All the information in the article are preparatory to place the Smart Controller on the market by the end of this year, perhaps in conjunction with the 2016 edition of the important BIMU Milan Exhibition

THE INSTALLATION OF THE SMART CONTROLLER DEVICE, DESIGNED BY MANDELLI, ON ITS MACHINING CENTERS, ALLOWS ITS CUSTOMERS TO DRASTICALLY REDUCE HARMFUL VIBRATIONS GENERATED BY THE USE OF PARTICULARLY STRICT CUTTING PARAMETERS, THUS GUARANTEEING THE OPTIMIZATION OF THE PRODUCTION CYCLE.

[SMART CONTROLLER]

by Flavio della Muzia and Ezio Zibetti

Intelligent Technology

High productivity in a machine tool means finishing the work-piece in a short time through the adoption of appropriate cutting parameters to ensure a stable and reliable process. However, this is not always possible because of the vibrations caused by the chip removal operations which, according to the type of material, generate harmonic frequencies that can lead to either the machine tool components damage or, at best, to a poor quality surface. Today, thanks to the technical expertise and know-how of the engineers working for Mandelli (a company engaged for more than eighty years in the production of machining centers and industry automation), the HMC's performances can be increased by installing the innovative *Smart Controller* inside the control cabinet and on the machine. Born in response to the need for vibration reduction, in stock removal machining operations with particularly strict cutting parameters, the system directly intervenes on the process instability which appears under the form of increasing vibrations that can damage certain HMC parts such as the tool or the spindle bearings. With the adoption of the Smart Controller, the operator is no longer forced to limit the cutting parameters and depth thus achieving high quality mechanical processing in a framework of general recovery of the productivity level. «The Smart Controller is identified, within our *Industry 4.0* strategy, among the so-called intelligent systems able to act automatically, through a self-diagnosis process, when it becomes unstable- said Stefano Musletti from Mandelli Sistemi SpA. It consists of a calculation and data processing unit accompanied by a series of sensors such as the accelerometer installed on the spindle and the hydrophone, positioned within the HMC working area, which allow us to read a wide spectrum of frequencies thus covering the whole field of stock removal mechanical machining». The low and medium regimes typical of titanium and steel are analysed through the accelerometer while the high frequencies, which are triggered off in aluminium cutting, are intercepted by the hydrophone. With this important information we can thus apply the *sensor fusion*, i.e. the mixing of data from two sensors by the control unit located inside the electrical panel which can figure out what's going on in the system by adopting vibration reduction strategies where necessary. Besides reading the signals coming from the two sensors, the unit acquires from the NC even those signals that identify its functioning (such as the current used by the axes, the two spindles or the operating parameters) to estimate the cutting forces that act on the tool and obtain a complete real time monitoring of the system status. At this point, if necessary, the Smart Controller acts in terms of the chattering suppression (name by which the phenomenon that induces harmful and increasing vibration frequencies is identified) implementing independently the most suitable strategy between the *spindle speed variation* and the *spindle speed tuning*. The former is based on the spindle rotation speed variation that is the cutting speed, modulating it according to a sinusoidal law: the system automatically sets the amplitude and the frequency of the

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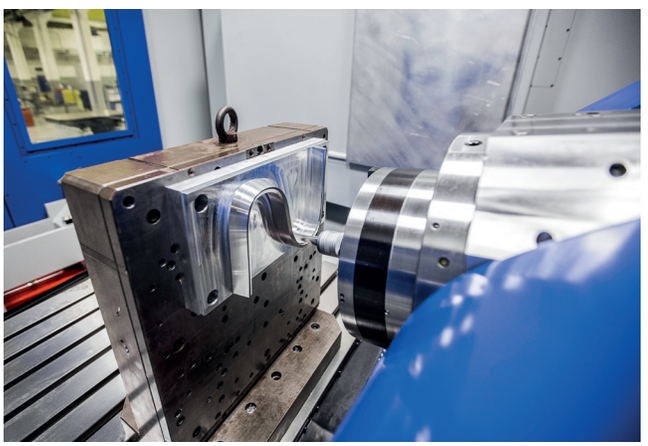
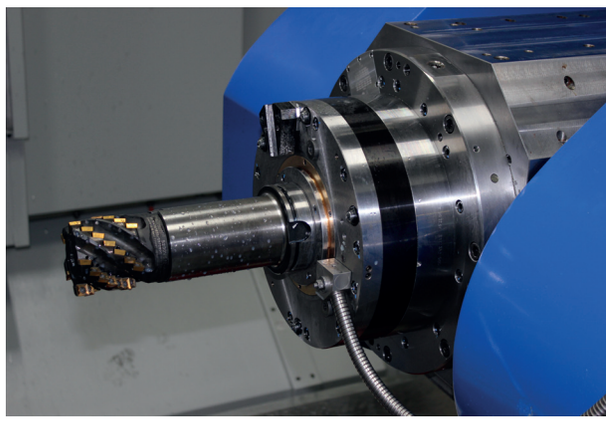


sinusoid so that the spindle is subject to a series of accelerations / decelerations around the nominal value that guarantee the suppression of vibrations in those materials that require a low cutting speed (generally titanium and some types of steel). The latter strategy however, is based on the automatic selection of the best cutting speed without adjusting its variation but opting for a specific constant value which guarantees the absence of vibrations. Starting from the nominal working speed, the system intelligently understands if and when the production process becomes unstable thus increasing this speed so as to return the process to a vibration free condition. The latter being a technique which is apt for the machining of materials with high cutting parameters such as certains types of steel and the entire field of light alloys.

Quick and effective, the device is exclusively based on the management of signals from peripheral sensors without requiring the analysis of the HMC's dynamic behaviour



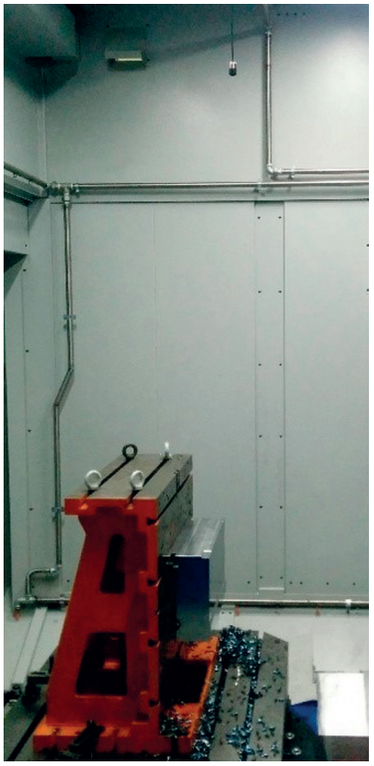
Electric cabinet

Demonstrated efficiency

«The use of the Smart Controller on machining centers enables companies to adopt high depth cuts ensuring high productivity and machining time reduction, all with a top quality finished product, a low wear of the tools and spindle bearings which are also potential sources of economic losses in the general calculation of the process - continued Stefano Musletti. Our device will be offered as an option to those companies belonging to several manufacturing sectors, from the aeronautic, which makes extensive use of titanium (where the cutting speed is necessarily low) and aluminium (which, on the contrary, adopts high speeds up to 100 meters per minute and more), to the field of general mechanics, that is in all the processes of complex high-cost components made of materials difficult to machine and characterized by significant stock removal».

The *Smart Controller* is an extremely compact product which can easily be integrated in the HMC, very flexible and versatile when operating, because it can operate on different types of processes, tools, cutting parameters and materials, as well as being completely

The Spark line HMCs are Mandelli's flagship



Above : hydrophone

Right : the Smart Controller is an extremely compact product which can easily be integrated in the HMC, very flexible and versatile when operating

autonomous. In fact, the intervention of an operator is not required, but the device automatically selects the best speed parameters for the suppression of those frequencies which generate vibrations. Among the features for which it stands out we can highlight the energy saving resulting from its use (due to the fact that the absorption of current decreases thanks to the lower stress levels to which the spindle and the tool are subject), the longer lifespan of the most sensitive components installed on the machining center such as the spindle bearings. Quick and effective, the device is exclusively based on the management of signals from peripheral sensors without requiring either the analysis of the HMC's dynamic behaviour, as it occurs when adopting different methods for vibrational damping, or idle tool learning cycles as it is required by other systems that need the acquisition of the so-called " vibration modes " without the work-piece being in the machine.

«Developed as part of some research projects implemented in collaboration with the Laboratory of Machine Tools and Production Systems of Piacenza, the Smart Controller is now being industrialized through a series of real application cases. The effectiveness of the control with this device has already emerged both in the *spindle speed variation* method in milling operations, which has ensured a 75% head vibration reduction, in internal turning operations with a 50% vibration reduction, added Stefano Musletti. Besides, we have also analysed the spindle speed tuning in milling operations getting an 85% reduction of vibration on the same material, in *slot milling*».

This is very interesting information for those companies that will have to increase their productivity level without incurring in all the problems caused by vibrations. It is also preparatory information for placing the Smart Controller on the market by the end of this year, perhaps in conjunction with the 2016 edition of the important BIMU Milan Exhibition.

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THE SMART CONTROLLER DEVICE IS NOW BEING INDUSTRIALIZED WITH A COMPLETE SERIES OF APPLICATION CASES

Left : example of a machining operation on a complex work-piece

Below : the result of a turning operation