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Development of automatic regrinding program for PC-based tool grinding machine

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Abstract

The main goal of this development is the PC-based controller setup on the CM2 tool grinding machine. Concerned cutting parameters with know-hows can be transferred to a useful program and then embedded in the PC-based controller. By automatic positioning of probes the automatic procedure can be achieved. An automatic and intelligent PC-based grinding machine for regrinding has been developed in this investigation. With the new machine and automatic procedure, regrinding process will be distinctly simplified. Based on a manual grinding machine CM2, a PC-based controller is integrated in the machine. The know-hows of the regrinding technology have been integrated with a self-developed program. For automatic dimensional inspection a contact probe is utilized as inspection sensor. By the programming and automatic dimensional inspection, the functions of tool regrinding machine have been enhanced greatly.

Keywords: Regrinding; Tool grinding machine; Probe

1. Introduction

A cutting tool would be one of the indispensable and paramount tools in mechanical manufacturing and processing, where the performance and quality of cutting tool would have direct and severe influences on the precision and efficiency of cutting processing, and on the quality of products. In the past, the precision of milling cutter was not satisfied due to reshaping of cutting tools by the traditional tool grinder and grinding at different stages, while the technology of reshaping of milling cutter was derived from the experiences of manufacturers acquired in their numerous trial and error methods. Yet a lack of consistent and common principle for reshaping has delayed the standardization of regrinding operation.

Due to the development of multiple axes CNC tool grinder in recent years, the on-off grinding of milling cutter can be realized. And that would be beneficial to promote the precision of milling cutter. Yet in terms of reshaping, there is still a lack of a set of systematic and efficient computer aided manufacturing software as well as the plan for computer aided cutter grinding programs, which can be used to achieve the intelligence and automation of overall operation.

In this study, we have applied the tool grinder produced by the Top Work Industry Ltd, plus with a PC-based controller to develop a set of computer aided reshaping software of milling cutter and plan the process of reshaping of milling cutter. Meanwhile, the technical know-how of reshaping was converted into a program to be equipped into the PC-based controller. In this way, for five axes tool grinder we

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have integrated and developed a computer aided reshaping system of milling cutter.

2. Construction of the PC-based controller

The PC-Based controller refers to a PC as a control center installed in a manufacturing system or machine, which can utilize its numerical computation to monitor and control ordinary or special industrial machines and then to achieve the partial or full performances of such an industrial system like the controls of positioning processing and manufacturing procedures [1, 2]. Originally, the majority of FA engineers always tended to be highly doubtful about the stability and reliability of PC applied for machine tool. However, along with the fast promotion of performances of PC, their prices and improvement of quality (e.g. their resistances to noise, oscillation and high temperature), these problems have been gradually overcome.

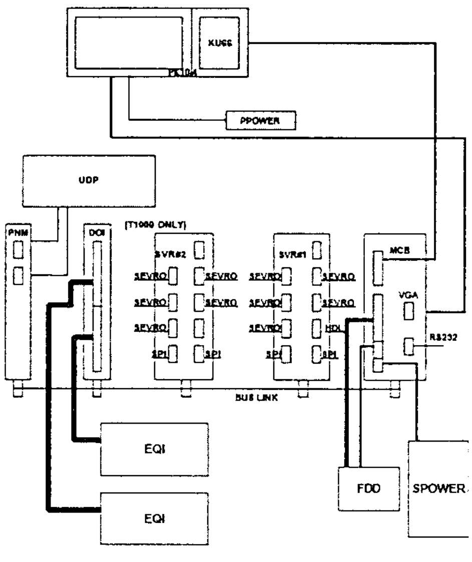

Fig. 1. Construction of the PC-based controller.

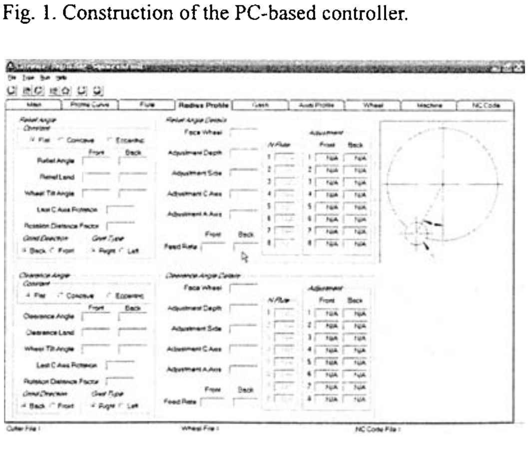

Fig. 2. Structure of regrinding program.

In this study, the INCON-M650 PC-Based controller has been used, while its software and hardware structures are described in Fig. 1. To enhance the operation speed of controller (real-time performances), a dual CPU structure has been adopted in some controllers, where one of these two CPUs is specifically designed to deal with the real-time control and the other is used to integrate such human-machine interface (HMI) functions as operation, data record and monitoring. Currently tendency in the market would be utilization of digital signal processor (DSP) chips, which are used as the processors of real-time controllers. HMI Processors would be mainly the CPUs of PCs such as the Intel and AMD processors.

To integrate the manufacturing-related programs such as controls, HMI and production management, an operation system of high stability, high integration and affluent resources is usually needed to serve as the central control and coordination system. General operation systems for PC-based controllers involve OS/S, QNX, Unix-like and Windows, where approximately, the Windows operation system is now adopted on over 90% of the PC-based controllers because of its high popularity.

3. Reshaping program interface

The developed human-machine interface is divided into two parts: one is the cutter grinding software based on Microsoft Visual Basic 6.0 and the other is the program for the communication interface between cutter grinding software and the PC-based controller, which is compiled by means of Borland C++ Builder 6. Herein, kernel of the cutter grinding program is the geometrical know-how of the cutter, by which the grinding procedure of cutters is designed as an easy-to-operate processing program. The controller communication interface program is a suite of TCP/IP protocol network specifications formulated by way of Windows Socket (WinSock) to connect the interface of users with that of the controller.

The post-CAM processing program is edited by way of Microsoft Visual Basic 6, where the cutter-related geometric relationships are introduced and compiled by the program codes. It can allow the users to set the corresponding processing NC code, namely to start the direct processing, only if they enter the settings on the needed varieties of cutters, sizes of various parts, grinding wheel parameters and machine limits as shown in Fig. 2.

Users can use the structure of reshaping program to enter the conditions step by step according to their own needs. The reshaping software will follow the conditions as set processing NC code by the users. Thus, users can directly use the tool grinder to manufacture the designed cutters.

4. Communication interface of controller

Human-machine interface is connected to the control unit via the networks, where the human-machine interface plays the role of client, and controller acts as the server (Fig. 3). WinSock is a suite of TCP/IP protocol network specifications formulated by Microsoft, Novell and Sun Microsystems on the basis of Berkeley Socket of the UNIX. Application programs developed by such specifications can be connected to all the TCP networks, while WinSock can exist in the form of dynamic link library (DLL). Therefore, application programs can call upon the low order functions via the WinSock.DLL.

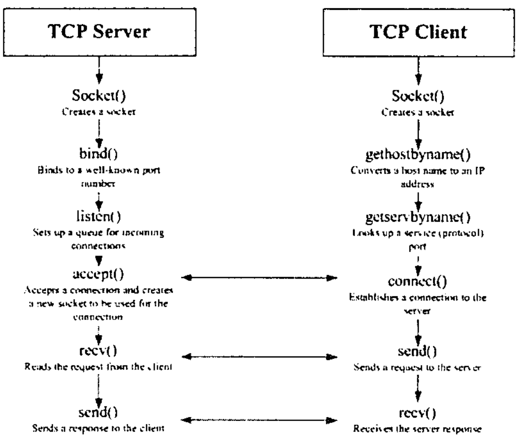

Fig. 3. Communication between server and client.

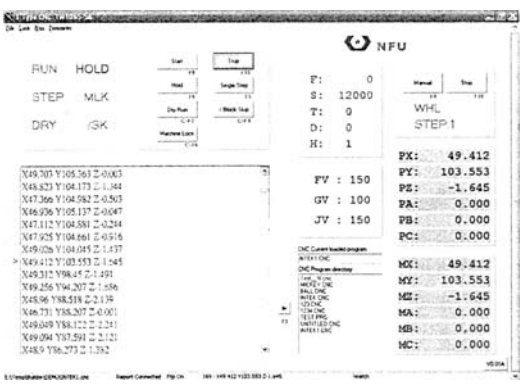

Fig. 4. Communication interface of controller.

A TCP data package includes header information as start address, end address, package sequence number, package information, check digit and flag indicators, and subsequently the transferred data. As Fig. 4 shows, the communication interface is counting on the TCP/IP communication protocol to build a synchronous connection with the controller via the Ethernet, where commands such as start, stop and open a file can be directly given to the controller via the interface software [3]. On the other side, the controller will timely display the current coordinate position, rotary speed and status on the communication interface to fulfill the structure of communication between the dual systems.

5. Simulation and experimental tests

Based on the reshaping program software, the design of a milling cutter with flat relief dual edge is realized and then by the process of reshaping program the NC processing code can be acquired. Furthermore, cutter's profile is simulated by the software VERICUT 5.3 (CGTech) and by the TG-5 five axes tool grinder (Top Work) the actual cutter is manufactured. Meanwhile, by the image measurement system, various dimensions of the actual cutter can be inspected and that should be compared with cutter parameters preset by the reshaping program software.

In the example of a milling cutter with dual edged flat relief, the setup of its profile parameters are shown in Table 1.

Table 1. Theoretical geometrical dimensions.

radial		axial	
Rake angle	7.5°	Gash angle	40°
Core	5mm	Rake angle	5°
relief angle	6°	End angle	1.5°
relief land	0.5mm	relief angle	4°
clearance angle	22°	relief land	0.8mm
diameter	8mm	clearance angle	15°
Helix angle	35°		

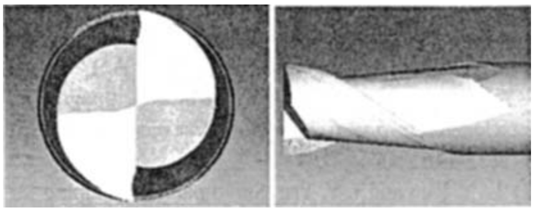

Fig. 5. Simulated profile of milling cutter.

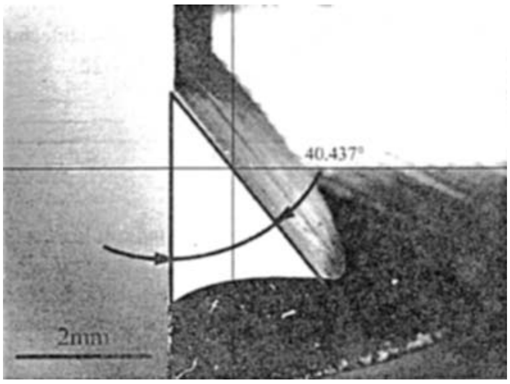

Fig. 6. Measurement of gash angle.

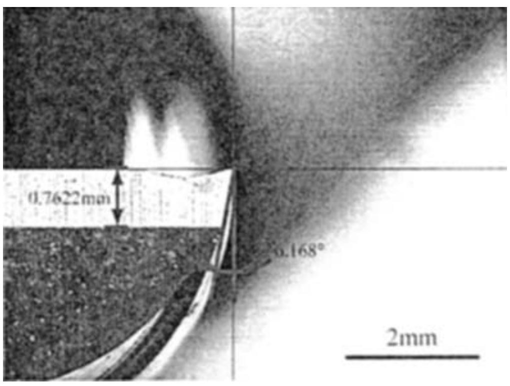

Fig. 7. Measurements of radial relief angle and land width.

By VERICUT 5.3, a tool grinder module to simulate the course of processing can be established. The theoretical profile is shown in Fig. 5.

After manufacturing process, different dimensions of the cutter have been measured by the image measurement system (Figs. 6, 7). A comparison list (Table 2) showed the theoretical and actual dimensions and the differences between them, i.e. errors. With this result, it can be proved that the relative error is less than 5%, that is able to satisfy the requirement of cutter's quality.

Table 2. Error analysis of geometrical parameters.

Parameter		Theoretical dimension	Measurement dimension	error (%)
radial	Rake angle	7.5°	7.667°	2.227
	Core	5mm	4.968mm	-0.64
	Relief angle	6°	6.168°	2.8
	Relief land	0.5mm	0.52mm	4
	Clearance angle	22°	22.288°	1.309
	Diameter	8mm	7.952mm	-0.6
	Helix angle	35°	34.23°	-2.2
axial	Gash angle	40°	40.437°	1.093
	End angle	1.5°	1.501°	0.067
	Relief angle	4°	4.004°	0.1
	Relief land	0.8mm	0.7622mm	-4.725
	Clearance angle	15°	15.566°	3.773

6. Conclusions

By this investigation, the human-machine interface of the easy-to-operate cutter grinding program has been developed. With the introduction of know-how of geometrical relations into the software, a cutter grinding software with the cutter design functions has been realized.

The utilization of dual system structure can separate the human-machine interface and controller into different hardware settings. And then by the Ethernet and the TCP/IP communication protocol, a communication interface can receive the real time monitoring and directly operate the controller.

The used close-style CNC controller can be upgraded by the PC-based controller, so that the maintenance becomes easier, the cost can be reduced and the market competitiveness will be enhanced.

By utilizing of the reshaping program developed in this investigation, the error is less than 5% that cab be verified by image measurements.

Acknowledgments

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