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DIRECT ACCESS OF CNC DATA FOR VIBRATION CONTROL

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Abstract. *This paper discusses the direct access to CNC data in order to control in real time the CNC parameters and avoid the vibration problems. The purpose of the direct data access is to integrate an external system with the CNC controller. This external system must be able to monitor the level of noise and change in real time the parameters of the CNC process in order to avoid excessive vibration.*
Many of the controllers available in the market for CNC machine have a number of functions that are usually not used by the CNC manufacturer. In this sense, this work explores the use of these functions for implementing direct access to CNC data. The direct access is tested in both ways (read and write). The purpose is to map what are the monitoring parameter that can be directly accessed and what are the control parameters that can be changed in real time.

Keywords*: direct access, CNC machine, CNC controller, manufacturing process, numeric control.*

1. INTRODUCTION

The shortest deadline to introduce in market, reduced life cycle and high multiplicity of variants of the industrial products have been pressed the enterprises to search new technological and organizational solutions, in order to maintain competitive. The HSC (High Speed Cutting) arises as a considerable potencial for increasing the quality and productivity of enterprises of important industrial sector, such as: aeronautical, automobilistic and moulds and dies manufacturing, and others (Polli, 2005).

Several aplications have been developed with intention to make data acquisition and remote monitoring of CNC (Computerized Numerical Control) machine. Some aplications face production monitoring, and others monitoring of milling process data.

Example of remote monitoring of production is presented in Ferraz (2002). This monitors the quantity of produced parts, milling cycle time and speed of machine axis. Other aplication is presented in Silva (2008), where the author proposes and aplies a method to develop software of production monitoring.

Example of remote monitoring of milling process is presented in Del Conte and Schutzer (2007). This work aims to determine optimum strategy to data acquisition from CNC machine. Similar method is presented in Souza (2001), that makes an internal data processing, obtaining higher precision and sample rate.

Instead of remote monitoring, few aplications have been developed about remote control in CNC machine. This data way is required in some aplications, such as in vibration control in CNC machine. According Polli (2005) and Cabral (2007), the vibration control, also called chatter control, aims to remove the vibration during milling process. It brings reduced time in milling, better surface finishing and longer tool life.

In the context, the purpose of this paper is to present the data what can be remotely changed in a CNC machine, towards to vibration control, and test a solution that makes remotely speed selection of spindle of CNC machine.

The paper is organized as follow. Section 2 describes the vibration control in milling process. Section 3 desribes the CNC tool-machine used in this work. Section 4 presents the research about direct access of CNC data. Secction 5 shows the results of work. Finally, Section 6 presents some conclusions and discusses about work.

2. VIBRATION CONTROL IN MILLING PROCESS

In order to perform the vibration control it is necessary to understand how and where it occured in process.

2.1. High Speed Machining

Milling is a cutting process in which the removal of material of the part is made in intermittent mode by tool rotary moviment, generally multi-cutting, denominated mill. The part moves with advance speed among mill. A process characteristic is that each edge cut of mill removes material portion of part in form of small chips. It is widely process applied in the aeronautical, automobilistic and moulds and dies manufacturing (POLLI, 2005).

High Speed Machining (HSM) or High Speed Cutting (HSC) can be defined considering reached cut speed, it suggests to work in cut speed significantly higher than typical had been worked in a specific material.

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2.2. Machining Vibration

Machining of the materials is invariably followed by vibrations between part and tool, however, due to intermittent character of machining process. The tolerable maximum vibration level, that is, the maximum vibration amplitude in a machining process depends on your aplication. In roughing stage, what determine the tolerable vibration is mainly the effect that vibration exerts on tool. In finishing stage, superficial quality and dimensional precision are parameters that determine the maximum vibration level (ALTINTAS, 2000).

The appearance of vibration durring process is a function of chip thickness variation that occurs due to tool or part vibration, or both. This form, vibrations can have origin in different sources:

- external vibrations to machine-tool;
- vibrations caused by machine-tool;
- vibrations caused by interrupted cut;
- vibrations due to lack of part homogeneousness;
- regenerative vibrations (chatter vibrations).

Some strategies can be used to aviod vibration during the milling process:

- Special tools;
- Process Planning using stabiliy letter;
- Cyclic variation of cutting speed;
- Vibration detect and control during the process

2.3. Stability of milling process

To verify the stability of milling process in HSC, frequently have been used stability letters (SCHMITZ, 2006). Figure 1 shows a stability letter.

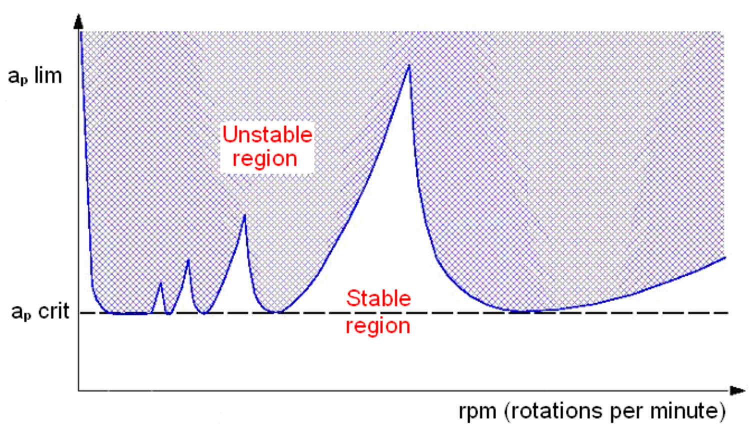

Figure 1 – Stability Letter

In these letters, both regions, stable and unstable, show to be dependants of selected machining rotarion and depth. This diagram can be analytical calculated or using techniques in time dominion (BAYLY et al, 2002). In any situation, it is required knowledge of machine dunamics. In many cases, system dynamics can be obtained by impact test, ou modal analysis. The frequency response function (FRF) is mesured in tool end and nultiple modes adhere to results. Other possibility is realization of milling assays to direct selection of stable speeds, where tool rotarion is altered for various ap values.

The stability letter allows the user to select the preferential rotations and to avoid unstabilities. For roughing operations, where tool presents high radial cut depths, the user must select rotation values defined by peaks of stability letter, that means to excite the system with vibration modes more flexible. For finishing operations, where tool presents low radial cut depths, the user must select rotaion values defined by valleys of stability letter, that means to excite the systema with vibration modes less flexible.

Then, the cutting parameters of milling process that influence the process stability, are:

- axial cutting depth;
- radial cutting depth;
- cutting speed;
- tool advance;
- number of tool teeth.

2.4. Vibration control

To control the vibration during milling process, the user had to collect many data from it. Starting with the impact test, when the user needs a frequency response hammer and an acceleromether. The output this is FRF (Frequency Response Function) in form by chart. The FRF shows which frequencies are more flexible to system.

After obtain the FRF, the user note how many cutting edges the tool has in it body, and starts the exhaustive tests to obtain the limts of ap for each rotation value. A spindle speed and ap are selected and this last is increased up to system of sound pressure acquisition inform what the sound level is to high. This ap is taked as higher value before vibration. And the user repeats this process for each spindle speed, until to conclude the stability letter.

The whole vibration control process is showed in form of blocks diagram in Fig. 2.

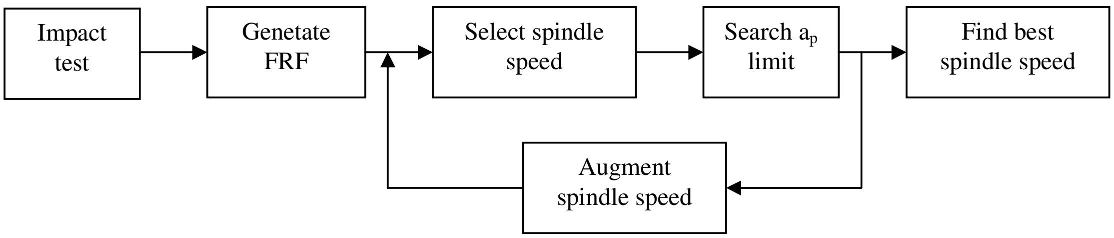

Figure 2. Blocks Diagram to obtain best spindle speed

After this process, the user inform to programmer of CNC machine the best spindle speed for specifc tool and machine.

It would be a ideal situation if had a automatic process to obtain the best spindle speed to milling a part. And it lead this work.

3. CNC TOOL-MACHINE

The CNC tool-machine of this work manufactured by Hermle and model C600U, is placed in laboratory CCM (Center of Competence of Manufacturing) do ITA (Aeronautics Institute of Technology). This machine work with HSM (High Speed Machining) technology.

The Hermle machine has five movement axes (X, Y, Z, A e C). The machine and movement axés are showed in Fig. 3.

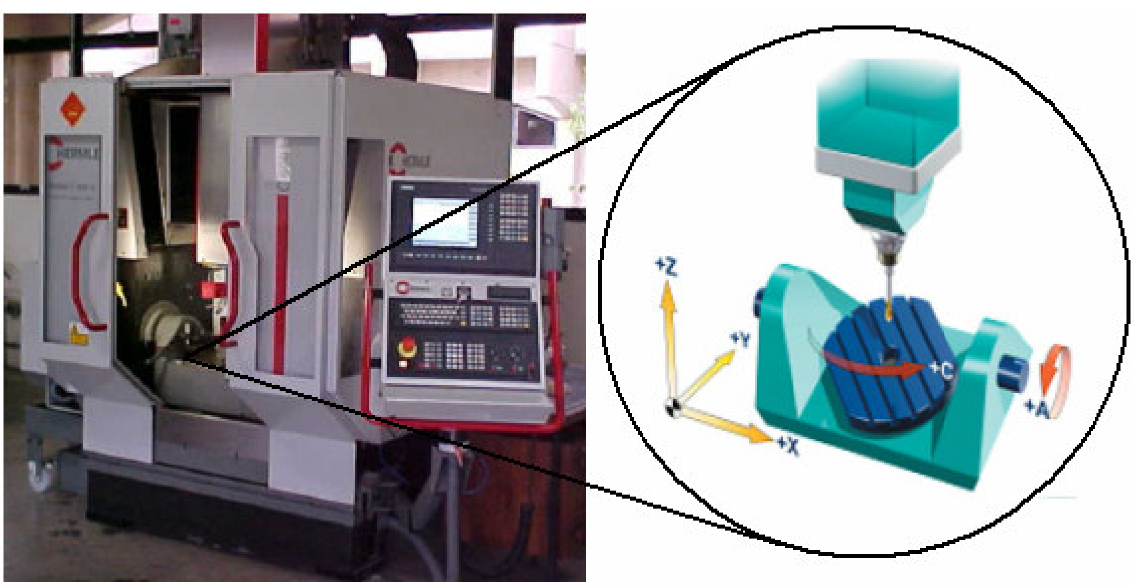

Figure 3. CNC tool-machine Hermle and movement axes.

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To control the axes motion, the tool-machine uses a CNC controller made by Siemens, model Sinumerik 840D. This system has besides high capacity of information processing, it has a mixed architecture, that integrates a CNC (Computerized Numerical Controller) to a PLC (Programmable Logic Controller) of Simatic S7-300 family.

The Hermle machine uses a serial communication protocol, the MPI (Multiple Protocol Interface, a simple version of Profibus) to connect in a single network the processing components, such as the HMI (Human-Machine Interface), the PLC (Programmable Logic Controller), control panel and others (SIEMENS, 2006).

4. RESEARCH ABOUT DIRECT ACCESS OF CNC DATA

The focus of this paper is vibration control, and it must guide all over the research of direct access of CNC data.

As showed in section 2, in order to control the vibration in CNC machine, it is possible to guarantee the stability process with correct selection of spindle speed. And to make it an automatic process, it is necessary to research how to input a comand to CNC machine, from external side, to select some spindle speed.

Silva (2008) showed a form to make data acquition from CNC machine using DDE variables. This aplication used the same CNC controller of Hermle machine. Then, following the same form to acquire data from CNC controller, this reaserch will try to make the same way for send controls to CNC controller. Figure 4 shows the system architecture that will be used as programming tool for sending data to CNC controller.

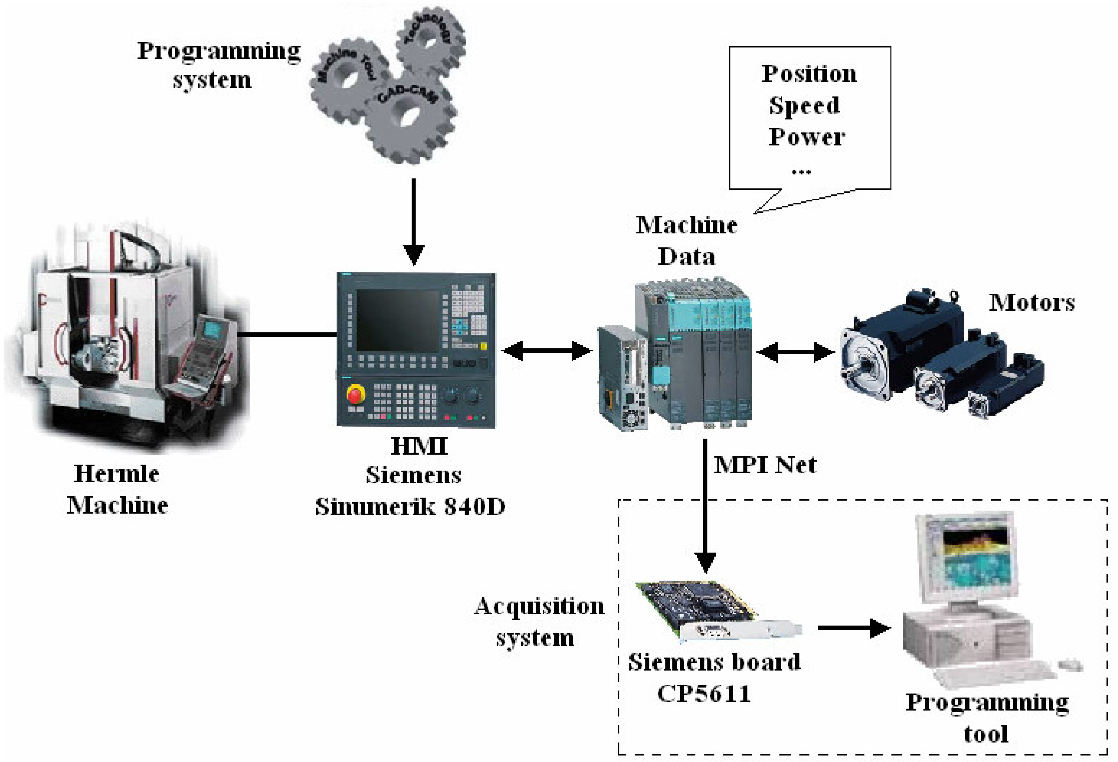

Figure 4 – System architecture

The system architecture is composed by: Hermle CNC machine, Siemens PCI board CP 5611 and a PC (Personal Computer). In this case, the acquisition system will be used as interface system to connect both side in bi-directional way.

The programming tool can use the NC (Numerical Control) variables as DDE (Dynamic Data Exchage) variables. It is possible due Siemens converter offered together CP 5611 board. The converter called NCDDE Server converts NC variables in DDE variables, and vice-versa. Figure 5 shows the way from CNC machine to programming tool.

When CNC controller receives a command to start spindle, internally the controller create a desired spindle speed command and control the actual spindle speed variable. In tests, it was discovered that, the desired spindle speed command created by CNC controller cannot be changed before neither after this one. It is a command for restrict use of CNC controller (SIEMENS, 1997). And from this way, it is not possible to change the spindle speed.

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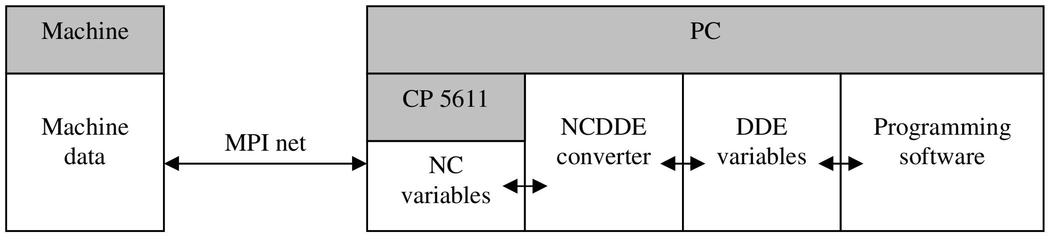

Figure 5 – Data exchanging between machine and programing software

DDE variables:
"/Channel/Spindle/cmdSpeed[1]", only read;
"/Channel/Spindle/actSpeed[1]", only read.

According Silva (2008), the PLC variables and R parameters from Siemens CNC controller can be changed from outside of controller. Then, another way was tested, but this one needs an advanced command of CNC programming.

The main idea is to use a R parameter to select the spindle speed before to start the CNC program. It can be done by inserting one programming line in the CNC program. AT point of CNC program, the programmer must set the spindle speed before to start the milling process. In this way, this line must be changed as following:

"M3 S5000", start the spindle speed with 5000 rpm;
"M3 S=R10", start the spindle speed with rpm recorded in R10 parameter.

In any way, if the R10 parameter was not recorded before the start CNC program, the CNC controller will use the last recorded value. And it does not cause any problem to CNC controller, only can set an wrong spindle speed to process, depending of selected tool.

DDE variables:
"/Channel/Parameter/R[10]", R10 parameter;
"/Plc/Input/Bit[2.1]", set start CNC program;
"/Plc/Input/Bit[3.7]" set stop CNC program.

Then, this form the user (or some software) can select the correct spindle speed before the start CNC program, besides starts and stop CNC program, all it remotely.

If someone success to develop some software to obtain e calculate the optimum spindle speed, it can access CNC data from the same way of this work. And it is a desired solution by many enterprises.

5. RESULTS

After to change the CNC programming line as suggered, it was developed an application in Visual Basic 6 software, due facility to handle DDE variables in this environment.

In this application was inserted a command to select spindle speed, a function to monitoring spindle speed, a command to start CNC program and a command to stop the CNC program.

For run the developed application, previously it was run the NCDDE server (Siemens software).

The application is showed in Fig. 6, and it was called Spindle Control Software. The example shows a situation when it was selected the spindle speed 1000 rpm and give the start CNC program start.

As result, the machine spindle recept the command, and it started to rotate. It show that the application made, can be used to spindle control of any Siemens CNC machine.

6. CONCLUSIONS

This paper presents and discuss an effort to make an automatic vibration control of CNC machine. It also shows that mapping the CNC data which can be changed from outside of CNC controller, only apper the PLC data (input, output, flag data, data block, timer, counter, clock ans alarm mensages) and R parameter, and do not appear spindle speed data directly.

We can conclude through this paper that, if someone success to develop some software to obtain e calculate the optimum spindle speed, it is possible to access CNC data and to make the vibration control of CNC machine. And it is a desired solution by many enterprises.

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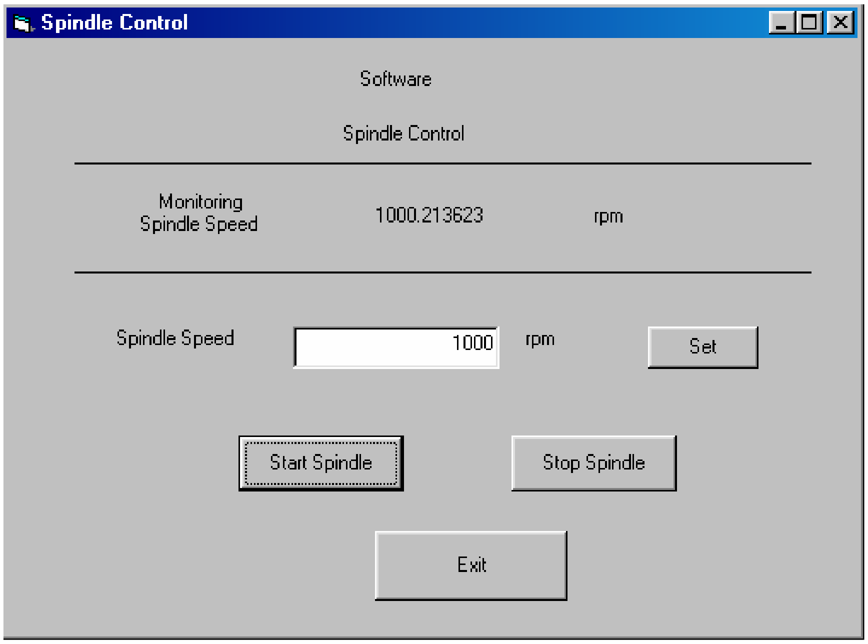

Figure 6 – Spindle Control

7. ACKNOWLEDGEMENTS

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