TECHNICAL INSIGHTS

ADVANCED MANUFACTURING

TECHNOLOGY ALERT

09th August 2014

1. MODEL TO PREDICT AND INCREASE LOAD BEARING CAPACITY OF CERAMIC SCREWS

Screws are very widely employed in various industries. Currently, most of the screws manufactured are made of steel. When the screws made from steel are exposed to environments that have high temperatures or are acidic in nature, and the chance of failure increases. Due to the above mentioned drawback that us seen in with steel screws, there are increasing opportunities in industrial sectors for ceramic screws which are viewed as more stable with respect to harsh environmental conditions. Even though the ceramic screws are more suited for extreme weather conditions, they are susceptible to load failure. Researchers from the Fraunhofer Institute for Mechanics of Materials (IWM) (Freiburg, Germany) have created an innovative model for accurately predicting the stress resistance level of ceramic screws.

The researchers have created a model that would reduce the failure of these screws when they are used in various applications. The model has been developed by using a screw test rig and simulations. The researchers are currently testing different ceramic screws and examining the accurate level of stress that these screws can withstand. This project has been funded by the Federal Ministry for Economic Affairs and Energy of Germany (BMWi) and the German Federation of Industrial Research Associations (AiF). In addition to analyzing the stress level of the ceramic screws, the researchers are also working on optimizing the design of the screws. The challenge in optimizing the load capacity of screws is that it varies significantly even among screws having the same design. For instance, one screw would be able to tolerate high stress compared to another screw having similar specifications. The composition of the

ceramics used in the screws is seen as the deciding factor for a screw's load bearing capacity. If the bonding of the tiny grains that constitute the final product is incorrect during manufacturing, small cracks develop, which later result in the failure of the material. The researchers have now been able to optimize the manufacturing process of ceramic screws, which would reduce the occurrence of the cracks. With this, they have also been able to reduce the range of the distribution curve, and raise the resistance of the screws to stress. According to the research team, there is scope for further improvement in the last step of the manufacturing process in the future. When the last step of the manufacturing process is optimized completely, it would change the way in which threads implanted into the screws using injection molding or sanding. The optimization of the thread imprinting process would result in increasing the load bearing capacity of the threads. From the various experiments carried out on ceramic screws manufactured in the laboratories of IWM, it was seen that the load bearing capacity was increased by 30% to 35% . The researchers have also used the test rig to test the stress resistance of these ceramic screws.

Some of the advantages of this novel model are that it increases the load bearing capacity of the screws, which in turn reduces the failure of ceramic screws when they are employed in different applications. This testing and the manufacturing optimization process developed by the researchers has opportunities to be adopted on a large scale once it is commercially available.

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2. ROBOTIC SYSTEM TO INCREASE PRODUCTIVITY IN THE AEROSPACE SECTOR

Though robots have been developed for various manufacturing processes in different industries, they have not traditionally been so widely adopted in the aerospace industry. For instance, the wings of aircraft are still assembled manually, which results in increased time and reduced efficiency of the production process. The assembly of aircraft parts has involved significantly high manual process and labor, which can result in reduced production output. The aerospace industry has been looking for ways to automate the assembly process, and in

certain cases it has been a challenge primarily due to the complicated internal structure of the wings that consist of a series of hollow chambers. Researchers have now developed a snake-like robot that is capable of tightening the bolts present in the some of the most inaccessible places of the airplane wing.

A research group from Fraunhofer Institute for Machine Tools and Forming Technology IWU, Germany, is currently working on developing an automation solution based on a flexible robot with articulated arms, which reduces the time and effort required in the assembly of airplane parts. Conventional robots currently available in the market are not flexible enough to pass through narrow openings, and their rigid arms are not capable of reaching out to the outermost regions of the workspace that usually extend up to five meters in length. The robot developed by IWU addresses the above-mentioned challenges with the help of eight articulating arms that are connected in series, thereby allowing it to be rotated or inclined within a narrow radius. A tool based on the task that is to be carried out is first attached to the series of eight limbs in the robot for carrying out the desired application. This tool can also be replaced with an inspection camera if required. The arm of the robot is 2.5 meters in length is capable of supporting tools that weigh up to 15 kilograms. Kinematics, used to drive this robot, is based on a sophisticated mechanism that also includes a novel gear system developed by the researchers, for which they have filed a patent. A small motor has been integrated into each of the eight robotic arms and is capable of producing high torque of up to 500 Newton-meters. The reason for using a small high-powered motor is because conventional motors would not be suitable for the robotic arms due to their compact design. Small motors are used in combination with a cord and a spindle drive system that enable the arm to move independently and turn with an angle of 90 degrees. The researchers would be presenting a working prototype of the robot at the Automatica trade show, which is to be held in Munich, Germany from June 3 to June 6, 2014. They are expecting to develop the complete version of the robotic system equipped with an eight-part articulated robotic arm by the end of 2014. Some of the potential applications for this robot are aircraft and automobile manufacturing, and also in power plant designing.

Some of the advantages of this robotic system are its facilitating reduced manufacturing time in the aerospace sector and increased adoption of robotic systems in this sector. Due to the above-mentioned capabilities and advantages, this robotic system has potential to be adopted on a significant scale in various industries.

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3. TACTILE SKIN FOR MAKING ROBOTS MORE TOUCH RESPONSIVE

At present, there are limitations to the tactile sensing capabilities of robots. For instance, the robots can carry a cup of coffee, but they would not be able to feel how hot or cold it is. Researchers have now developed a novel method to incorporate the feeling of touch into the robots.

Researchers from the University of Glasgow in Scotland are currently working on making tactile skin that would significantly increase the feeling of touch in robots. They are trying to achieve this by creating an ultra-flexible tactile skin for the robots. Until now, it has been difficult to achieve such a skin because either the large sensor or the electronics used in them have not been sufficiently flexible. The researchers from the University of Glasgow are close to achieving it by inventing a novel way of incorporating both electronics and sensors on a flexible, silicon-based surface. This silicon surface is said to have a thickness of 50 microns, which makes it extremely thin. The creation of this silicon surface has helped the researchers in producing silicon-based nanostructures such as nanowires that were printed on the flexible substrates of the tactile skin.

This has helped them in creating the flexible electronic or tactile skin for robots, which has the sensors and electronics distributed on them. The development of a printing method for high-mobility materials such as silicon can also help in obtaining high-performance electronics at a very low cost. According to the researchers, this research can help equip the entire body of the robot with tactile skin, thereby increasing the capabilities of the robots in a wide range of application sectors in different industries. This is seen as a unique approach to make the entire robot touch responsive. The researchers also believe that the

printable method used in this research could be applied for the development of flexible electronic parts in the future. For instance, it could help in the development of flexible screens for computers, phones, and tablets. The researchers have already been able to establish a strong relationship with a couple of industries in UK to collaborate for the next steps in their research.

One of the advantages of this novel tactile skin for robots is that it increases the capabilities and potential of the robots used in the healthcare sector. The potential application areas can also increase in the future. With the increasing adoption of robots in different industries and sectors, this development could propel the adoption of this tactile skin for robots once it is commercially available.

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4. PATENT ANALYSIS OF ELECTRIC DISCHARGE MACHINING

Electric discharge machining (EDM) is a manufacturing process by which a desired shape of the final product is obtained using electrical discharges. In this process, the material is removed from the work piece by applying a series of rapidly repetitive discharge of current between the two electrodes that are used. The electrodes are separated by a dielectric liquid, which is subjected to an electric voltage. One of the two electrodes is called the tool electrode and the other electrode is known as the work piece electrode. When the distance between the two electrodes is reduced, the intensity of the electric field in the volume between the electrodes is increased. The increase in the intensity of electric field becomes greater than the strength of the dielectric which results in the breaking of the dielectric, thereby allowing the flow of current between two electrodes. When the flow of current is established, the material is removed from both the ends of the electrodes. Once the flow of current is stopped, a new liquid dielectric is usually conveyed into the inter-electrode volume, which enables the solid particles to be carries away and the insulating properties of the dielectric are again restored. This method of adding a new liquid dielectric in the inter-electrode volume of the inter electrode is termed flushing.

A major advantage is that, complex shapes--which are otherwise difficult to achieve using conventional cutting tools and methods--are possible with the EDM process. The other advantage is that it is possible to obtain good surface finish of the finished product using the EDM process. From the patents that have been exhibited, it can be seen that the research has been carried out in areas such as electrodes and the machining apparatus that are being used in this process. It can also be seen that there has been research carried out to improve overall process (including electrical discharge machining hole drilling). These areas of research that are being focused on would help in improving the quality of the products that are being manufactured using EDM process. Some of the key patent holders in various areas of EDM process include Tungsten Alloy Co. Ltd., Mitsubishi Electric Corporation, Sodick, Agie Charmilles, United Technologies Corp., General Electric.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Electrode for electric discharge machining	November 6, 2013/ CN 103003016 B	Tungsten Alloy Co., Ltd. of Japan	Yamaguchi Bowen, Yusuke Uchida	In order to use Cu (Ag)-W (Mo) Class discharge electrode discharge machining processing, improve the processing speed, the electrode consumption rate, the surface roughness of the workpiece is in Cu (Ag)-W (Mo)-based material Add the appropriate amount is selected from Mg, Ca, Sr, Ba, Sc, Y, boron oxide and iron group consisting of lanthanum metal components (M3) of the element. Boron oxide is particularly preferably used M32B2O5, boron oxide M3B2O4 shown.
Wire electric discharge machining apparatus	September 3, 2013/ US 8525063 B2	Sodick Co., Ltd.	Kiyoyuki Yamazaki	A wire electric discharge machining apparatus for machining a workpiece (**7**) by supplying current pulses to a work gap formed between a wire electrode (**8**) and the workpiece comprises a person detection sensor (**10**) for generating a person detection signal (EX) when the existence of a person is detected, and an NC device (**20**) that is configured to receive the person detection signal. When the NC device receives the person detection signal, it selects first machining conditions which improve machining speed. When the NC device does not receive the person detection signal, it selects second machining conditions which reduce the risk of wire breakage.
Electric discharge machine and electric discharge machining method	August 22, 2013/ US 20130213941 A1	Mitsubishi Electric Corporation	Yoshinori Asai, Masahiro Okane, Hidetaka Katougi	An electric discharge machine performs a hole machining on a workpiece by applying a voltage between an electrode and the workpiece to generate an electric discharge therebetween and moving the electrode to a position of a command depth. The electric discharge machine comprises: a storage unit; a current-coordinate detection unit; an electric-discharge-voltage detection unit a penetration detection unit; and a calculation unit. The storage unit stores therein a penetration determination voltage, a penetration determining duration, and a first projecting amount. The current-coordinate detection unit detects a current position of the electrode. The electric-discharge-voltage detection unit detects a minimum voltage of the electric discharge for each predetermined period. The penetration detection unit determines the electrode has penetrated through the workpiece. The calculation unit calculates, a position obtained by adding the first projecting amount to the current position of the electrode detected by the current-coordinate detection unit and updates the command depth.
Electric discharge machining device	August 15, 2013/ US 20130206732 A1	Mitsubishi Electric Corporation	Masaaki Nishio, Hidetaka Katougi	An electric discharge machining unit that performs electric discharge machining by clamping a target object with a clamper of a clamping device, the electric discharge machining unit including a timer that measures a lapse of a time, which has been set by a user as a preparation time for supporting the target object after an operation of a clamping/unclamping button for clamping or unclamping is detected, and a clamper control unit that causes the clamping device to perform an operation corresponding to the detected operation at a time-out of the timer.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Electric discharge machining method and apparatus	July 4, 2013/ US 20130168362 A1	Agie Charmilles Sa	Umang Maradia, Reto Knaak, Walter Dal Busco	A method of controlling an electric discharge machining apparatus having at least a tool electrode and a workpiece comprising positioning the tool electrode relative to the workpiece; generating at least one first type discharge impulse and at least one second type discharge impulse, wherein the at least one first type discharge impulse has a longer impulse duration than the impulse duration of the at least one second type discharge impulse, wherein the first type discharge impulse causes formation of a protective film against wear on the tool electrode and the second type discharge impulse causes erosion at least on the tool electrode; and applying the first and second type discharge impulses to a gap between the tool electrode and workpiece for material removal from the workpiece, wherein a ratio between the first and second type discharge impulses applied to the tool electrode causes predefined wear of the tool electrode.
Electrical discharge machining electrode loss compensation method based on opposite-forming principle	May 8, 2013/ CN 103093033 A	Zhejiang University , Zhang Yongping	Wang Jin , Sun Zhongming , Zhang Yongping , Chen Jian , Wang Yang , Lu Guodong	The invention discloses an electrical discharge machining electrode loss compensation method based on the opposite-forming principle. Before machining, a required electrode initial shape is reasoned out conversely according to a required ideal shape of a target workpiece and by the means of the electrode loss mechanism . The workpiece with the required ideal shape can be exactly machined out after electrical discharge machining of the electrode with the shape is accomplished and loss is caused. Namely, pre-deformation is performed on the electrode which is originally of the ideal target shape so as to offset the impact of the electrode loss and achieve the purpose of electrode compensation. In order to obtain the original shape of the deformed electrode, only the workpiece with the target shape is needed to be transformed to an electrode, the corresponding electrode is transformed to a workpiece, machining simulation is performed conversely, and the initial shape of the electrode can be obtained after electrical discharge machining procedures as same in normal electrical discharge machining are accomplished.
Electric discharge machining hole drilling	January 2, 2013/ EP 2540430 A2	United Technologies Corporation	Sergey Mironets, James M. Koonankeil, Edward F. Pietraszkiewicz, Thomas R. Davis	An apparatus and method for machining apertures into a conductive workpiece (10) is disclosed. The apparatus has a tank (34) capable of holding a dielectric fluid, and a fixture (24) for holding the workpiece in the tank. An electric discharge machine with an electrode (36), a power supply connected to the electrode that produces machining pulses for electric discharge machining through the workpiece, and a controller (39) for regulating the power supply and electrode position is also part of the apparatus. Finally, the apparatus has a pressure transducer (33) connected to the fixture, and a process controller (38) in communication with the electric discharge machine controller and pressure transducer.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Electric Discharge Machining Device Using Rotating Circular Blade	January 2, 2013/ EP 2255912 A3	General Electric Company	Yuefeng Luo, William Edward Adis	An electric discharge machining (EDM) device (100) includes a circular blade (102), a motor (104) coupled to the circular blade (102) for rotating the circular blade (102), and an electric discharge control system (106) operatively coupled to the circular blade (102) and a workpiece (110). The electric discharge control system (106) causes the rotating circular blade (102) to cut the workpiece (110) using electric discharge machining. The device (100) allows for removal of large chunks of material using EDM, minimizing the number of cuts, time and energy required to create a part.
Spark gap control for electro-discharge machining	August 30, 2012/ US 20120217225 A1	Mervyn Rudgley, Kenneth Gold, Michael Gibbons, James Legge, Richard Gerlach	Mervyn Rudgley, Kenneth Gold, Michael Gibbons, James Legge, Richard Gerlach	A control module for an EDM device, comprises: controls for managing power supplied to the EDM device, taking voltage measurements, calculating responses, and controlling advancement of an electrode of the EDM device. The EDM device may include a piezoelectric crystal that electrically in parallel with the voltage applied to a spark gap between the electrode and a workpiece.
Tandem micro electro-discharge machining apparatus	June 10, 2010/ US 20100140226 A1	Dong-Yea Sheu	Dong-Yea Sheu	A Tandem-type micro electro-discharge machining (EDM) apparatus comprises a EDM machining stage, a gradation twin-wire EDM device, an electrode tool, a workpiece, and a resistor-capacitor (RC) EDM circuit. The gradation twin-wire EDM device further comprises a wire supply reel unit, a wire take-up reel unit, a stepped insulating roller, a twin-wire conductor unit, and a discharge circuit unit. With the design of the gradation twin-wire EDM device, only one single EDM procedure is needed to simultaneously perform rough EDM and finish EDM processes together on the electrode tool to form a required micro electrode tool, which can be immediately used to perform micro-hole EDM or scanning EDM on the workpiece. Therefore, the Tandem-micro EDM apparatus of the present invention can be functioned automatically to achieve mass production of micro holes EDM and reduce machining time and improve machining efficiency and product's quality.

Exhibit 1 depicts patents related to electric discharge machining.

Picture Credit: Frost & Sullivan

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