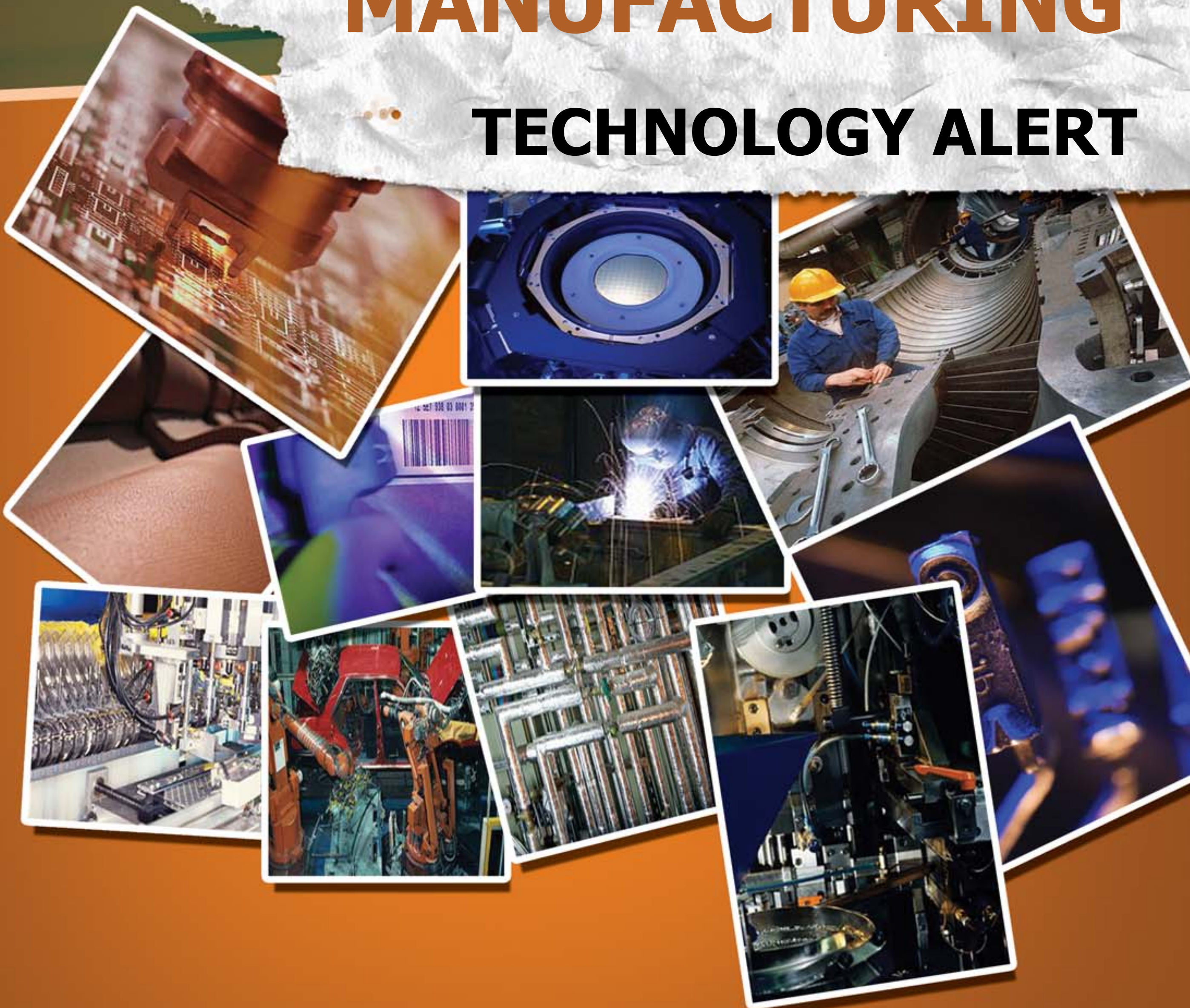
TECHNICAL INSIGHTS

ADVANCED MANUFACTURING

TECHNOLOGY ALERT



27th June 2014

1. MANUFACTURING TECHNIQUE FOR DEVELOPING SOFT MACHINES AND ROBOTS

Innovations in soft materials and microfabrication are spearheading interest in soft machines, which have promise to harness large deformations of soft materials to provide key functionality.

A group of researchers from the department of mechanical engineering of Purdue University has developed a novel manufacturing technique that could be used for developing soft machines that are made of elastic materials and liquid materials. The potential applications for these soft machines are expected to be in areas such as robotics, medical devices, and consumer electronics. According to the researchers, this technique would enable the production of robots with a sensory skin and of stretchable garments that people could use for interacting with computers and other therapeutic purposes. The researchers are also working on developing a fabrication technique that could be used in a custom built three-dimensional (3D) printer. The findings from this research have been published in the June 2014 edition of the *Advanced Functional Materials* journal.

The technique developed by the researchers employs materials such as alloys that are commonly used for manufacturing soft machines. In one of the experiments, embedded liquid alloy-based devices were developed using a silicon-based elastomer called polydimethylsiloxane. Liquid gallium-indium alloy was then used to create patterns of lines for forming a network of sensors. However, the drawback of the gallium alloy is that it forms a thick gallium oxide skin, thereby making it difficult to use conventional liquid processing techniques. Using the novel method, structural stability of gallium oxide has been utilized by the researchers, thereby enabling them to print liquid on a surface. This helps in stabilizing the structure of the product without moving. By employing this method/or technique, the researchers were able to embed the electronics in elastomer without altering the printed structures during the processing steps.

Based on the findings from their experiments, a soft strain gauge was developed using this novel manufacturing technique. As conventional strain gauges are made of rigid thin films, they cannot be used for measuring more than one percent of deformation before breaking, whereas the soft strain gauge developed by the researchers is said to stretch along with the material of the product that is being tested. This feature of the soft strain gauge allows it to measure 100% of the material's strain. Another key advantage of this soft strain gauge is that it can be used for detecting very high strains and also can deform with any material.

Another potential application for novel manufacturing technique is that it could be used for manufacturing sensors. Prototypes of sensors have also been developed by the researchers by using this novel manufacturing process. This method has enabled the digital fabrication of sensors on a micro scale. Pressure sensors, capacitors, and conductors are some of the products that could be manufactured using this novel technique.

One of the advantages of this manufacturing technique is that it could be used for developing new types of soft microelectromechanical systems (MEMS) that are commonly used in consumer electronics, automotive airbags, and other products, which are currently made with solid metals. This development of soft MEMS could have a lot of novel applications in the future. However, new manufacturing techniques are required before soft machines can become practical on a commercial scale. Due to the above-mentioned advantages and capabilities, this manufacturing technique could be adopted for manufacturing various products that are used in different industrial sectors.

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2. MANUFACTURING METHOD FOR DEVELOPING THIN FILMS AND TRANSISTORS

The appearance of organic thin film transistors and circuits in industrial products has been constrained due to challenge sin attaning the required device performance along with with high-volume production methods.

Researchers from the VTT Technical Research Centre, Finland have developed a novel method for manufacturing thin films using a roll-to-roll technique alone. Using this method, thin films can be manufactured using roll-to-roll techniques, such as, printing, for depositing the pattern on the substrate layer of the film. According to the researchers, this new method is expected to increase the potential range of thin films that are used in electronic components and products, with a significant reduction in the production cost for the companies. For instance, the thin films manufactured using this novel method would be more suitable than conventional silicon chip transistors for applications such as large surface displays, certain sensor applications, toys, games and smart cards. Another potential application for this method is the manufacturing of transistors. Transistors are electronic components that are meant to work as memory elements, amplifiers, and electronic switches. Currently, transistors are being made by partial roll-to-roll technique, which results in high production costs. This new roll-to-roll manufacturing technique is more advantageous for transistor technology because of the possibility to use large surface areas, mechanical flexibility, transparency and low production start-up costs.

The researchers at VTT have developed this roll-to-roll manufacturing method from the European Union (EU)-funded POLARIC (Printed Organic and Large-Area Realisation of Integrated Circuits) research project, which concluded in 2013. By using a special aligning technique, this new method has the potential to do away with the challenges of aligning the patterns in different thin layers accurately against each other in the roll-to-roll process. The other key benefit of this method is that the pattern size of the components that can be manufactured is significantly reduced, thereby increasing the range of thin films that can be manufactured for electronic products.

Production of thin films using the new method is one of the first experiments that the researchers have undertaken to test the new process. They are currently working on using this manufacturing method to develop more complex electronic circuits for various applications. Researchers are also in talks with various industry participants for further developing applications based on the printed thin film transistors. This new method is expected to be commercially available by 2016 for large-scale adoption.

Some of the advantages of this method are that it reduces the production cost and also increases the range of applications where thin films could be employed. As the size of electronic components has reduced significantly, this new method would help in developing thin films for electronic devices and products that are small in size.

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3. STUDY TO MAKE ROBOTS SAFER FOR WORKING WITH HUMANS

There has been a significant increase in the collaboration between robots and humans over the past few years. This trend is expected to increase further in the coming years with industries becoming automated and greater employment of more intelligent, envronmentally-awre robots in shop floors and in other manufacturing activities. There is an urgent need to evaluate the risk factors in the case of an accident due to the robots colliding with humans. There are have been no extensive studies so far to analyze the above-mentioned risk factors.

Researchers at the Fraunhofer Institute for Factory Operation and Automation IFF in Magdeburg, Germany have carried out a study for precisely analyzing the thresholds of biomechanical loads resulting from collisions between robots and humans. In this research, a pendulum was loaded with various weights and was pulled back and allowed to hit against different body parts of the humans. The pendulum's face was attached with a special sensor for measuring the distribution of pressure resulting from the impact. A force sensor, which was also located on the impact face, was used to measure various factors such as characteristic of the contact force, the maximum applied force, and the time of action. This has enabled the researchers to measure all the relevant parameters such as force, pressure distribution, impact velocity, momentum, and energy.

During the initial phase of the study, the researchers developed the measurement system and then refined the methodology for accurately analyzing the impact. Currently, they are working on producing the results from their first findings based on several participants in a preliminary stage. One of the potential market sectors expected to significantly gain from this study is the consumer sector, where robots have potential to be employed for carrying out a variety of household activities. Using the findings of this study, the robots can be made safer for the household activities in the future, thereby increasing the adoption rate of robots in the consumer sector. Fraunhofer IFF is also obtaining fundamental data in its study, the results of which would be incorporated in international standards. Robots developed incorporating the key findings from this study are expected to be available in the market for adoption in the coming years

One of the advantages of this study is that it would help in developing robots that would be safer for humans, thereby increasing the potential application sectors for robots. This study addresses the increased need for safer operation between robots and humans.

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4. PATENT ANALYSIS OF EXPLOSIVE WELDING PROCESS

The explosive welding process is a type of cold state welding process in which the welding joint is created by employing a controlled high velocity that is produced by an explosion or detonation. This welding process is used on a large scale for cladding low-cost carbon steel with expensive corrosion resistant materials. The clad plate developed using this welding process is usually employed as tube sheet for heat exchangers in the chemical and petrochemical industries. In this type of welding process, the metal to be welded is placed below a parallel metal, which is used as an explosive in this process. The parallel material is provided with a piece of buffer that is usually made of rubber or cardboard, which protects the surface of the parallel material during the explosion. The material to be welded, also known as the parent material, is placed on the anvil of the welding machine. The explosion is carried out by igniting the detonator. The velocity during detonation is less than the sonic velocity that is observed in both the materials. During the explosion, significantly high pressure is generated, which causes a relative shear or sliding pressure between the materials. Due to the relative motion, a high velocity is formed on the surface of both the metals. This velocity aids in producing the welding joint between the two metals. One of the advantages of this welding process is that it can be used for welding dissimilar metals and large surfaces, without damaging the surface properties of the parent material.

From the patents that have been exhibited, it can be seen that the companies and universities are carrying out research for developing this technology to make it suitable for welding varied materials, for example, zirconium-steel-zirconium 3 layer pipe or C276 nickel-based alloy clad steel plate. The patents also pertain to such areas as an explosive welding least charging method that provides low energy consumption and improved quality of the compound plate and to applications for explosive welding such as forming an explosion welded gas turbine shroud segment.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Explosive welding least action charging method	October 17, 2012/ CN 102873453 A	PLA University of Science	Xiong Yun, Li Hongwei, Wang Yu	In an explosive welding process, the collision energy of a substrate and a compound plate interface is overlarge to enable the interface to generate a superfusion phenomenon if the charging amount is overlarge, so that a bonding interface generates various defects to lower the interface intensity so as to greatly lower the quality of the compound plate. The principle of least action is embodied as the principle of lowest energy consumption in the physical process of explosive welding, i.e., the best bonding quality can be obtained with the minimum interface bonding energy, or i.e., the best bonding interface can be obtained by the minimum charging amount. A least action charging method is applied in the explosive welding technology, the charging amount is greatly lowered, the production cost is lowered, in addition, the quality of the compound plate is improved, and meanwhile, various key problems relating to the explosive welding are simplified. The explosive welding least action charging method is characterized in that the charging amount is selected according to the lower limit least value, and an interval between the two plates is selected according to an upper limit maximum value.
Process of forming an explosion-welded gas turbine shroud segment	February 17, 2012/ EP 2492450 A2	General Electric Company	George Goller, Bill Damon Johnston, Srikanth Kottilingam, Melbourne Myers, Daniel Nowak	An explosion-welded turbine shroud (100) and a process of forming an explosion-welded gas turbine shroud are disclosed. The explosion-welded gas turbine shroud (100) includes a first alloy (102) explosion welded to a second alloy (106). In the explosion-welded gas turbine shroud (100), the first alloy (102) forms at least a portion of a hot gas path (101) or an expansion region (105) of the gas turbine shroud (100) includes the first alloy (102). The process includes explosion welding a first alloy (102) to a second alloy (106) to form the gas turbine shroud (100).
Explosive welding method for zirconium-steel-zirconium three layer pipe	May 19, 2010 /CN 101837512 B	Nanjing three State Metal Composite Material Co.,	Zhoujing Rong, Deng Ai, Chenshou Jun	The invention relates to an explosive welding method for a zirconium-steel-zirconium three layer pipe. An outer zirconium pipe in an outer zirconium pipe-steel pipe-inner zirconium pipe has the diameter of 60-505 mm and the thickness of 1-8 mm, and a steel pipe has the diameter of 55-500 mm and the thickness of 8-200 mm; the inner diameter of the steel pipe is 4-6 mm larger than the outer diameter of an inner zirconium pipe, and the inner diameter of the outer zirconium pipe is 4-6 mm larger than the outer diameter of the steel pipe; the inner diameter of the inner zirconium pipe is 10-15 mm larger than the maximal diameter of a buffer cone; the explosive welding method comprises the following steps of carrying out the surface treatment and alignment of a base pipe, treating the zirconiumpipe; guaranteeing the straightness of the zirconium pipe; assembling which comprises the steps of matching, vertically mounting the inner zirconium pipe, the outer zirconium pipe and the steel pipe on a technological bottom plate and mounting a pressure reduction cone at the center inside the inner zirconium pipe; carrying out re-explosive-cladding which comprises the steps of horizontally placing the device assembled on an explosive table, additionally mounting a pipe-shaped outer frame at the outer part of an outer steel pipe, and uniformly placing explosives around the pipe-shaped outer frame and the buffer cone of the inner pipe and denotating through detonators placed at the top of the buffer cone; and firmly binding the surfaces of the zirconium pipe and the steel pipe under high braking pressure.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
An arrangement for explosion welding a hot gas component of a turbine and a method thereof	April 1, 2009/ WO 2010115812A1	Siemens Aktiengesellschaft	Andreas Graichen	The present invention explains explosion welding of the hot component parts (2) of a turbine or power plants. The arrangement includes a cladding material (1) deposited onto a surface (9) for welding associated with the hot gas component (2) and an explosion material (3) laid on top of said cladding material (1) and finally an ignition means (4) is used to ignite the explosion material, wherein a welding is made possible when an explosion is performed.
Explosive welding method of C276 nickel-based alloy clad steel plate	December 08, 2008/CN 101559517 A	Sichuan Jinglei Science and Technology Co., Ltd.	WANG Dian Chan	The invention relates to an explosive cladding process for metals. The process is characterized by comprising the following steps: substrate treatment, composite treatment, applying and pairing, explosive cladding, repair welding, heat treatment and post-treatment. The process can help clad C276 nickel-based alloys with general steel plates effectively so that the clad steel plates can have the required strength on the premise of owning all the advantages of the C276 nickel-based alloys, thus saving consumption of expensive metals. The clad steel plates have high welding quality, and can certainly remain stable in long-term use without sealing off.
Special explosive for explosively welding noble metal composite material and preparation thereof	October 14, 2008/ CN 101412650 B	Luoyang dual Swiss Metal Composite Material Co..	Yuezong Hong, Xin Bao, Deng Guangping	The invention discloses a detonator which is specially used for explosive welding and has a cladding layer made of copper, copper alloy, aluminum, aluminum alloy, titanium, titanium alloy and other noble metal composite materials and a manufacturing method thereof. The detonator comprises the following compositions in mass portion: 64 to 75 percent of ammonium nitrate, 2 to 3.5 percent of composite oil phase, 2.5 to 3.5 percent of wood powder, 15 to 30 percent of salt and 1.5 to 3.0 percent of hollow glass microsphere. Firstly, the ammonium nitrate is subjected to swelling treatment; secondly, swelled ammonium nitrate in a wheel mill is mixed with the composite oil phase, the wood powder, the salt and the hollow glass microsphere; and finally, a material is discharged at the temperature of 40 DEG C below zero to obtain the product. The detonator does not contain a composition of TNT, stable explosive performance, low cost for the raw materials and simple manufacturing method, and is suitable for industrialized production; and an interface of the noble metal composite material for explosive welding has high bonding rate and bonding strength.
Explosive welding device for bulk amorphous alloy and common metal	April 18, 2008/ CN 101559516 B	Beijing University	Valence, Liu Kaixin, Li Xiaojie, Yan Hong Hao	The invention discloses an explosive welding device for a bulk amorphous alloy and a common metal, and belongs to the technical field of welding. The device comprises a welding base plate which is a chopping block with a groove. The bulk amorphous alloy is embedded into the groove of the chopping block so as to limit deformation of the alloy during an explosive welding process. The chopping block is made of a material having wave impedance matched with that of an amorphous alloy plate so as to prevent brittle fracture caused by bounce of the amorphous alloy plate during the explosive welding process. The length direction of the groove arranged on the chopping block is perpendicular to a sliding explosion direction so that the brittle fracture of the amorphous alloy plate is prevented during the explosive welding process. The device has advantages of keeping non-equilibrium constant and integrity of the amorphous alloy and welding the bulk amorphous alloy and the common metal together in large area.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Explosive welding process of ultrathin coherer Composite panel	July 11, 2007/ CN 100515649 C	Changgen	Changgen	The present invention is a thin metal composite explosive welding apparatus and method. Thin metal composite explosive welding, characterized wherein complex boards, substrates middle gap and placed in parallel on a steel base; steel base is under Chaki; complex board coated with butter, and with the kit attached to the together; kit filled with dynamite inside; explosives with detonators on. Advantages of the Invention: The present invention uses the ratio of explosive charge critical minimum thickness can be achieved not only explosive welding thin metal material, and the success of thin metal composite explosive material does not produce bending, surface is not damaged by the explosion.
Composite explosive welding explosive charge from ammonia oil for low-explosive speed steel plate	October 14, 2005/ CN 1778777 A	Four Southern Red Chemical Co., Ltd.	Zhang Haibin, Zhu Xuejiang	A composite explosion welding powder with eucalyptus oil for low explosion speed steel plate is prepared by taking ammonium nitrate 80-94 proportion, surface activator 0.1-1 proportion, loose inflammable agent 2-12 proportion and fuel oil 0.5-3.5 proportion and mixing proportionally. Its advantages include low cost, no environmental pollution and need for diluting agent and easy control for components, water content and fineness.
Method of explosive welding	February 13, 2004/ WO 2004073913 A2	Ball Burnishing Machine Tool L, Linzell Geoffrey Robert	Linzell Geoffrey Robert	The practical usefulness of impact welding of metals is limited by difficulties associated with applying an intense pulse of energy, to accelerate and impact one body against another at velocities of about 300m/s colliding at an oblique angle averaging 8°. This invention employs a chemical agent to treat surfaces to be welded with a chemical agent that, during the welding cycle, releases chemical elements that scavenge oxygen and diffuse into treated surfaces and which lowers the velocity to weld to typically below 150m/s (and therefore lowers the energy to weld); the reduced velocity to weld reduces jet cleaning efficiency, which is offset by aligning the micro roughness on the two surfaces with the direction of travel of the weld front. The process is useful for first - reducing overall energy to weld, and second - reducing local energy to weld where welding energy is marginal, at for example the start/finish split of an induction coil in electro magnetic impulse propulsion.

Exhibit 1 depicts patents related to the explosive welding process.

Picture Credit: Frost & Sullivan

Back to TOC