（様式２）

学位論文の概要及び要旨

氏　　名　LU LIN　印

題　　目 Study on High Precision Ball End Milling (Development of Avoiding System of Chatter Vibration and High Precision Machining of Cylindrical Surface)
（高精度ボールエンドミル加工に関する研究（びびり振動回避システムの開発と円筒面の高精度加工について））

学位論文の概要及び要旨

Ball end milling is often used to manufacture precise machined parts with complicated shapes. In recent years, due to the advances in machine tool, ball end milling is becoming more and more important and necessary in key industries, such as dies, molds, automotive and aerospace component manufacturing. Therefore, the demands for high manufacturing productivity and high accuracy of parts are increasing. Due to the relatively low stiffness of ball end mill, the surface integrity in ball end milling is most affected by the chatter vibration and tool deflection, which are usually undesirable because they will lead to chipping or rapid wear of cutting tool, damage of machine tool bearings, dimensional inaccuracies and poor surface finish of machined parts. In order to achieve the specified part accuracy, it is essential to build up an avoiding system of chatter vibration, and to develop a model for the prediction of cutting forces and machining error in ball end milling.

In this thesis, firstly, an avoiding system of chatter vibration in ball end milling is developed. Secondly, an analysis model is also developed for the prediction of cutting forces and machining error in ball end milling of curved surface. The summary of this study is concluded as follows.

1. Development of avoiding system of chatter vibration

An automatic avoiding system of chatter vibration in ball end milling of square and wedge-shaped plates is developed. Furthermore, in order to clarify the validity of this proposed system, the experiments of chatter vibration avoidance are carried out at various cutting conditions.

The results show that chatter can be avoided well by changing cutting conditions, such as spindle speed, feed rate or radial depth of cut. It is also seen that better surface roughness can be obtained by using this avoiding system of chatter vibration compared with that without the

avoiding system.

Thus, the validity of the avoiding system of chatter vibration is demonstrated by the experiment results.

2. Analysis of cutting forces and machining error in ball end milling of cylindrical surface

An analysis model for the prediction of machining error in ball end milling of cylindrical surface at arbitrary tool-feed directions is developed. The instantaneous cutting forces are calculated based on the undeformed chip geometry and the properties of tool and workpiece. The machining errors across the machined surface are evaluated based on the instantaneous tool deflections. The influences of milling position angle, tool-feed direction angle and the various cutting modes on machining error are discussed with the results of the theoretical and experimental analyses. The model is verified in ball end milling of mild steel.

It is seen that the machining error in all cutting modes generally decreases with the increase in milling position angle.

It is further seen that the largest machining error may occur at different part of the machined surface depending on the tool-feed direction angle. When the tool-feed direction angle is 0°, in Left cross-feed, high accuracy can be achieved in Upward cut mode, while in Right cross-feed, high accuracy is achieved in Downward cut mode. When the tool-feed direction angle is in the range from 30° to 60°, the converse is true. It can also be seen that the machining error of concave surface is larger than that of a convex surface.

The calculated and the experimental results are in a good agreement qualitatively. Therefore, the suitability of the model is demonstrated.