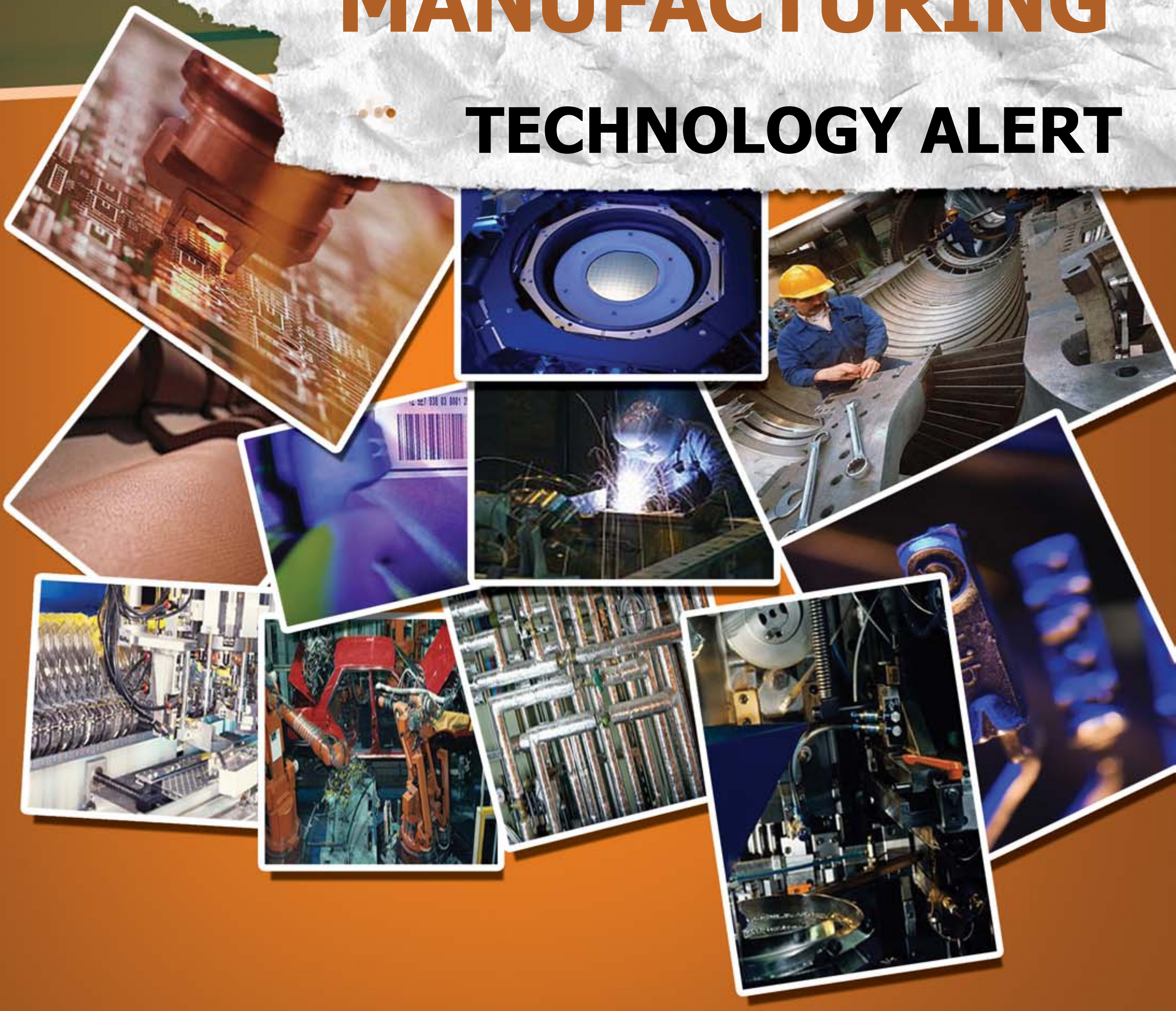
TECHNICAL INSIGHTS

ADVANCED MANUFACTURING

TECHNOLOGY ALERT



21st February 2014

1. AUTONOMOUS ROBOTS FOR CONSTRUCTION ACTIVITIES

Robots have been used for a variety of applications in various industrial sectors. Key industrial applications for robots include material handling, robotic welding, robotic assembly, as well as robotic processing.

A group of researchers from Harvard School of Engineering and Applied Sciences (SEAS) and Wyss Institute for Biologically Inspired Engineering at Harvard University, USA have created an innovative autonomous robot. The system in the new robot eliminates the need for a supervisor or any other form of communication for controlling it. Such autonomous robots have the capability to cooperate with any number of similar robots by modifying their environment.

This robot, named TERMES, has demonstrated that collective systems of such robots would be able to build a three-dimensional structure without having any central command or a prescribed role. The researchers presented the results from this project at the American Association for the Advancement of Science (AAAS) 2014 meeting, which was held in the USA. The results were also published in the February 2014 edition of the magazine, *Science*. According to the researchers, TERMES robots would be able to build structures such as towers, castles, and pyramids made out of foam bricks autonomously. The robots would also be able to build staircases that are required for reaching higher levels and add bricks for building a structure. With these capabilities, the team believes that robots similar to TERMES could be used for laying sandbags in the event of a flood or carrying out simple construction work on Mars. Each of the TERMES robots used for a particular work would execute the process of building in a parallel way with the other robots. This allows the robots to work individually, and if one of the robots breaks, it does not affect the other robots or the entire process. This concept also allows any number of robots to execute the same operation. The algorithms developed by the Self Organizing System Research Group of Harvard University have been employed in this robot, enabling them to work as a colony. TERMES robots have been designed in a way that they can perform all the key tasks such as carrying blocks, climbing structures and attaching blocks. To carry out all the above- mentioned tasks, the robots are equipped with four simple types of sensors and three actuators. This design structure has made the robot more reliable and robust in addition to simplifying the amount of computing that is required for the processor that is fitted on the robot. According to the researchers, this robust design significantly reduces the number of small-scale errors that might arise in the robots. This can also help in detection and correction of errors that might cause the entire system to fail. The novel design approach could also be used for improving efficiency and reducing failures in other robotic systems. This research was funded and supported by the Wyss Institute for Biologically Inspired Engineering at Harvard University. The team is currently working on filing the patent for this novel robot and expects it to be commercialized by 2015.

The advantage of this robot is that, the design approach in simple, making it easy to detect any errors or failures which could lead to the increased performance of the robot. This robot and the other innovative aspects, such as the design and the algorithms used, have potential to be adopted in the marketplace. once commercialized.

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2. BRUSHLESS MOTORS FOR FUEL DELIVERY MODULE IN AUTOMOBILES

Fuel pumps that are employed in automobiles can use a Fuel Delivery Module (FDM) which consists of components that are capable of filtering and pumping the gasoline to the engine at a specified pressure and flow rate from the fuel tank. The FDM consists of a reservoir assembly in order to maintain the supply of fuel at the inlet of the pump; and the other support components are pressure regulators, filters, level sensors in addition to the electrical and hydraulic connections that are made to pass through the tank. The conventional systems that are currently available in the market employ passive electrical components, such as brush pumps and resistive fuel sensors which are connected independently to a control module and voltage supply. There are a few new systems that are currently available in the market which have a voltage controller for modulating the supply voltage to the pump, depending on the speed and design of the engine, thereby increasing the efficiency.

An innovative FDM that has been developed by Delphi Powertrain Systems, Michigan, USA, employs a brushless (BL) motor in the assembly of the pump and also consists of an integrated controller in order to provide the electrical communication for the motor. The BL motors are said to be more efficient that the conventional motors and also the controller in this novel FDM provides a closed loop speed control. These two factors in the FDM are said to provide significant improvements in terms of the power consumed and reduction in the carbon dioxide that is emitted. Other key factors such as durability and reliability are also increased in this novel FDM due to the magnetic coupling that is present between the stators of the motor and rotor which eliminates the contact between them, thereby reducing wear and tear. The integrated controller used in this FDM also provides the diagnostics of the pump, such as a sensor signal processing circuit present within the assembly of the tank, and the additional performance factors of the system. Reduction in noise in addition to the sensorless motor speed measurements are some of the other benefits that are obtained using the BL controller. The BL controller also compensates for the variations in the parameters of the pump and time induced drift. The performance of the system is optimized by minimizing the distance from the integrated FDM assembly and the BL pump. A control algorithm is also incorporated based on the design of and applications of the pump. Factors such as voltage, drive currents, controller temperature, and speed of the motor are also monitored by the controller present in the FDM. The system shuts down automatically when the variations in the above-mentioned parameters are more than the acceptable limits, thereby significantly reducing the risk of damage. Engineers have used robust techniques and statistical tools in order to derive the ideal solution that is required to meet the torque, speed, pressure and flow requirements. The ideal combination was derived from various tests that were carried out in the laboratory using motor assemblies. The company is looking to incorporate this novel FDM in all its powertrain systems by 2015.

The advantage of this FDM is that it provides improvements in terms of the power that is used and also reduces the level of carbon dioxide that is emitted. Due to the above-mentioned advantages, engines having this FDM technology could be adopted on a significant scale.

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3. ADDITIVE MANUFACTURING PROCESS FOR PRODUCING TITANIUM PARTS

In recent times, most spacecraft structures are manufactured using materials, such as carbon/polymer matrix composites. Titanium alloys are only used for a few components, such as brackets, fittings, propulsion tubing lines, and support tubes. The metallic brackets that are used in spacecraft applications are usually machined from bulk rolled or extruded parts of a specific alloy.

A group of researchers from Lockheed Martin Space Systems, Denver, CO, USA have employed an electron beam melting (EBM)-based additive manufacturing process for producing titanium alloy (Ti- 6Al-4V) brackets. These alloy brackets were manufactured, surface finished and then tested in order to determine the mechanical properties when compared with bulk alloys. Before manufacturing the brackets, the computer aided design (CAD) model of each of the bracket drawing was developed in order to include the slightly excess surface layer necessary for machining in order to achieve a smooth surface. The cost and benefit analysis was also performed to calculate the advantages of employing the electron beam melting additive manufacturing process for producing components that could be used for spacecraft applications in the future. The researchers also produced various Ti-6Al-4V rod specimens for carrying out subscale tests to measure the mechanical properties. The results have suggested that the average material properties were relatively comparable to the wrought alloy. All the manufactured parts were also subjected to inspection using non-destructive testing methods, thereby ensuring the quality of the finished part. In addition to the non-destructive testing, a few component level destructive tests were also carried out in order to validate the margin of safety required by the parts to survive various load conditions.

Ti-6Al-4V is seen as an attractive material for use in spacecraft structures as it is light weight and also it has a superior combination of several key properties. Some of these key properties are high strength, low density, high modulus, low coefficient of thermal expansion and higher thermal operational temperature when compared to the aluminum alloys. The researchers also conducted a few other experiments to evaluate the use of electro polishing in order to obtain an acceptable surface. Products that were manufactured using this process were then completely machined to attain the final dimensions in order to gain confidence in using the metal additive manufacturing process for producing parts that could be used for spacecraft structures. The final results from the various experiments have shown that the components produced using this process were of high quality and robust. Four sets of the waveguide brackets produced using this process were then used in the Juno spacecraft and it was seen that the brackets endured successfully to vibration and thermal cycling. The titanium alloy parts produced using the additive manufacturing process could be used on a significant scale by 2016.

The advantages of using additive manufacturing for producing titanium parts is that the lead time is significantly reduced in addition to increasing the productivity rate and quality of the finished product. Due to the above-mentioned advantages, this method has the potential to be adopted by industrial sectors, such as automotive and aerospace for manufacturing various parts and products.

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4. PATENT ANALYSIS OF ULTRASONIC MANUFACTURING PROCESS

Ultrasonic additive manufacturing is also called ultrasonic consolidation. In this process, a delicate welding process is employed to secure strips of metal parts together thereby manufacturing a part containing one sheet of a metal. Ultrasonic additive manufacturing bonds the metal strips together using the ultrasonic welding process, which is solid state welding where a bond is created without the metal being melted. The low temperature used in the ultrasonic welding process eliminates the brittleness that occurs in the layers of metals that are created with other welding processes. This method also allows the metallic bonds to be formed between different metals. Once the first layer is manufactured using the ultrasonic additive manufacturing process, the excess metals are cut away using a CNC mill, thereby completing the cross section. This process is repeated, building the object one layer at a time. The ability of the ultrasonic additive manufacturing process to produce structures having multiple combinations of metals with tight bonds makes it a highly suitable process for manufacturing end use components of high value. The resolution of the metal layer for this process is defined by the feedstock of the material and it could be as thin as a sheet of paper. Some of the commonly used materials in this process are metallic materials, such as nickel, titanium, molybdenum, tantalum, silver, stainless steel, and a variety of aluminum alloys.

The advantages of this process are that the friction caused is significantly low and it has rapid cycle times. Also, ultrasonic additive manufacturing is conducive to joining dissimilar metals.

From the patents that have been exhibited, which pertains to ultrasonic additive manufacturing as well as ultrasonic manufacturing and related additive manufacturing techniques, it can be seen that research is being carried out on the components and techniques that are being used in ultrasonic additive manufacturing to enhance the process, improve the quality of products that are produced and reduce the cycle time.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Ultrasonic probe and manufacturing method thereof	November 12, 2013/ US 8581472 B2	Nihon Dempa Kogyo Co., Ltd.	Yasunobu Hasegawa	A manufacturing method of an ultrasonic probe that has a signal foil made of a copper foil patterned by an additive method is provided. The manufacturing method includes preparing a base material and forming an insulating layer on a surface of the material, patterning the insulating layer by exposure, development, and peeling according to a lithographic technique, forming a cavity reaching an upper surface of the base material in the insulating layer along the patterning, forming a signal foil by performing plating in the cavity in the order of copper plating and solder plating, and demolding the formed signal foil from the cavity.
Extrusion-based additive manufacturing system for 3d structural electronic, electromagnetic and electromechanical components/devices	July 11, 2013/ WO 2013103600 A1	Board Of Regents, The University Of Texas System	Ryan B. Wicker, Eric Macdonald, Francisco Medina, David ESPALIN, Danny W. MUSE	The present invention provides a system and method for making a three-dimensional electronic, electromagnetic or electromechanical component/device by: (1) creating one or more layers of a three-dimensional substrate by depositing a substrate material in a layer-by- layer fashion, wherein the substrate includes a plurality of interconnection cavities and component cavities; (2) filling the interconnection cavities with a conductive material; and (3) placing one or more components in the component cavities.
Torsion sonotrode, ultrasonic welding device and method for producing a welded connection by means of ultrasonic sound	March 28, 2013/ US 20130075454 A1	Telsonic Holding Ag	Albert Buettiker	The invention relates to a torsion sonotrode, comprising two mutually opposing end faces (S1, S2) and a circumferential surface (U) which surrounds a torsion axis (T) and on which at least one working surface (A1, A2, A3, A4) is provided at a radial distance from the torsion axis (T).
System for enhancing sonotrode performance in ultrasonic additive manufacturing applications	January 16, 2013/ EP 2544880 A1	Edison Welding Institute, INC.	Matthew A. Short	An ultrasonic welding assembly, comprising: a sonotrode having a single welding region and two nodal regions formed on either side of the welding region; a mounting plate for supporting the sonotrode having a force application region on the upper surface thereof; at least one ultrasonic transducer connected to the sonotrode; at least one diaphragm spring disposed between the ultrasonic transducer and the sonotrode; at least one roller bearing connected to the diaphragm spring; at least two linear guides connected to the roller bearing, wherein the at least two linear guides are connected to the mounting plate and support the roller bearing and the sonotrode in a flexible manner; and first and second low-friction linear bearings in contact with nodal regions for the application of downward force to the sonotrode, wherein the first and second linear bearings are connected to the mounting plate.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Method for producing a watch case middle of reduced weight	August 8, 2012/ EP 2485099 A2	Richemont International S.A.	Laurent Cataldo, Greg M. Morris, Eli Liechty	A method for producing a watch case middle (10) having reduced weight is disclosed. A 3-D data set is generated for the case middle, the model comprising at least one internal cavity (50) within the case middle. The 3-D data set is converted into a plurality of layers, each layer representing a cross-sectional layer of the middle, and then the case middle is formed layer-by-layer from powdered material using an additive manufacturing process such as DMLS in order to provide the case middle with a unitary construction. Loose powder is removed from each cavity via one or more powder evacuation holes (60,62) formed between the cavity and an external surface of the case middle, and a through hole (40,42) formed through the middle is machined to a desired finish and/or precision, the through hole being designed to receive a control member stem when a watch movement is mounted inside the middle.
Methods for fabricating gradient alloy articles with multi-functional properties	October 30, 2012/ WO 2013112217 A2	California Institute Of Technology	Douglas C. Hofmann	Systems and methods for fabricating multi-functional articles comprised of additively formed gradient materials are provided. The fabrication of multi-functional articles using the additive deposition of gradient alloys represents a paradigm shift from the traditional way that metal alloys and metal/metal alloy parts are fabricated. Since a gradient alloy that transitions from one metal to a different metal cannot be fabricated through any conventional metallurgy techniques, the technique presents many applications. Moreover, the embodiments described identify a broad range of properties and applications.
Methods for fabricating gradient alloy articles with multi-functional properties	October 30, 2012/ WO 2013112217 A2	California Institute Of Technology	BORGONIA, Robert P. DILLON, Eric J. SUH, Jerry L. MULDER, Paul B. GARDNER,	A method of fabricating a multi-functional multilayer article comprising: determining a shape for the article and defining at least two spatially separated regions on said article, said two regions to be formed of at least two distinct materials being joined by at least one compositional gradient transition region;

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Ultrasonically-assisted extrusion methods for manufacturing powdered nutritional products	December 22, 2011/ Abbott Laboratories	Abbott Laboratories	Terrence B Mazer, Gary M Gordon, Rima Tabash	Disclosed are methods of manufacturing powdered nutritional products, including powdered infant formulas and powdered adult nutritional products, using extrusion. The methods include utilizing ultrasonic energy in the extruder during manufacturing. The application of ultrasonic energy to the extruder allows the fat globules present in raw materials to be effectively emulsified by hydrated protein present in the feed stream such that the resulting powdered extruded product has a low free fat level, is less susceptible to oxidation and rancidity, and can be reconstituted without substantial fat separation.
Surface roughness reduction for improving bonding in ultrasonic consolidation rapid manufacturing	May 24, 2007/ US 20070295440 A1	Stucker Brent E, Gabbita Durga J R	Brent Stucker, Durga Gabbita	A method for enhancing the bonding and linear weld density along the interface of material layers deposited in accordance with an ultrasonic consolidation manufacturing process, the method comprising: initiating an ultrasonic consolidation manufacturing process; depositing a first material layer having a contact surface; reducing surface roughness of the contact surface to prepare the contact surface to receive a subsequent material layer, the step of reducing facilitating an increased percentage and quality of material contact between the first and subsequent material layers; and bonding a subsequent material layer to the contact surface of the first material layer, as prepared.
Ultrasonic object consolidation system and method	October 8, 2002/ US 6463349 B2	Solidica, Inc.	Da wn White, David E.E. Carmein	Machine tools combine material addition via ultrasonic object consolidation and subtractive techniques for imparting high-dimensional accuracy to a finished object. A material supply and feeder, ultrasonic horn, and feedstock cutting device are integrated with a material removal subsystem preferably including a cutting tool and an excess material removal system. Any metal, plastic or composite material suitable for ultrasonic joining may be employed as a feedstock, and these material may assume the form of tapes, sheets, wires, filaments, dots or droplets, with the feeding and material cutting components being designed for the specific feedstock employed. The cutting tool for excess material removal, may be a knife, drill/mill, grinding tool, or other tool capable of accurately cutting the external contour of a cross section of the part being built, and for removing excess feedstock remaining following the application process. The material removal could consist of a vacuum or blower system, chip auger, or other suitable apparatus. A machine disclosed as part of the preferred embodiment is able to deposit material in one step, and optionally and selectively remove it in another. Through the expeditious combination of deposition and removal, the fabrication of objects of arbitrary shape may be realized.

Exhibit 1 depicts patents related to the ultrasonic manufacturing process.

Picture Credit: Frost & Sullivan

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