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Metal Removal: There's a Robot for That

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Intelligent Industrial Robots for Better, Safer and More Mobile Manufacturing

In reference to industrial robotic technology used in manufacturing, automation and transport system may immediately come to mind. Industrial robots are automated, programmable and highly sophisticated. With rapid technological advances, industrial robots today are not only used for transport, pick and place, but can also weld, paint, assemble, pack, palletize, label, conduct inspection, and more.

Industrial robots used in the manufacturing sector are designed to help improve efficiency, safety and quality of work. Since industrial robots are capable of movement on two or more axes, they can provide greater flexibility in terms of motion range and function in comparison to human personnel. In addition, industrial robots have limited downtime, safety concerns, and less floor space requirement than large computer numerical control (CNC) systems. Moreover, robotic systems can be programmed and reprogrammed to fulfill specific needs that are repeatable, making them a flexible yet reliable manufacturing solution.

INDUSTRY 4.0 and the Evolution of Automation

The manufacturing sector has recently entered a new era known as Industry 4.0, driven by cyber physical systems, the Internet of things (IoT) and cloud computing. In Industry 4.0, automation has advanced one step further to not only replace human workers on the assembly lines, but to also provide connectivity to a large amount of data, problem-solving capability and other highly optimized intelligent support. Industrial robotic technology is a part of the driving force behind the evolution of automation and promotes the computerization of manufacturing. With the integration of big data and remote monitoring, manufacturing process can be efficiently evaluated and improved for better work quality and cost savings.

METAL-REMOVAL: Robots

At the center stage of Industry 4.0, more is being expected from robotic systems, and the recent trend has geared toward a new specialty – cutting. Many industrial robots today can perform a wide variety of cutting for material removal applications, such as grinding, finishing and polishing, deburring, waterjet cutting, laser and plasma cutting, ultrasonic cutting, trimming and routering, just to name a few.

HOW IT WORKS: Multi-Axis Robots

Multi-axis robots can be adapted for machining processes such as milling and drilling. Just like any type of automation, programming is required to help guide the robot along the area to be machined. To begin, a cutting tool has to be attached to the end of the robot with a high-speed routing spindle. Once the setup has been completed these robots can potentially create more quality parts per hour than CNC systems as they are able to change parts and tools more quickly and easily.

Material-removal robots, however, have their limitations. Rigidity, hardness of material and precision requirements are key factors in metal-cutting applications. Due to the construction of multi-axis robots, which are composed of a series of linked joints, they often lack the rigidity required for tight-tolerance machining. The lack of rigidity limits the amount of force the robot can exert on a part thus, up until recently, material-removal robots have only been able to process soft materials such as plastics.

APPLICATION OF METAL-REMOVAL ROBOTS in Aerospace Manufacturing

In the past decade, great strides have been made in material-removal robotic technology. A number of industrial robot manufacturers have successfully developed sturdy serial-link robots capable of applying the required force for high-accuracy machining for materials such as carbon fiber reinforced polymer (CFRP).

In the past, aluminum alloy and stainless steel have been widely utilized in commercial aircraft applications due to their good casting characteristics. However, unlike aluminum alloy, CFRP does not oxidize. By replacing aluminum alloy with CFRP, parts will become more durable and aircraft fuel consumption can be significantly reduced. CFRP is a corrosion-resistant, stiff and strong material composed of mixtures of fiber. Machining CFRP often involves a high degree of difficulty because of its multilayer property. Finding consistency is difficult due to the various types of CFRP (ex. cross directional, unidirectional, etc.) in the market and the requirement of varying tolerances and delaminating issues. CFRP manufacturing requires a high degree of flexibility, and the latest industrial robots are able to fulfill such a requirement. As a result, the usage of metal-removal robots has significantly increased for the automated manufacturing process of wide-body commercial airliners.

In the construction of aircraft, many parts are required to be machined by cutting tools in order to connect the various sections and components. To automate the manufacturing process, rails are installed within the aircraft body once the floor beams and frames have been assembled. Industrial robots are then placed on the rails to maneuver back and forth to work on fuselage panels including the sides and the ceiling with their exceptional motion range capability. For maximum efficiency, the robots often work in pairs handling different operations. With improved rigidity, precision and flexibility, industrial robots have become a cost-effective option for aerospace manufacturers to automate production.

COLLABORATION Between Machine Builder and Cutting Tool Manufacturer

Fanuc Corporation, one of the world's largest manufacturers of industrial robots, is among the few that offer metal-removal robotic solutions that are capable of machining composites. Fanuc's core business domains include the manufacturing and sales of FA products such as CNC systems, industrial robots and small machining centers. It was the first private company to succeed in the development of NC's and servomechanism in Japan. Ever since this success in 1956, Fanuc has consistently pursed automation in factories. In terms of industrial robots, Fanuc offers a comprehensive lineup to cover a wide spectrum of operations such as loading and unloading of machine parts, welding, palletizing, painting, assembling, deburring, etc. Fanuc's industrial robots are equipped with powerful software that enables them to diagnose, to trouble-shoot, and to continue learning to improve productivity. Their products are well known for reliability and ease of use.

Today, Fanuc has bases in 257 locations in 45 countries throughout the globe to offer solutions to minimize downtime in factories all over the world. This year, Fanuc announced the sales of the FIELD (Fanuc Intelligent Edge Link & Drive) system to further promote unmanned factory using the latest IoT and AI technologies.

At the 2016 Japan International Machine Tool Fair (JIMTOF), Fanuc collaborated with OSG Corporation to display their latest metal-removal robotic technology. A manufacturer called NSK Nakanishi was also instrumental in this collaboration in securing spindles for mounting the robot and the cutting tool. The tool used for cutting the composites was OSG's D-DAD diamond coated double angle drill. This combination has successfully demonstrated cutting results with low cutting resistance, which allowed the Fanuc robot to cut CFRP even with OSG standard cutting tool items with exceptional hole quality.

The collaboration drew great interest from visitors at the exhibition. Many manufacturers have stopped by to ask questions regarding the technology. Despite the benefits metal-removal robots could bring, adaptation in Japan is slow due to the various constraints involved. Implementing new technology often is a challenge especially or small and midsize enterprises. Aside from the upfront equipment cost, job routine has to be altered. The transfer of knowledge must also take place from the old operation to the new process, which can be seen as an investment risk from a management standpoint. In order for small and midsize companies to execute the technology migration, the cost must be clearly justified on the basis of savings over time.

THE FUTURE OF METAL-REMOVAL ROBOTS

To further accelerate and promote Industry 4.0, government involvement may be required in the form of incentives such as rebates. From the standpoint of industrial robot technology, additional evolution is also required. Currently, no industrial robot has yet to be able to consistently and successfully machine aluminum and steels, which are common materials used in manufacturing due to their low cost and high tensile strength properties.

Due to steel's toughness, rigidity must be enhanced in the design of material-removal robots in order to exert the required force while maintaining precision. Improvements in clamping technology, such as increasing the responsiveness and strength of the clamp, can overcome the nature of the robot's serial-link structure. In addition, software improvement can also help further enhance rigidity and accuracy. With enhanced analytic capability, the industrial robot will be able to evaluate processes to make required adjustment during cutting, such as reducing the cutting distance by moving closer to the workpiece to improve rigidity.

THE ROLE OF CUTTING TOOLS

In addition to the design of industrial robot and programming, cutting tools used for the metal-removal robots must also continue to evolve. Because serial-link robots tend to lack rigidity required for high precision cutting, the cutting tool must be sharp to minimize cutting resistance. Cutting tools play a vital role for high precision metal-removal robots. Sharpness in the cutting edge is required for low cutting resistance. At the same time, too much sharpness can cause the cutting edge to chip easily. The engineering team at OSG is continuously researching and testing new tool geometry that can achieve the ideal balance between sharpness and durability for metal-removal robots. In addition to tool geometry, coating of the cutting tool can also be a determinant in the machining of hard materials. Coating technology such as Nano coating can help create a thin protector for the tool to prevent chipping without increasing thickness thus without reducing sharpness.

Paired with the right tooling, advanced robotic systems can offer manufacturers the ability to easily manage and optimize machining processes, reducing the need for expensive, large and specialized multi-axis CNC machines. Intelligent mass production is not far from the future. Once technology further matures, robotic systems designed for metal-cutting applications will be able to better support physical workers in their increasingly complex work with flexible solutions, revolutionizing the way of manufacturing.

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