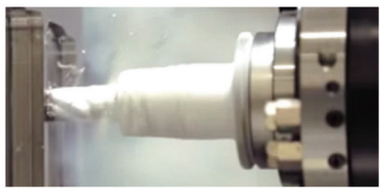
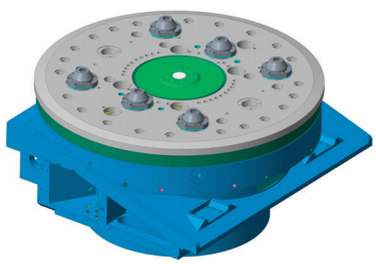
Solutions for
Dynamic Dumping



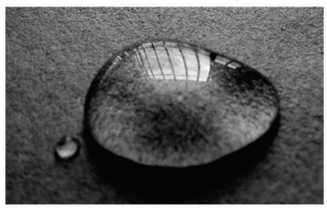
Innovative Cooling

Self-diagnostics and Predic

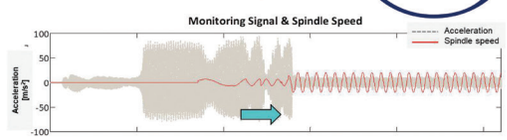


HP Turning Table

Additive Cell

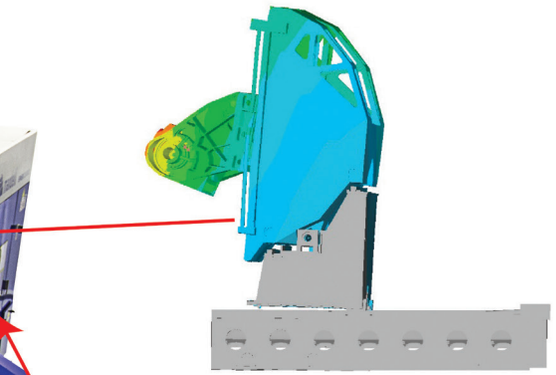


Amphiphobic Surfaces

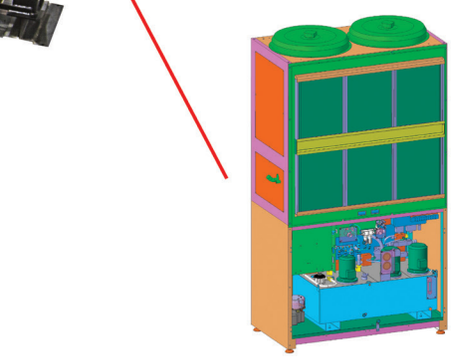


Intelligent Vibration Control

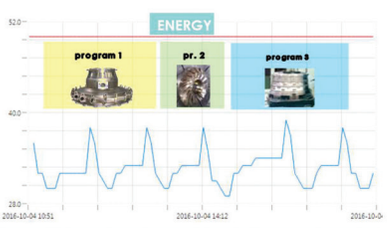
tive Maintenance iPuma suite4.0



Filling Material Structures



Energy System Optimization



High productivity Hybrid System

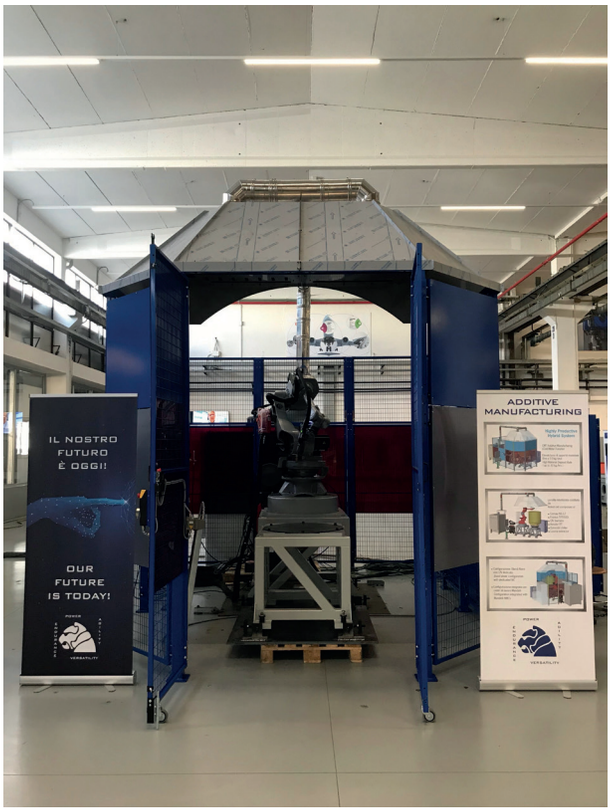
THE SP@RK-4.0-I.E.S. PROJECT BY MANDELLI SISTEMI FOR THE DEVELOPMENT OF A **HYBRID&SMART HIGH PRODUCTIVITY SYSTEM** IS AT ITS TURNING POINT. CHIP REMOVAL AND ADDITIVE TECHNOLOGY IN THE SAME CELL TO MACHINE HIGH RESISTANCE MATERIALS FOR AEROSPACE APPLICATIONS.

by Edoardo Oldrati and Ernesto Imperio

Research & Development has always played an important role in the organization of Mandelli Sistemi which, for over 80 years , has been designing and manufacturing 4 and 5-axis horizontal machining centers and flexible FMS systems whose highly innovative content has elected the company to being one of the leading players in the world aviation industry. In this context of Mandelli Sistemi's strategic vision, there is an ambitious project, partially funded by the Ministry of Economic Development within the "Sustainable Growth Fund"; the project is aimed at studying and developing a high-performance hybrid intelligent production system that integrates additive technology with milling and turning operations on high tenacity materials such as titanium alloys and heat-resistant superalloys HRSA (Heat Resistant Super Alloys). Other scientific realities are participating in the project, including Istec, a CNR spin-off, Inspire AG Research Center, an ETH Zurich Federal Polytechnic spin-off, MUSP, the University of Bergamo and industrialists who give their contribution of expertise, research & development on some objectives included in the project.

Objectives of the project

The final objective of the Sp@rk-4.0-I.E.S.

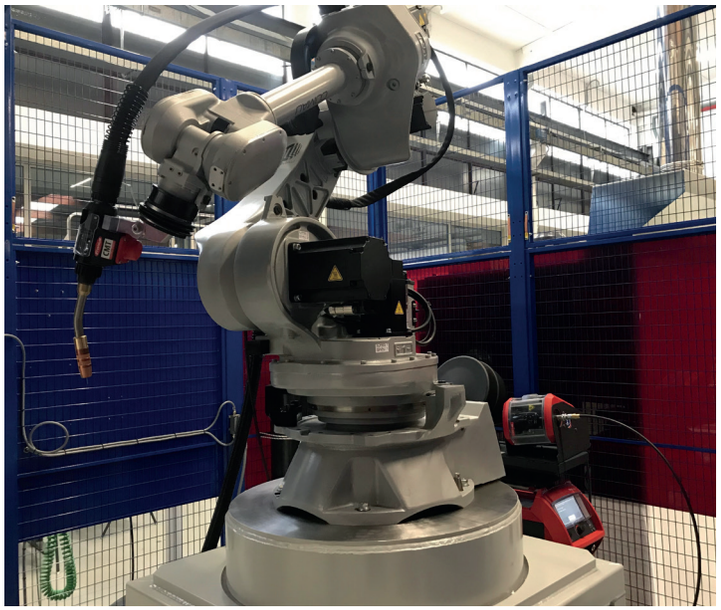


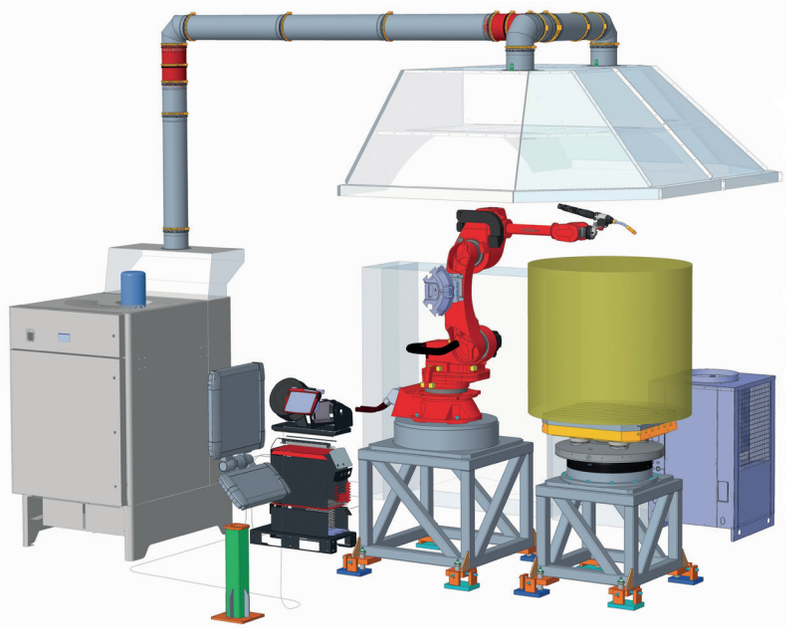
Left : Sp@rk-4.0-I.E.S. is a prototype of an automated cell that integrates a Spark 5-Axis HMC and an additive manufacturing robot station

Above : the hybrid system NC control iPuma by Mandelli

(Interconnected, Efficient, Sustainable) consists in manufacturing an automated cell prototype that integrates a Spark line 5-axis machining center, properly configured and sensorized, with an additive manufacturing robot station; it is a highly technological project that represents the synthesis of several development objectives, the main of which are related to: an increase in productivity and production efficiency to reduce the machine processing and managing costs, the development of advanced digital systems for the cell self-diagnostics and network interconnection, the optimization of the system consumption and functioning.
These objectives respond to specific needs emerged from a recent market analysis that Mandelli Sistemi has carried out among its customers operating in the aerospace industry which show increasing attention to materials that are difficult to machine used in the manufacture of engine and structural components. In this perspective, the Sp@rk-4.0-IES project aims at increasing the technological level of the productive solutions to favor the significant increase in performance in the production of structural elements where the reduction of vibrations that can occur during the cutting process is fundamental. In this way, it will be possible to enhance the Material Removal Rate (MRR) while maintaining high levels of surface finish.
No less important is the Research & Development activity that Mandelli technicians will dedicate to the development of a product capable of maximizing performances, energy and process efficiency and, therefore, allowing for the operating costs reduction for the end user.
«This innovative project, which has a three-year duration and will end in mid-2020 - says Marco Colombi, Mandelli Sistemi's Sales Manager - arises from the need expressed by the aerospace world for new production solutions that allow for a significant technological leap forward in the production of mechanical components and subsystems. For about 20 years the world of chip removal has been showing a certain maturity and the evolutions we are witnessing are bringing slight improvements, in terms of precision and speed, but we cannot speak of a technological leap.

> THE AEROSPACE INDUSTRY **SHOWS GREAT ATTENTION TO THE MATERIALS DIFFICULT TO MACHINE** WHICH ARE USED TO PRODUCE STRUCTURE AND ENGINE PARTS





Above, from the left : the AM station uses a Comau anthropomorphic arm "dressed" with a last-generation Fronius welding unit

In the rendering, all the units composing the AM robot cell

Additive manufacturing could be the right path and many machine builders are working on it knowing that this new technology completely changes the way we design and produce objects. On the basis of these brief considerations has grown the idea of developing the Sp@rk-4.0-I.E.S. project which starts from a clear design assumption: additive technologies do not generate cutting stresses, therefore, an additive processing station is not justified within a machining center whose intrinsic notion is precisely based on the presence of such stresses during removal.

Thus, the starting point was to create a cell, served by a pallet change system, to integrate the AM station with our Spark machining center: a definitely cheaper choice which, moreover, benefits from our specific know-how in the flexible automation field, in fact, 90% of our machine tools are already supplied in cell configuration. In this project, we are not going to create a completely new solution but we are going to take advantage of solutions we have already widely developed, by dedicating one of the 7 stations, normally provided by the cell, to additive technology. For the latter, our choice has favored the metal casting solution with respect to the powder solution, a technology that can reach the highest Material Deposition Rate (MDR) rates in additive manufacturing avoiding the problem of storing and dealing with the metal powders inside the cell».

Main innovative aspects of the cell

Among the eight Realization Objectives the Mandelli project consists of, we recognize different design and construction solutions with a high innovative contents.

Here we will try to highlight the most qualifying ones to make the high productivity hybrid system prototype.

«The adoption of additive technology - says Matteo Tamborini, Project Engineer at Mandelli Sistemi - certainly represents the technological leap inherent in this new production cell for the aerospace industry. In particular, the AM station uses an anthropomorphic arm, whose movement is managed by a numerical control, "dressed" with a last-generation welding unit. The power source developed for welding and additive manufacturing applications allows for the deposition of material according to the CMT - Cold Metal Transfer process, thanks to which it is possible to cast material using a process similar to arc welding yet with lower thermal inputs and better surface quality: the thermally altered areas (ZTA) are reduced and no splashes are generated».

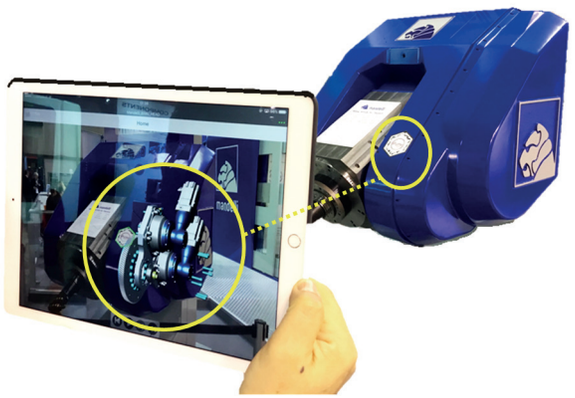
Other important innovations about this project are related to the chip removal process for which two solutions have been developed, applied to the cooling lubrication system. The first solution uses traditional emulsions brought to the tool tip at very high pressure rates (350 bar) with the aim of fragmenting the chip immediately after its separation from the work-piece (Ultra High Pressure Cooling).

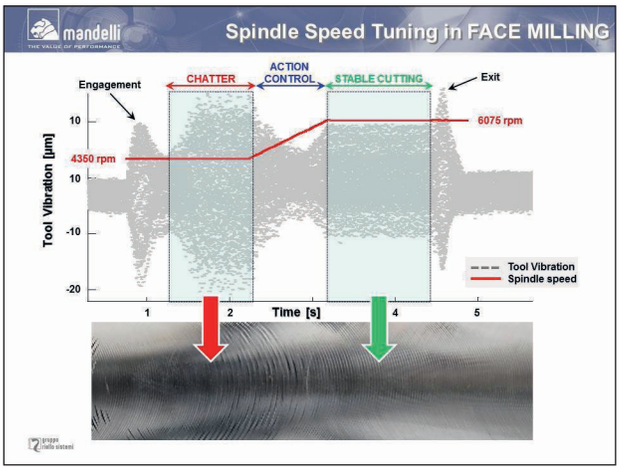
The second solution is based on cryogenic technologies: «In short - says Colombi - with nitrogen or carbon dioxide technologies we can refrigerate the contact area between the tool and the piece up to -200 ° C by using special lubricating cryogenic emulsions.

This greatly reduces the cutting edge wear with obvious advantages on the

THANKS TO NITROGEN AND CARBON DIOXIDE TECHNOLOGIES MANDELLI **CAN REFRIGERATE THE CONTACT AREA BETWEEN THE TOOL AND THE PIECE** TO -200°C

components and collect operating information: specific algorithms will define the times for maintenance operations.
This brief and non-exhaustive examination of the Sp@rk-4.0-I.E.S. project completes two other development activities concerning the optimization of the cell energy consumption and the development of augmented reality applications. The first is





Left : iPum@-reality is the APP that ensure an autonomous, quick "smart maintenance" through a specific AR APP dedicated to troubleshooting

iPum@-smartcut is the innovative HN & SW system to monitor and supervise the cutting process

processing efficiency, especially on tough materials such as titanium and Inconel alloys typically used in the aerospace industry, a sector that represents more than 50% of our market. In addition to the cryogenic technology, we are also working on surface coatings to make them amphiphobic, that is water and oil repellent as well as repellent to solid charges impregnated with these fluids, with consequent optimization of chip evacuation. This type of solution is of great help especially in unmanned operations which, increasingly produce impressive quantities of chips that must not build up in the work area».
Another goal is the industrial development of a "Smart Controller" control platform and its highly dynamic turning table; the objective is the control of the vibrations according to strategies chattering reduction based on the variation of the spindle speed with consequent verification of reliability and effectiveness.
«What we are implementing - adds Colombi - is a sort of intelligence to be included in the Spark HMC numerical control capable of replicating a behavior that expert operators know how to do in the case of difficult turning operations. In fact, in processing difficult materials using long tools, it is difficult to optimize the cutting parameters and it is necessary to keep under control the vibrations which, if triggered, must be rapidly damped by modulating the spindle rpm override, i.e. by accelerating or slowing down the rotation speed. Our goal is to automate this operation by introducing an advanced vibration and noise sensors system and an algorithm able to quickly evaluate the need to vary the spindle rpm. We have concluded the testing and experimentation phase and the results are very promising».
Another activity being developed and implemented is the "Predictive" and "Smart" maintenance system to replace the components of the cell at the right time so as to maximize the real usage time and simplify the work of the operators. The starting point to achieve this objective is to appropriately sensorise some machine based on the development of strategies to regulate and monitor the different machine groups to reduce global energy consumption in the various operating phases, also in consideration of the time slots with the lowest energy cost.
The second activity involves a dual use of augmented reality: assessing ergonomic, logistic, machine accessibility and, in general, factory layout during the development of the Sp@rk-4.0-I.E.S project; support Service activities, by the manufacturer or user. ■