Development of an Intelligent Machining System for Detecting and Suppressing Milling Chatter


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1. Overview

In the manufacturing industry faced with fierce price competition and demands for even higher product quality, further improvements in machining efficiency is a major issue. Although technological advances have enabled highly efficient machining, conventional machining conditions are still applied to some products. The reason is that vibration occurs easily in such efficient machining conditions. When chatter occurs, it may damage tools or workpiece surface; therefore operators must take time to find better machining conditions.

But it is difficult to identify the kind of chatter and to take appropriate measures. We have developed an intelligent machining system (IMS) to obtain the optimum machining conditions quickly and easily under such circumstances.

2. Technical Feature

Fig. 1 shows the schematic of our intelligent machining system. The acceleration sensor is mounted on the spindle unit so as to detect chatter vibrations, and then the system calculates the optimum spindle speed to reduce the chatter and changes the spindle speed automatically. The results of this adjustment are recorded in the CNC unit as tool information.

At the next spindle speed command in the NC part program, it will be possible to automatically make the change with the recorded, chatter-free spindle speed.

Self-exited chatter is a type of the chatter vibration, which has stable/unstable regions like the stability limit diagram shown in Fig. 2.

As self-exited chatter appears to change with different spindle speeds in stable and unstable regions alternately, it is possible to get highly efficient machining performance by choosing optimum spindle speeds in the stable region. This stability limit diagram can also be calculated with impulse excitation test results, which must be measured by experts with expensive instruments. However IMS takes advantage of the actual machining conditions; thus the results are more accurate and it is not necessary to conduct conventional vibration tests.

Here is an example of IMS applied to pocket milling (mold base) with the cutting conditions shown in Table 1. Spindle speed was automatically changed from 4,900min^{-1} to 5,270min^{-1}, the optimum chatter-free spindle speed, to produce the fine surface roughness as shown in Fig. 3.

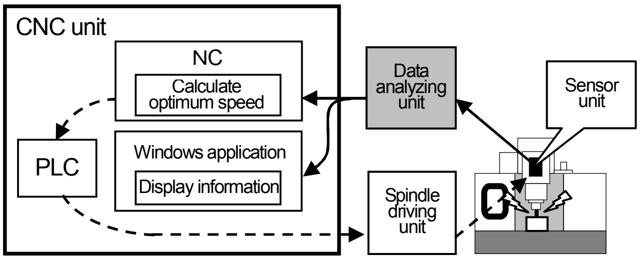

Fig.1 Schematic of intelligent machining system

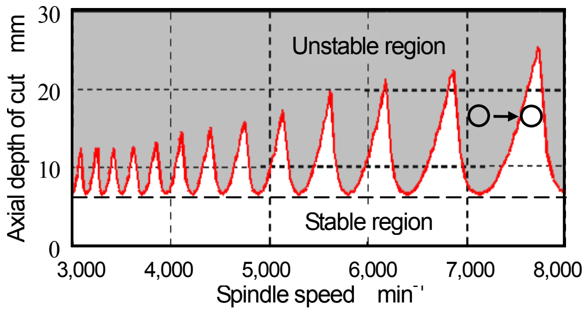

Fig.1 Stability limit diagram

Table 1 Result from intelligent machining system

Workpiece material	HPM7
Workpiece size	300 × 200 × 50 mm
Tool dia.	φ16
Axial depth of cut	40 mm
Radial depth of cut	0.05 mm
Spindle speed	4,900 → 5,270 min^{-1}
Feed rate	2,600 → 2,796 mm/min

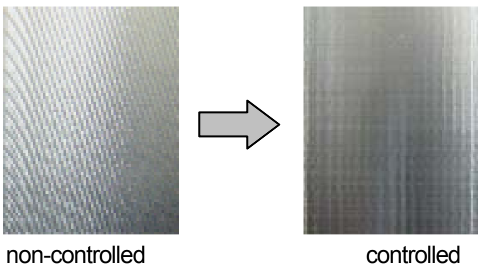

Fig. 3 Improvement of workpiece surface

3. Summary

This newly developed Intelligent Machining System, with over 200 deliveries since its launch in 2009, has contributed to improved customer productivity. We will continue our efforts to raise machine tool performance levels.

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