed, Micro hole, Chatter, Dynamics, Stability lobes.

1. Introduction

All manuscripts must be in English, also the table and figure texts, otherwise we cannot publish your Microspores are usually referred to as holes less than 1 mm in diameter. With the development of science and technology, the application of tiny holes is more and more widely, such as filters, electronic printer print heads, instrument components and spinnerets, etc. There are tiny whole parts. The tiny holes are not only more and more widely used, but their apertures are getting smaller and smaller .In some cases, microspores with a diameter of 0.025mm-0.1mm often appear, and the processing accuracy requirements are also raised.

At present, the commonly used micro-hole processing methods can be roughly divided into two categories according to the processing principle: special processing methods .And machining methods. Special processing methods include: EDM, electron beam processing, electrolytic processing, Electroforming, laser processing, photolithography, microwave processing, and photolithography. Each of these methods has its own characteristics, but there are problems of low processing precision, complicated process and expensive equipment. The machining method is directly. Drilling with a micro drill. Micro-hole drilling has high productivity and is not limited by the conductivity of materials. The characteristics of large depth-to-diameter ratio,

surface quality and processing accuracy are economical. Processing method with superior precision and efficiency

The machining method uses a tool to remove the blank material to obtain the required part size and shape. It is a long-established traditional processing method and is widely used in various processing fields. In the field of micro whole machining, the common machining method is drilling. Drilling has high productivity, is not limited by the conductivity of the material, and the micro whole length to diameter ratio is processed. Large, high surface quality and high processing precision are a kind of processing method with superior economy, precision and efficiency. In the electronics, precision machinery, instrumentation and other industries, it still receives much attention. However, the drilling of the micro holes still has the following problems: the manufacturing of the drill bit becomes more and more difficult due to the small diameter of the drill bit. Moreover, due to the reduction of the diameter of the drill bit, the rigidity and strength thereof are remarkably lowered, and it is easy to break under the action of cutting force or machine vibration, especially when machining deep holes, the chips are difficult to discharge, thereby causing damage to the drill bit. At the same time, due to the difficulty in heat dissipation in the processing area, the temperature of the drill bit is high and the service life is low. In the deep hole drilling, in order to obtain a certain cutting speed, a high rotation speed is required, and the general requirement is above 10 000 r/min, and The spindle's rotation error is required to be small. More difficult to process harder materials

Organization of the Text

2. Linear Stability Analysis

2.1. Research Status of Chatter Generation Mechanism

Chatter can be divided into three categories according to the reasons of its excitation: regenerative chatter theory, coupled chatter theory, friction chatter theory, especially the regenerative chatter theory is the most common in actual production. The regenerative chatter theory first proposed by RS Hahn believes that the cutting force will cause fluctuations in the cutting force when the tool is cut to the previous time, and the change of the cutting force is affected by the phase difference between the two cutting lines. The influence of the cutting force will input energy to the vibration system within a certain range of phase difference. If the vibration response of a certain mode of the vibration system can maintain this phenomenon, regenerative chatter will occur. Using the theory of regenerative chatter, Sun Shenzhen and other large-scale thin-walled parts systems with time-varying mass and stiffness are the research objects. The dynamic characteristics of the system are analyzed for different residual wall thicknesses. State parameters, frequency response function) and it’s changing laws. Starting from the analysis of the stability of the regenerative cutting chatter system, Wang Xiao Jun analyzed the main factors affecting the stability of the cutting system of the machine tool, and proposed the prediction method of the limit cutting width and the unstable cutting speed section of the turning machining system. The coupled chatter theory refers to chatter caused by the close proximity (ie, coupling) of two natural modes due to the similar stiffness of the vibrating system in two directions. Yu Joni et al. studied the influence of the stiffness orientation of the lathe spindle on the cutting stability by using the coupled chatter model. The friction type chatter mechanism reveals the negative friction phenomenon in which the cutting force existing in a certain speed range decreases with the increase of the cutting speed. In the tool vibration phase, the relative speed of the chip relative to the tool is always greater than the relative speed of the vibration phase. Therefore, the force in the vibration phase is always greater than the force in the vibration phase, so there is continuous chattering. Produce. Wang Liang et al. used the friction chatter theory to establish a multi-degree-of-freedom theoretical model based on the nonlinear dynamic cutting force coupling between the tool holder elastic subsystem and the work piece elastic subsystem, and revealed the mechanism of internal resonance in the system.

2.2. Stability Lobes

Micro-drilling is the process of producing holes less than 50 μm in diameter with a micro-tool. Micro-drilling is the process of producing holes less than 50 μm in diameter with a micro-tool Micro-drilling is the process of producing holes less than 50 μm in diameter with a micro-tool. When micro-drilling is taken in Deeping rotary drilling of the rock, in micro-drilling of the rock, the cutting width of the material being processed is reduced, when the depth of cut is reduced to micrometers, the size effect of cutting should be taken into account.in micro drilling process, the minimum cutting thickness is caused by the radius of the cutting edge of the tool, and the minimum cutting thickness is proportional to the radius of the blunt edge of the cutting Different from conventional Deeping rotary drilling process, micro drilling can machine holes with a diameter of less than 1mm on the rock to meet the special requirements for resource extraction. When the micro-drilling is used in the Deeping rotary drilling system, the Cutting depth of rock decreases, when the depth of cut reaches micro-nan scale, the size effect of cutting will appear. In the progress of micro-drilling The minimum cutting thickness is caused by the blunt radius of the cutting edge of the tool, and the minimum cutting thickness is proportional to the radius of the blunt edge of the cutting edge, in the process of micro- drilling, the cutting width and tool radius are in an order of magnitude. The spindle speed during high-speed drilling is usually 10000 r/min or more. According to the principle of metal cutting, the rate of change of drilling force with drilling speed is much smaller than the rate of change with feed rate. In the case where the feed rate remains constant, increasing the drilling speed may significantly reduce the drilling torque and axial Feed force to reduce the cutting load of micro drills and reduce the chance of broken drills. Modeling vibration stability in micro-drilling, drilling parameters, drilling machines, tools and work piece parameters all affect the machining stability, in this section, the influence of the axial viscous damping coefficient on the drilling stability is analyzed.

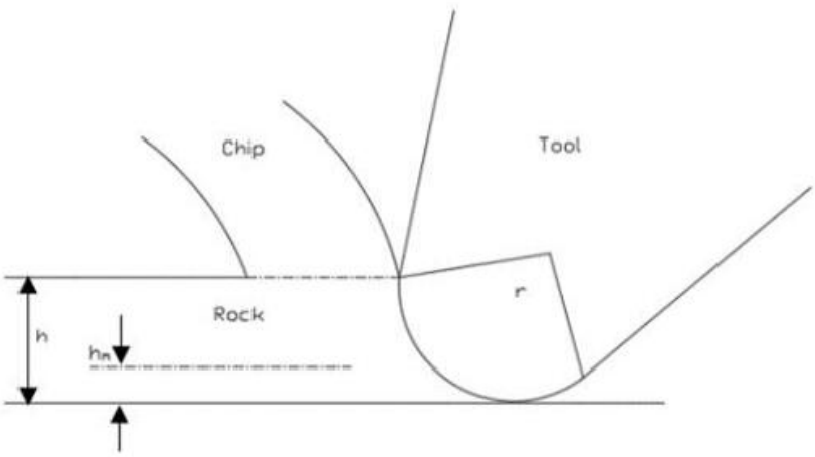

Fig 1. Schematics of micro-drilling process

Fig 2. Dynamic model of drill bit

In the micro drilling process, micro vibration is studied, Micro amplitude can be expressed as:

$$y(t)=A\sin wt$$

Where A is the amplitude

$$y(t-t_n)=A\sin(wt-wt_n)$$
$$=A\sin wt\cos w\,t_n - A\sin w\,t_n\cos w\,t$$
$$=y(t)\ \cos wt_n - \frac{\sin wt_n}{w}\ \dot{y}(t)$$

t_n Is the time taken by the micro-drill-bit to rotate by an angle of 2π/n, Set the initial condition $y(t)$, $\dot{y}(t)$ is 0, performing Laplace transform of the equations of motion where s=σ+iw.Derived from the principle of control engineering, the stability of the vibration system depends on the nature of the characteristic equation s, s=iwi. The stability of the micro drill machining system and the value range of the real part σ of the root s obtained by the characteristic equation have the following relationship. When σ is greater than 0, the system is in an unstable state. When d is less than 0, the system is in a stable state. When d is equal to 0, the system is in a critical state of stability and instability. Set σ to 0 and bring s=is into the characteristic equation, taking the experimental data and the parameters of the tools into the characteristic equation, the stability lobes of the progress of the micro-drilling of the rock is presented Fig.6 shows stable lobes with axial viscous damping coefficients of 0.3, 0.4, and 0.5.

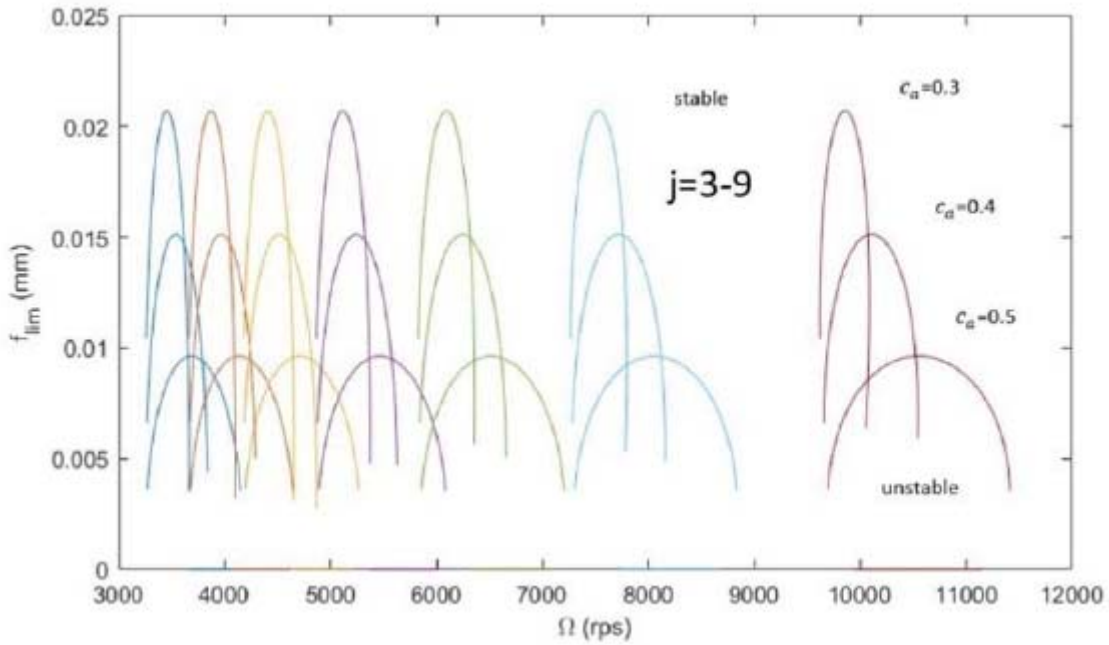

Fig 3. Comparision of chatter stability libes due to the changes of the axial viscous coeffcient in drilling

3. Conclusion

In this paper, We have established a two-degree-of-freedom drilling model(axial and torsional) ,presenting modal analysis of non-rotating parts of the rotary drilling , This paper focuses on the prediction of drilling and micro-drilling stability using the method available in the earlier literature We have established stability lobes for micro drilling , presented a detailed analysis of the Deeping rotary drilling system, the influence of changing the axial damping coefficient on the critical rotating speed during drilling is analyzed in micro drilling. Overall we have studied fairly rich matching dynamics for Deeping rotary drilling system. In this study, the axial viscous progress damping between the drilling tools and the material is obtained. This rubbing mechanism tends to dampen the vibration and it plays an important role in the stability of the tools. And also, another parameter play a significant role in damping vibration is the chisel edge, but in the present study, the piloted holes were used and the impact of the chisel

edge was excluded. Therefore, the parameters of this paper will have great research value in the future.

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