CNC 工具機的新挑戰

New Challenges of CNC Machine Tools

Julio Zurbitu
Fagor Automation Marketing Manager

摘要：自動化數值控制器已廣泛應用於工具機領域數十年，然而隨著工業 4.0 革命來臨，自動化數值控制器的挑戰時刻也隨之到來。
今日的數值控制器已可取得大量過去未曾取得的訊息。雖然工具機製造商不斷增加機台上的感測器，但是單純整合感測器本身，並不會增加機台與製程的附加價值。因為有了自動化數值控制器的協助，所有的新信息才可用於提高加工過程的質量和效率。除此之外，工業 4.0 革命已為開發 CNC 整合服務應用的第三方公司開闢大門。
在本文中，我們將解釋在 Fagor Automation 中所做的一些發展，以及第三方在實施 CNC 先進發展的所有可能性，克服等待著我們的新挑戰。

Abstract：CNC controllers have been used in machine tools for decades, but it is now, due to the industry 4.0 revolution, that CNC controllers are facing new challenging times.
Numerical controls today have access to a quantity of information never seen before. Machine tool manufacturers are increasingly installing numerous sensors into machines, but the integration of sensors by itself does not add any value to either the machine or the process. It is thanks to CNC that all this new information is available to improve the quality and efficiency of machining processes.
In addition, the 4.0 revolution has opened the door to the development of services developed by third companies that can be integrated into numerical controls.
In this article, we explain some of our developments at Fagor Automation, as well as the possibilities for third parties to implement advanced developments in our CNCs and to overcome the new challenges that await us.

關鍵詞：工具機機電整合模型、結構變型量、最佳化控制策略
Keywords：Mechatronic Model of Machine Tools, Structural Deformations, Optimum Control Strategy

The industry 4.0 revolution has emerged from the need to increase the precision, productivity and efficiency of machines in order to be more competitive in a globalized market. Two ways to achieve this goal have been the integration of additional sensors into machines and the advanced use of existing information.

That is why this revolution focuses on the acquisition, treatment and use of all accessible information from the productive processes that need to be optimized.

Historically, in a numerical control machine, the most common sensors were current and position sensors in the motors for controlling the movement of the axes, an external measurement system for increasing the precision of the parts and pressure and temperature sensors for controlling the auxiliary systems of the machine.

So far, each of these sensors has been used exclusively for its main function: i.e., if a motor had a current sensor, this information was used exclusively to close the driver's current loops. This concept of purely local information use has changed. In order to improve productivity and efficiency, all available information has to be shared between the different systems that integrate the machine tool. In this way, a control system with a global vision of the productive process can improve the process as a whole. Additionally, thanks to the reduction of costs and the miniaturization of sensors, the most advanced machine tools integrate more and more extra sensors, such as accelerometers, temperature sensors, force and many more.

So, numerical controls today have access to a quantity of information never seen before, but the integration of these sensors by itself does not add any value to either the machine or the process.

In order to take advantage of all available information, it is necessary to process information, analyze it and interact with the process in real time. This treatment of information implies that it is necessary to synchronize the reading of the different integrated sensors in the machine, to treat all the data in a global way and to act on the system in a few milliseconds. Here is where the role of CNC becomes important, because it will be the core of the process, due to its privileged access to all the information in real time, its ability to interact with the physical components of the machine and the possibility to integrate custom algorithms.

In order to fulfil all these requirements, the design of the various components of the system must be optimized so that they work together. That is why Fagor Automation offers a complete solution, from motors, heads, drivers, rules and encoders to numerical controls; only thus is it possible to reach the highest levels of precision and productivity.

However, not only is it necessary to centralize all the information from the sensors, to treat that information in real time and to interact with the system. It is equally important to know the mechanical behavior of the machine in order to optimize it. In recent years, there has been a great advance in the design of the various structural components of machines and it is possible to have models of their behavior in the digital design phase of a machine. If the electronics model is added to the mechanical model, we obtain a mechatronics model of the machine that will allow us to improve the accuracy of the parts produced.

To facilitate this process of mechatronic modeling of the machine, Fagor Automation's numerical controls integrate tools for frequency analysis. With these tools, the excitation of the machine is achieved using the drivers and the measurements with the position sensors integrated. With this information, it is possible to extract a mechatronic model of each axis and in this way to implement advanced algorithms.

With the mechatronic model of the machine and the information of the sensors integrated, it is possible to develop an optimum control strategy to minimize the losses of precision and quality of the pieces and thus to optimize productivity. As for the development of advanced control algorithms, a thorough knowledge of both the machine and the part to be manufactured is necessary. Usually, the machine manufacturer is the one that develops these algorithms and integrates them into the numerical control in order to provide a competitive advantage for their own machines.

Fagor Automation offers tools and support so that manufacturers can develop these algorithms in a simple and efficient way, allowing the manufacturer to protect the know-how that differentiates them from other manufacturers.

The numerical controls need to be programmed in high level languages so that third party users will find it straightforward. That is why C code is supported for programing, allowing the manufacturer of the machine to develop its control strategy in an external system, such as Matlab or Simulink, and once validated, to automatically generate the C code from Matlab or Simulink and integrate it into the numerical control in a natural way.

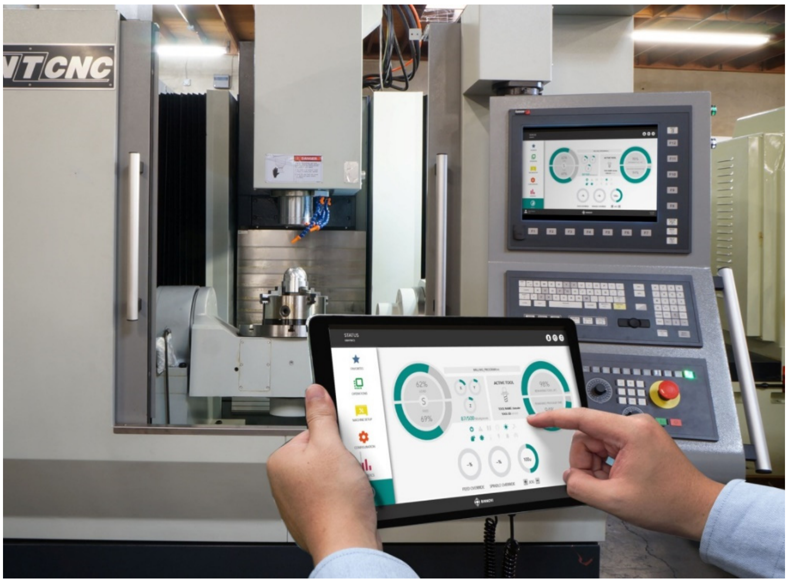

Fig 1. The common application of real-time feedback

Some of the most common cases in which real-time feedback is used to improve the productivity of machines are shown below (**Fig. 1**).

In machines with high dynamics where high accelerations are reached, the deformation due to less rigid components can be large. The conventional solution in this case is to reduce the acceleration of the machine in order to produce parts with the required precision.

The solution to this problem, following an industry 4.0 approach, may be to model the machine using the frequency analysis tools that have been integrated into the numerical control, to measure the acceleration of the machine by using accelerometers, to calculate the machine deformation due to that acceleration and to compensate for it in real time, using algorithms in C code that have been integrated into the synchronous PLC. In this way, it is possible to meet the precision requirements without reducing productivity.

Another common example is structural deformation due to temperature. In this case, temperature sensors are integrated into the critical areas of the machine. Three-dimensional measurements of the deformations are made as a function of temperature and these deformations are compensated for in real time.

Historically, at Fagor Automation, we have always opted for an open numerical control architecture that allows manufacturers to have total control over the machines they produce. With the advent of the industry 4.0 revolution, this open architecture has proven to be a fundamental element for meeting the new demands of quality, precision and productivity, allowing manufacturers to model their machines, develop advanced algorithms in tools such as Matlab and Simulink and integrate these real-time algorithms in a simple way into the controls.

■