TECHNICAL INSIGHTS

ADVANCED MANUFACTURING

TECHNOLOGY ALERT

13th November 2015

1. NOVEL 3D PRINTER TO PRINT FUNCTIONAL OBJECTS

There have been challenges surrounding the use of 3D printing to create fully functional products and 3D printing of electronics.

Addressing this need, a team of researchers at Purdue University, Indiana in the USA has created a new 3D printing system that can print functioning products containing electronic circuits and motorized components in them. 3D printing systems have been developed to print objects with complex geometries and surfaces using various materials. However, this is a unique 3D printing system that will be capable of printing objects that can function as soon as they are printed.

In the traditional manufacturing method, the electronic and other functional components are assembled with the body of the object. Similarly, using the existing 3D printing methods, the body of the object can b e 3D printed and then the electronic components are assembled inside the printed parts. Also, while printing overhanging or protruding parts of objects such as arms or other peripherals of the object, traditional 3D printers tend to form support structures. The supporting structures will need to be removed after the printing process which results in waste of material and extends printing time.

The research team from Purdue planned to work around these issues and has created a 3D printing system called 'RevoMaker', which not only prints the object around electronic components, but also eliminates the need for supporting structures while printing protrusions and extensions on objects' bodies.

In contrast to a conventional 3D printing system, which has a fixed printing platform over a planar printing bed, RevoMaker will feature a print bed which a cuboid. The cuboid can be can be rotated about an axis, which will enable

orthogonal printing on the sides of the cuboid. Additionally, the space inside the cuboid will serve as the space where electronics, motors, batteries or other functional components will be embedded before the onset of the printing process. The cuboid is designed in such a way that it can be replaced with multiple small cuboids, with each cuboid enclosing some unique functioning components and can be snapped together after the printing process is finished.

The basic purpose of this invention is to elevate the existing 3D printers without much complexity to print objects in a multiple axes, which otherwise is very expensive and complex to print using 3D printers with multi-axial printing capabilities. The cuboid in the RevoMaker can be simply rotated using the axis buttons- X, Y and Z provided on the machine. This utility adds more functionality and capability to a simple 3D printer.

Further, software developed for the new system will design the object ergonomically around the central cuboid. The software encompasses an algorithm that designs the geometrical structure of the object to be printed by considering a cuboid with as a large volume as possible in order to save the printing material. Also, the algorithm designs the object with an optimized orientation to reduce the materials required for printing support structures for protrusions and extensions from the object's body. One of the major advantages of the RevoMaker system is that it has reduced the overall printing time and the material required for printing an object by around 37%.

The research team has printed many functioning prototypes using RevoMaker to find its possible applications in various fields. One of the notable prototypes printed using RevoMaker is a mouse customized to a person's hand. The team is now looking to expand the capabilities of the printer by using new materials and designs.

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2. POP-UP MANUFACTURING METHOD TO PRODUCE MILLIMETER FORCE SENSORS

Robotic surgery has been gaining increasing popularity. Complex robots are replacing scalpels and enabling surgeons to perform very precise and minimally invasive surgeries. The precision and efficiency offered by robotic surgery has reduced the time of hospital stay for several patients, owing to the reduced healing times of minimally invasive surgeries. Nowadays, surgical robots with flexible and soft tools are able to perform very complex and delicate surgeries in intricate parts of the body, which holds promise for surgical robots to eventually make inroads into operation theaters.

However, advancements in surgical robotics have failed to match the ability of the human hand to sense and adjust force.

A new research study by researchers in John A. Paulson School of Engineering and Applied sciences and the Wyss Institute of Biologically Inspired Engineering at Harvard University, graduate student Joshua Gifford, Robert J. Wood, Charles River professor of engineering and applied sciences, and Conor Walsh, assistant professor of mechanical and biomedical engineering, have succeeded in improving force sensing surgical robots.

The research team has found a manufacturing method to make millimeter scale force sensors that can be manufactured at low cost. However, one of the biggest challenges in making these sensors is their size.

The millimeter force sensors are fitted into the tools of soft surgical robots. The soft surgical robots usually perform surgeries in hard-to-reach areas and hence have narrow tips and surfaces. The force sensors must be made in such a way that they can be placed conveniently on the narrow endings of robot arms. This means that the force sensors can only have dimensions of only a few millimeters.

Manufacturing the millimeter force sensors using traditional manufacturing techniques would limit the required complexity and sophistication of the sensors in the millimeter scale. Moreover, the traditional approach would raise the assembly and implementation cost of the force sensors. This limitation will restrict the rapid adoption of millimeter force sensors in surgical robots.

In order to overcome the limitations of the conventional manufacturing methods, the researchers turned to another method of manufacturing, popularly known as ‘pop-up manufacturing’. Pop-up manufacturing is a manufacturing

technique inspired by origami and pop-up books, which puts together complex micromachines by arranging laser-cut materials in layers to form flat plates that will work as a complete electromechanical device. An interesting feature of this approach is that it eliminates human intervention during the complete manufacturing process by allowing the devices to build themselves. This will reduce the overall cost of manufacturing.

The millimeter force sensor created through the pop-up method consists of 4 layers of laser machined stainless steel layers sandwiched together. The four layers are laminated by a flexible polyimide layer and are provided with copper on both sides of the sensor for electrical conductivity. The force sensor has a dimension of 2.7 m. This size is so small that it can easily pass through the port of an endoscope, which is around 8.6 mm in width.

The force sensor basically works on the principle of Light Intensity Modulation (LIM). The sensors sense force in the millinewton scale using the LIM principle. In LIM, a light emitter and a light detector are connected through an elastic element. The elastic element deforms every time a force is encountered by the sensor. The deformity is directly proportional to the force. As soon as the elastic element deforms, it brings the light emitter and detector closer. As a result, there will be a slight change in the irradiance sensed by the detector. This change can be translated into the applied or the incident force.

The researchers believe that this new 'pop-up' method will be able to produce millimeter sensors rapidly at low cost. This is believed to create soft robotic surgical tools that can perform minimally invasive surgeries at a low cost. The millimeter force sensors have opportunities to find a wide range of applications in medical technologies, such as laparoscopy and endoscopy

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3. HUMANOID MOTORCYCLE-RIDING ROBOT

The automotive industry has been innovating and implementing new navigation and safety technologies to achieve autonomously driven vehicles, particularly on four wheelers. Yamaha Motor, a leader in the two-wheeler manufacturing segment, has surprised the automotive world by developing a humanoid called Motobot, which is able to ride and maneuver a two-wheeler similar to humans.

This newly developed humanoid is equipped with six actuators and has the capability to ride a motorcycle and at the same time twist the accelerator, brake and change gear transmission similar to the way humans ride a motorcycle. The humanoid consists of an internal data analysis system which obtains and processes information gathered by advanced sensors fitted on the motorcycle and the robot itself. The data gathered helps the humanoid to steer the motorcycle according to the changing track conditions.

The Yamaha team is planning to install a high-precision GPS system, advanced sensors and machine learning systems on the humanoid which will allow it to make its own decisions regarding the track conditions, maneuvering the motorcycle accordingly to achieve high performance and efficiency. The artificial intelligent system will allow the robot to learn and improve its performance and at the same time make autonomous decisions based on real-time data.

The humanoid is designed to adjust itself according to the complex motions of a motorcycle at various speeds and different weather and track conditions. At present, the motorcycle has attached balancing wheels and frames on both sides along with sensors to guide the humanoid during sharp turns and bends. This method also helps to prevent the robot from falling during the testing stages.

Yamaha is also planning to apply the same technology to make new humanoids which will be able to drive other two-wheelers such as snowmobiles and ATVs, and is also aiming to integrate the artificial intelligent systems in industrial robots to increase their performance and efficiency.

Motobot is expected to be adapted for other vehicles and watercraft around the end of 2016 and the company is planning to incorporate Motobot technology into other consumer product projects. Motobot is designed to assist racers in the track during competitions. Conventionally, humans are used for crash and

performance testing of new motorcycles, which might cause injuries to the riders. The humanoids can replace humans for testing new models and designs of motorcycles without endangering lives.

Similarly, companies such as Google. Inc. and DIY consumers have researched new techniques and technologies to implement autonomously driven motorcycles .Google has submitted documents for obtaining permission for testing self-driving motorcycles on public roads. The US Department of Defense (DoD) has also collaborated with key automotive manufacturers to develop humanoids which will be useful for maneuvering vehicles in remote and dangerous places. The vehicles used for defense purposes have also been modified to carry supplies and are equipped with weapons.

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4. ASSISTING SYSTEMS DEVELOPED BY AUTOMOTIVE INDUSTRY

The automotive industry has been constantly implementing new technologies to improve the overall performance of vehicles and at the same time increase the safety of the motorist.

Key automotive manufacturers like Lexus have been working on automatic high-beam control systems. These advanced systems automatically dim and increase the high-beam headlights according to real-time traffic and road conditions. The system consists of advanced sensors and a camera installed in the rear view mirror to detect oncoming traffic and the vehicles travelling in the same direction. According to the data collected by the system, the high beam is switched on and disabled.

Similarly, Mercedes-Benz has implemented an adaptive high beam assisting system in its new E-class vehicles. This system automatically lowers and increases the high beam light distribution according to the distance of approaching traffic. The system also dims the headlights while taking sharp turns and gradually enables and adjusts the high beam to approaching real-time traffic after the turn is completed.

Mercedes-Benz is also currently working on a system called Night View Assist Plus which provides night vision along with pedestrian detection. This system pinpoints and alerts the driver about pedestrians. Bavarian Motor Works

(BMW) is also implementing similar systems to its luxury model vehicles. The pedestrian identifying system shows the direction in which the pedestrian is currently moving. The system alerts the driver using the night vision monitor as well as the head-up display on the windshield as the distance between the vehicle and the pedestrian decreases.

Independent components and parts manufacturers have also been working on optimizing the product's performance and efficiency. Yokohama, a key participant in the tire manufacturing market, has been innovating new methods to increase the performance of its tires. The company has added a number of fin-shaped protuberances to the outside of the tire walls to reduce the vehicle drag and increase the aerodynamic efficiency of the vehicle. When the tires of the car rotate, the fins also rotate to the top of the tire providing suppress lift characteristics and at the same time decreasing the drag of the vehicle.

Automakers like Volvo are developing systems to deal with precise problems faced by motorists.in places like Australia, where many accidents occur due to collision with animals like kangaroos, moose and reindeer. Now, Volvo is currently working on a kangaroo detection system to prevent these collisions. The system consists of a radar, sensors, and an on-board computer to scan for kangaroos and predict their movement paths. The system then warns the driver regarding the animals distance and direction of movement. The system automatically brakes at a reaction speed of 0.05 seconds, which is 24 times faster than that of human reaction speed when a collision is detected by the system. Volvo is currently testing the systems in real-time scenarios and working on optimizing the systems for performing more efficiently and accurately. Volvo is currently testing the systems in real-time scenarios and working on optimizing the systems for performing more efficiently and accurately. Volvo will be installing these new systems in its mid and luxury model segments by the end of 2017.

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5. PATENT ANALYSIS--PROJECTION WELDING

Projection welding is a type of welding process which uses electric resistance to produce welds. Heat is generated from the resistance to the flow of the electric current to weld two components. This method has an efficient power transfer system which makes it easier to weld thick materials together. The heat energy generated depends on the resistance between the electrodes, magnitude and duration of the current set in the machine. The current set in the machine determines the quality of the weld. If the current is less, there is a chance that the weld might not have good penetration strength. If the current is less, there is a chance that the weld might not have good penetration strength. If the current is set high, the weld might appear as beads or might burn through the component or part. Hence, the energy of the current should be controlled properly to achieve good quality weld. The typical projection welding designs are stud-to–plate, annular and embossed.

From the patent analysis on projection welding, it is evident that most of the patents filed are from Japan and the US followed by China and Germany. Key companies such as Toyota Motor Corp. (Japan) and Wuhu Zhongshan Technology Co., Ltd.(Japan) have filed the most number of patents. Most of the patents filed pertain to methods, various types of systems, and apparatus used for projection welding.

A patent (US 20150298245) filed by Hyundai Motor Company (Korea) pertains to a projection welding device which consists of an upper and lower welding tip with a gun body through the shank. The rotation unit for rotating the shank is present between the shank and the gun body. Similarly, a patent (JP 2014223662) filed by Kyokutoh Co Ltd., (Japan) is for a compact projection welding machine in which the internal devices are strong and do not break easily. The patent also illustrates and explains the design of the projection welding machine in detail.

Title	Publication Date/ Publication Number	Assignee	Inventor	Abstract
Projection welding device	Oct 22,2015/ US 20150298245	Hyundai Motor Company	Do-Woon Cho	A projection welding gun device includes an upper welding tip and a lower welding tip that are combined with a gun body through a shank, where the upper welding tip presses an upper panel corresponding to a protrusion portion that is formed on a lower panel to weld the upper and lower panels, and a rotation unit that is rotated by a driving portion is disposed between the gun body and the shank to rotate the shank.
Resistance welding device, resistance welding method, and protrusion shape for projection welding	Oct 22,2015/ WO 2015159907	NSK LTD	SUNAGA Takash	In order to provide a resistance welding device and a resistance welding method whereby a determination can be made regarding join quality during joining of conductors by resistance welding, in order to provide a protrusion shape used in projection welding suitable for determinations about join quality, etc., and in order to improve electrical reliability and mechanical join strength by using the resistance welding device, the resistance welding method, and the protrusion shape for projection welding, when connecting conductors in an electric power steering device: a travel amount measurement unit (1007) is provided in the resistance welding device (1000); the gap between conductors (1004, 1005) to be joined is measured before and after joining; an evaluation is made regarding join quality, on the basis of said gap; and, in order to make securing the gap between the conductors after joining easier, a protrusion (200) comprising a base (210) and a protruding surface (230) is provided in the conductor (1005) to be connected.
Projection welding device and welding method	April 04,2015/ JP 2015071187	AOYAMA SHOJI	AOYAMA YOSHITAKA	PROBLEM TO BE SOLVED: To prevent action of an abnormal external force due to an electrode operation on a steel plate component grasped by a carry-in and carry-out mechanism. **SOLUTION**: In a projection welding device which inserts a shaft-like component 1 into a reception hole 45 formed in a guide pin 31 for positioning and welds the component 1 to a steel plate component 12, a carry-in and carry-out mechanism 13 for the steel plate component 12 is provided, the cary-in and carry-out mechanism 13 is so configured as to hold a part of the steel plate component 12 while grasping the part, and a carrying-out operation of the carry-in and carry-out mechanism 13 is so set that an extraction operation of the shaft-like component 1 is started along an axial direction O-O from the state such that the steel plate component 12 firmly adheres to an end surface 11 of a stationery electrode 100. Consequently, the steel plate component 12 is not deformed by a return operation of the guide pin 31 and so on. **COPYRIGHT**: (C)2015,JPO&INPIT
Projection welding of metal sheets	Mar 19,2015/ WO 2015037986	AL-S TECHNOLOGY B.V.	PIETERMAN, Karel	The invention relates to projection welding of a second metal sheet above a first metal sheet (50), wherein the first metal sheet is of a non-ferrous metal or metal alloy having as main component aluminum or magnesium, wherein the first metal sheet comprises an elongate projection that locally extends above the main upper surface of the first metal sheet to come into contact with the main lower surface of the second metal sheet, wherein the projection comprises an upper surface having a convex first section (65) with a first radius (R1) that defines in its middle the top height of the upper surface with respect to the main upper surface of the first metal sheet, and a convex second section (64) with a second radius (R2) along both elongate sides that merge into the first section, wherein the first radius is larger than the second radius.

Title	Publication Date/ Publication Number	Assignee	Inventor	Abstract
Welding head for projection weld	Dec 08,2014/ JP 2014226699	NIPPON AVIONICS CO LTD	ITO ATSUSHI	PROBLEM TO BE SOLVED: To provide a welding head for projection weld which allows a parallelism adjustment work to be easily performed. **SOLUTION**: The welding head for projection weld includes between a slide shaft and a welding electrode 27, a parallelism adjustment mechanism for respective pressurization surfaces of the welding electrode 27 and a metal to be welded, comprising the following constituents : a) an upper plate 26B for a parallelism adjustment fixed to the slide plate; b) a lower plate 26D for a parallelism adjustment which is so attached to the upper plate 26B that the lower plate 26D is rotatable at a predetermined angle; c) a hard ball body which is interposed between the upper plate 26B and the lower plate 26D and separates both plates from each other by a predetermined distance; and d) a screw for a parallelism adjustment which fixes the upper plate 26B and the lower plate 26D at a predetermined angle. **COPYRIGHT**: (C)2015,JPO&INPIT
Projection welding device	Dec 04,2014/ JP 2014223662	KYOKUTOH CO LTD	KUSANO YU	PROBLEM TO BE SOLVED: To provide a compact projection welding device in which internal devices are less likely to be broken. **SOLUTION**: A projection welding device includes: a lower electrode 5 on which a metal plate S1 is placed; an upper electrode 3 disposed above the lower electrode 5 facing the lower electrode 5 so as to move in a vertical direction; a detection shaft 7 which has a positioning pin 7a, on which a weld nut 10 is fitted, at an upper end and may move in the vertical direction; and a fluid pressure cylinder 8 disposed at the lateral side of the detection shaft 7. The fluid pressure cylinder 8 includes: a cylinder body 81; and a piston rod 82 which expands downward from the cylinder body 81 and contracts. The piston rod 82 is connected with the detection shaft 7 by a connection member 83. An expansion/contraction amount detection sensor 81a capable of detecting an expansion/contraction amount of the piston rod is provided in the cylinder body 81. A control section 9 includes a determination section 9a which compares an expansion amount of the piston rod 82 with a preset reference value to determine whether or not positioning of the weld nut 10 is properly performed. **COPYRIGHT**: (C)2015,JPO&INPIT
Lower electrode device for projection welding nuts of car parts	Aug 06,2014/ CN 103962702	SHANGHAI ANLAIDE AUTO PARTS CO., LTD.	CHEN CHEN	The invention relates to a lower electrode device for projection welding nuts of car parts. The welded nuts are welded on the car parts by the lower electrode device which comprises a positioning pin, a lower electrode, a lower electrode base and a ventilation connector. The positioning pin is mounted into the lower electrode base after being penetratingly arranged on the lower electrode. The ventilation connector is mounted on the lower electrode base. A gap is reserved between the positioning pin and the lower electrode. The welded nuts and the welded car parts are mounted on the positioning pin. In a process of projection welding, gas enters the lower electrode base via the ventilation connector and is blown out via the gap between the positioning pin and the lower electrode, and the blown out gas blows splashes generated during projection welding. Compared with the prior art, the lower electrode device has the advantages of wide application range, high yield, lower production cost, convenience in maintenance and the like.

Title	Publication Date/ Publication Number	Assignee	Inventor	Abstract
Electrode support holding rod for point projection welding	Aug 06,2014/ CN 103962705	SHANDONG AOLIN CAR FITTINGS CO., LTD.	WANG YONG	The invention relates to an electrode support holding rod for point projection welding. The electrode support holding rod comprises a cooling water joint, an electrode support rod, a cooling water pipe, and a bushing, wherein the cooling water joint is arranged at one end of the electrode support rod; the bushing is arranged at the other end of the electrode support rod; the cooling water pipe is located inside the electrode support rod, and is connected with the cooling water joint; the bushing on the electrode support rod prevents the upper diameter of the electrode support rod from being enlarged during the use process due to pressure; as the cooling water pipe inside the electrode support rod is connected with the cooling water joint, the cooling effect is realized by allowing cooling water to enter the electrode support rod. Compared with the prior art, the electrode support holding rod, provided by the invention, has the advantages of stable welding quality, low cost, low repair rate, and the like.
Electrode cap changing tool for projection welding robot workstation welding	Aug 06,2014/ CN 103962711	HANGHAI ANLAIDE AUTO PARTS CO., LTD.	YOU MOXIAN	The invention relates to an electrode cap changing tool for projection welding robot workstation welding. The electrode cap changing tool comprises an initial electrode cap positioning base and an electrode cap fixing stamping rod. The initial electrode cap positioning base comprises an iron support, a nylon base and sensitive steel sheets, the iron support is connected to the upper portion of the nylon base through bolts, the sensitive steel sheets are mounted at the end of the nylon base, and the electrode cap fixing stamping rod comprises a stamping member and rods at two ends of the stamping member. Compared with the prior, the electrode cap changing tool has the advantages of lightweight, durability, safety, reliability and the like.
Projection bolt for thin plate and welding method of the same	Jun 12,2014/ JP 2014109380	AOYAMA SHOJI	AOYAMA YOSHITAKA	PROBLEM TO BE SOLVED: To prevent a thin steel plate from being excessively melted when welding a projection bolt to the thin steel plate. SOLUTION: A projection bolt 1 is formed by a shaft part 2, an enlarged diameter part 3 integral with the shaft part and a welding projection 4. A welding current for melting only the welding projection 4 is applied to the welding projection, a plastic deformation part 7 including a melting part 7A and a softening part 7B is formed between the welding projection 4 and the enlarged diameter part 3, the volume of the plastic deformation part 7 is set smaller than the volume of the welding projection 4, and an inclination angle θ1 of an enlarged diameter part inclined plane 6 is set smaller than a taper inclination angle θ2 of the welding projection 4. Much melting heat is passed through the volume-reduced plastic deformation part 4 and positively transmitted to the bolt to prevent excessive melting of a steel plate component 9. COPYRIGHT: (C)2014,JPO&INPIT

Exhibit 1 depicts patents in projection welding.

Picture Credit: Frost & Sullivan

Back to TOC