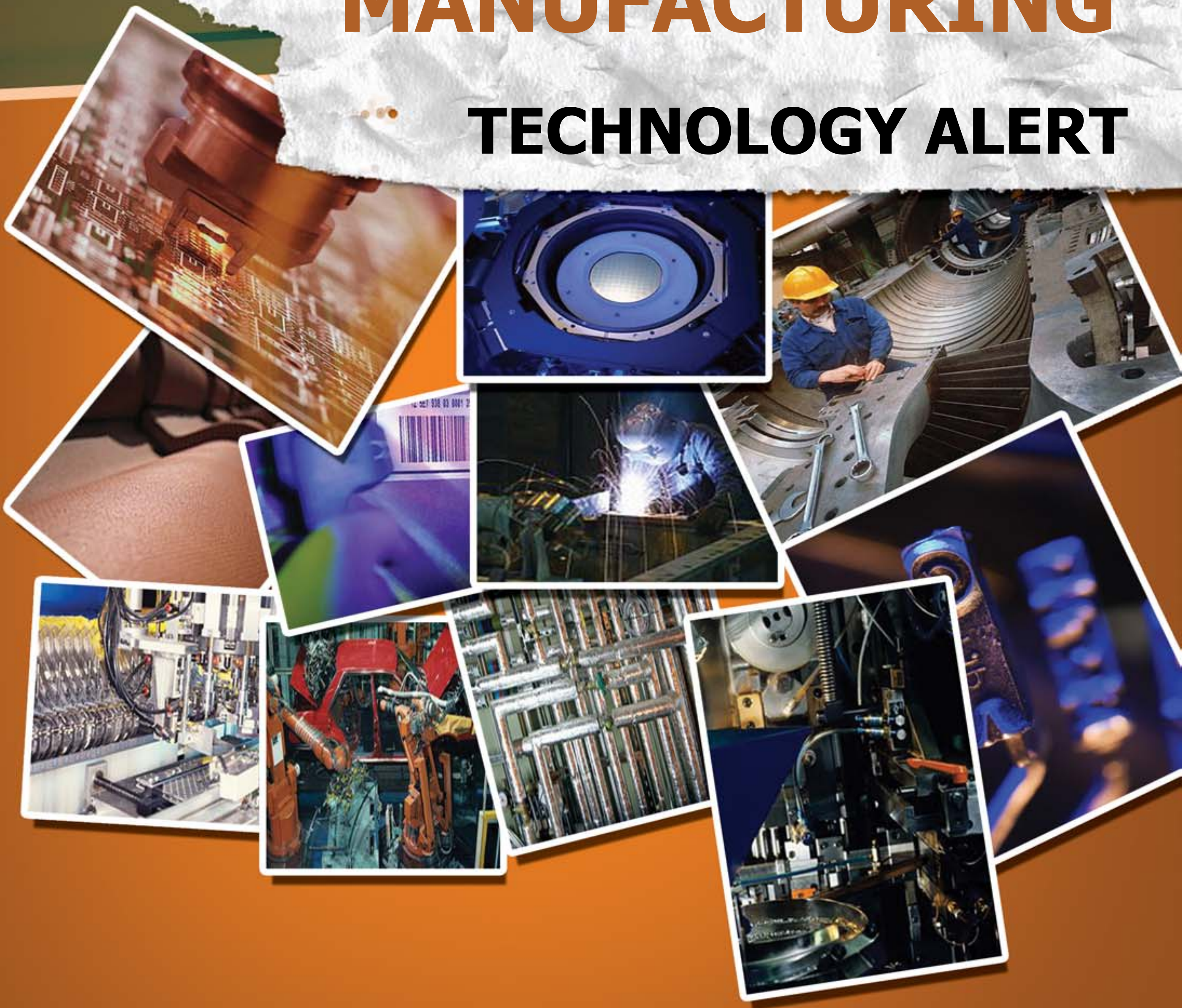
TECHNICAL INSIGHTS

ADVANCED MANUFACTURING

TECHNOLOGY ALERT



01st August 2014

1. ROBOTIC RIVETERS APPLIED TO AIRCRAFT ASSEMBLY

The Boeing Company (with headquarters in Chicago, Illinois; and major aircraft assembly plants around Seattle, WA) has been looking for a way to speed up the assembly line to service a growing order book. The fuselage and other commercial airliner structures are typically riveted manually with a 2-worker team: the pneumatic rivet machine operator on the outside of the fuselage and a skilled "rivet bucker" inside. The inside employee holds a bucking bar that deforms the tail of the rivet coming through, work on hardening it and pulling the assembly tightly together.

Multiple sheet aluminum components and layers are fastened together in this fashion. The rivets not only pull and hold components in a vertical plane, they provide essential resistance to shear forces that want to slide sheet components apart, in a sideways motion. The traditional manual riveting can become a bottleneck in the assembly process, and requires costly well-trained workers with several years of hands-on experience.

In the largest change to its airliner assembly line methods since the birth of the 707 in the 1950s, Boeing is planning to proceed with robotic drilling/riveting (or robotically aided assembly) for fuselages: a major development in aircraft manufacturing. The priority is streamlining production on the 777 wide body (starting in 2015) and 737 narrow body lines. The 777X will receive this robotic assembly process in 2017. The benefit is a 45% to 50% reduction in flow time, compared to previous methods. Boeing created in secrecy (since a 2012 start) its FAUB (fuselage automated upright build) system, which resembles automotive practices. Robots on both the inside and outside of the fuselage work together. Sensors on each side guide the drilling/riveting/bucking process.

The robots are sourced from KUKA Robotics USA, the North American operation for KUKA Roboter GmbH in Germany. Boeing employees visited KUKA in Shelby Township, MI (near Detroit) for training at KUKA University. The company managed to replicate perfectly the actual techniques and steps used by Boeing manual riveters, with the assistance of Boeing mechanics. Even with advanced training, it will take 1 year for Boeing staff to fully transition to robotic drilling/riveting. The first focus will be on assembly of forward and aft sections of the fuselage, which have tight spaces. The middle fuselage sections are easier for manual drilling/riveting so will be the last to be automated.

Tests are under way now to confirm that robotic rivets are not inferior to manual rivets. Engineers will examine fatigue performance and other structural aspects. Fewer people will be needed to assemble these aircraft, but the freed-up employees have plenty extra to do with the 777X program coming soon. The 777X twin-aisle airplanes will be ultra-efficient and have lower fuel consumption. The ultimate goal is to boost build rates (to better align with orders), which may create extra jobs.

Details: Elizabeth Lund, 777 VP and General Manager, Boeing Company, 3003 W. Casino Rd., Everett, WA 98204. Phone: 425-342-2121. URL: www.boeing.com.

2. ADVANCES IN ADDITIVE MANUFACTURING OF LARGE-AREA POLYMER PARTS

Cincinnati Inc. (CI) has made a splash this year (2014)) with demonstration of a large-area (up to tens of feet) polymer additive manufacturing machine, which will be commercially introduced at the 2014 International Manufacturing Technology Show (September 8 to September 13 at McCormick Place in Chicago, Illinois). The goals are printing speeds 200 to 500x higher than prior art, producing polymer parts 10x larger than those currently producible.

In the machine tool business continually since 1898, CI has evolved into a builder of newer manufacturing tools, such as: computer-guided laser cutting machines, automated composite pre-preg gantry-type tape layers for 3D aerospace structures, as well as 3D printers for polymeric materials and powder metal compacting presses. 3D printing is also known as additive manufacturing--

where thin layer after thin layer is built up into a finished part over time with a good finish, high accuracy, and high repeatability with no material waste. It does take time to print parts, but is well suited to generation of prototype parts, tooling, and limited production runs. Hollow parts can be generated in hours while larger solid parts typically could take days.

CI formed a partnership, or cooperative research and development agreement (CRADA), with the US DOE’s Oak Ridge National Laboratory (ORNL) in February 2014 to further develop this large-area additive manufacturing process. CI has already furnished many other machines (over 40) to ORNL over the years for R&D purposes, so a solid relationship already existed. CI will support the US Department of Energy (DOE)'s 'Clean Energy Manufacturing' initiative, designed to increase the efficiency of US manufacturing and promote development of innovative technologies. ORNL is not content to show or develop innovations, as the lab wants to move such innovations into real industrial applications. ORNL has also teamed with Lockheed Martin, a major aerospace contractor and hardware manufacturer, that envisions 3D printed pieces with dimensions up to the range of 60 to 100 ft.

Exhibit 1 depicts the prototype of the Big Area Additive Manufacturing Machine (BAAM).

Picture Credit: Cincinnati, Inc.

Fast linear motors, proprietary to CI, are a key to success in precisely covering large areas (envelopes up to 8 ft. x 20 ft. in the prototype machine). The laser melter movement rate is an exceptional: 2 Gs of acceleration, 10,000 inches/minute (equal to 9.5 mph, more than a brisk walk) with accuracy of plus or minus 0.001 inch in each axis. The prototype 3D printing machine uses the gantry frame and drives from a laser cutting machine as a baseline, plus a safety enclosure and other required features for additive manufacturing. A plastic pellet feed system plus special control software and operator displays have been incorporated.

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3. GENERAL ELECTRIC ADVANCES MANUFACTURING OF TURBOFAN ENGINE METAL PARTS

GE Aviation and its JV partner CFM International, both major turbine aircraft engine producers, are applying advanced additive manufacturing (also known as three-dimensional [3D] printing) methods) to the production of complex metal alloy parts. This places GE Aviation ahead of its competitors, such as Rolls-Royce in UK, as well as the Pratt & Whitney unit of United Technologies based in Connecticut, regarding real production applications for additively manufactured metal parts. The competitors are just now considering metal parts, while GE is flight-qualified and ready for serial production.

An example of GE dividing its R&D tasks to good effect is how the company created additive manufactured metal parts for production turbofan aircraft engines at GE Aviation. Although the Niskayana, NY corporate R&D facility has a world-class group doing basic research on 3D printing/additive manufacturing, the GE Aviation unit wanted to go to market with real metal parts in production turbofan engines ahead of rivals. In consultation with GE Global Research, GE Aviation acquired an up-and-coming player developing additive manufacturing technology, Morris Technologies. Morris was already working with GE Aviation. With that quick infusion of special expertise, GE Aviation rapidly developed and flight-qualified complex metal high-temperature fuel nozzles for the new CFM LEAP turbofan engine going into serial production by 2016. It is understood that GE Aviation is using the advanced ProX 300 additive manufacturing direct metal sintering (DMS) machine from 3D Systems with a 500 watt laser melter, based on technology acquired in 2013 from Phenix Systems of France. That laser beam can rapidly scan and melt powders on the target work piece at 3 meters per second.

The near-net-shape method of part production (additive manufacturing) used by GE Aviation reduces material requirements by about 75% (thus, a dramatic reduction in the material buy-to-fly ratio), simplifies parts (the fuel nozzle for the LEAP combined 18 parts into 1, with 19 per turbofan engine), reduces part weight by 25% (helping diminish fuel burn) and can deliver up to 50% reduction in finished part production time and cost. The 3D-printing/additive process eliminates casting, welding, brazing, cutting, and machining. GE is laser-melting cobalt-chromium (F-75 alloy) metal powders, thin layer by thin layer, for its fuel nozzles. A CAD (computer-aided design) file drives GE's 3D-printer. The fuel nozzle application is so hot (up to 3,000 degrees F) that internal coking of hydrocarbon (kerosene) fuel into carbon deposits frequently occurs, reducing conventional nozzle performance. GE's creative solution for the additive manufactured fuel nozzle was to build-in cooling passageways: elimination of coking was demonstrated in rig tests on prototype LEAP turbofans.

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4. PATENT ANALYSIS OF COLD PRESSURE WELDING PROCESS

Welding processes usually employ heat or a combination of both heat and pressure for welding two material parts. The cold pressure welding process is one of the welding processes where there is no heat employed at all for carrying out the welding activity. The principle of this welding process is that the work pieces are welded together by applying a pre-determined force. When force is applied, the deformation of plastic occurs, which causes the residual oxide layers to be pressed out and a metallic bond is created. This type of welding is used for work pieces that are made of materials such as copper and aluminum. Before the welding process is carried out, the grease and oxides from the surface are removed using wire brushing. A thin layer of grease is applied on the surfaces of the work pieces to be welded in order to increase the contact between the work pieces. Both butt and lap joints can be welded using the cold pressure welding process. This method is commonly employed in the manufacturing of electrical components and in the manufacturing of industrial packaging. The parts to be welded are first cleaned; then shearing is done to a short section of the part that is to be welded. Now the parts are placed between two die clamps, which are already set up at a particular extension. Once they are held in the die clamp, a pre-determined forging force is applied in order to weld the two parts together.

Some of the advantages of this welding process are that it can used for welding nano structures; and, since this process does not does involve any heat, it is highly suitable for manufacturing of electronic components without breaking them. From the patents with regard to this technology profiled in the exhibit include a foil coiling machine with a cold pressure welding device to replace traditional pneumoelectric welding for connecting copper (aluminum) fils and copper (aluminum) bars; solid-phase welding of aluminum-based rotors for induction motors; and a cold welding machine to weld the formation of a fuse in lithium battery production.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Foil-type coiling machine with cold pressure welding device	May 27, 2011/CN 102315013 A	Liaoning Xintai Co., Ltd.	Wen Dianchen	The invention discloses a foil-type coiling machine with a cold pressure welding device. A cold pressure welding mode replaces the traditional pneumoelectric welding mode for connecting outgoing lines of workpiece copper (aluminum) foils and copper (aluminum) bars; copper (aluminum) metals are subjected to plastic deformation only by means of pressure without any external heat source, so that oxide films and other impurities between welding joints are extruded out, thus the pure metal forms solid welding, thereby ensuring the product quality of coils. A foil material feeding device, a foil material decoiling device, a deflection regulating device, a pre-welding cleaning device, a cold pressure welding device, an edge belt decoiling device, a layer insulation transmission device, an insulation shearing device, a coiling device, a layer insulation decoiling device, a trimming device, an end supporting device, a release plate recoiling machine and other components are connected with a main framework, and control signal output and input ends of the coiling machine are connected with control signal output and input ends of a control device; and the stepless frequency control of a motor is controlled through a Siemens motion and vector control module.
Solid phase welding of aluminum-based rotors for induction electric motors	August 31, 2010/US 20120049687 A1	Richard J. Osborne, Qigui Wang, Yucong Wang	Gm Global Technology Operations, Inc.	Squirrel cage rotors of aluminum end rings solid state welded to aluminum conductor bars for use in electric motors and methods of making them are described. In one embodiment, the method includes: providing a laminated steel stack having a plurality of longitudinal slots; placing a plurality of aluminum conductor bars in the longitudinal slots, the conductor bars having first and second ends extending out of the longitudinal slots; contacting the first and second ends of the conductor bars with a pair of aluminum end rings under pressure; and oscillating the first and second ends of the conductor bars, the end rings, or both to form an oscillation friction weld.
Cold welding machine	February 8, 2010/CN 101791742B	Shenzhen Polytechnic	Liu Xianming, Zhong Jian, Chen Wei	The invention discloses a cold welding machine suitable for welding formation of a fuse in the lithium battery production. The cold welding machine mainly comprises a wire feeding mechanism, a pole piece positioning and driving mechanism, a welding formation mechanism and a solder spraying and reclaiming mechanism, wherein the wire feeding mechanism is driven by a step motor to feed wires, and meanwhile the pole piece positioning and driving mechanism delivers pole pieces to the welding formation mechanism to align with the solder wires accurately so as to realize the welding formation. The solder spraying and reclaiming mechanism is used for spraying the solder and reclaiming a part of solder during welding. Experiments show that the cold welding machine has the advantages of high intellectualization, accurate formation, good environment-friendly performance, high manufacturing yield and certain practical significance.
A process for continuous welding a composite pipe with outer stainless cladding layer	September 29, 2007/WO 2009003326 A1	Biao Yan, Mengjie Yan	Biao Yan, Mengjie Yan	A welding system (10) is disclosed. The welding system may have a power supply (18), a forging arrangement (16) configured to hold and move ends of two components (12, 14) to be welded together, and a plurality of contacts (25) connecting the power supply to the two components. The welding system may also have a controller (20) in communication with the power supply and the forging arrangement. The controller may be configured to regulate the power supply to selectively operate in a constant voltage mode and a constant current mode during different stages of a single weld cycle, and to actuate the forging arrangement to move the ends of the two components together during a final stage of the single weld cycle.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Roller type cold rolled sheet dislocation and location machanism	September 7, 2006/CN 100443249 C	Lin Qinghai, Xue Xiaohan	Dalian Bao Tong Industrial Control Ltd.	One kind of cold-rolled plate roller dislocation positioning mechanism comprises a rack and assembly of its upper and lower rollers and transition rollers, upper and lower limit roller, its technical points are: in the idler roller of the transition and between the roller and the roller misalignment between at least one pair of locator, locator each dislocation of the C-type limit slot opening frame assembly lower positioning rollers, limit shelf above the top of the opening assembly of the upper trough positioning wheel, and to the upper and lower rollers positioned on the opposite side in the circumferential cut in the same vertical plane. Its simple structure, reasonable design, using the same limit will be two shelves two rollers positioned staggered butt cold-rolled sheet, with a small friction, moving fast, accurate positioning advantages of long life, virtually eliminating the existing There can not be a continuous positioning technology exists and send ills butt cold rolled sheet, cold-rolled sheet effectively complete butt before welding continuous positioning, long distance transmission, help to improve the laser butt welding quality cold-rolled plate.
Cold-compression welding wire machine	April 12, 2006/CN 100503129 C	Zhe Wang, Xu coach	BYD Company Limited	The invention provides a welding electrode will be cold welded wire bonding residues machine. The cold welding machine comprises a welding electrode made of a ceramic material. In this cold welding machine, welding electrode as prepared by the ceramic material, and metal wire material quite different chemical structure and smooth ceramic surface, so sonotrode normal circumstances would not bonded with solder residue together, so as not to affect the next weld, the welding efficiency can be improved, and the welding quality.
Compression and cold weld sealing methods and devices	November 04, 2005/CN 101080359 A	Jonathan · R. · Kepei Ta	Micro-chip companies	Providing the pressure-cold welding method, connection structure and vacuum sealed accommodating means. The method includes providing a first substrate, the first substrate comprises a first metal having a first coupling surface composed of at least one first connection structure; providing a second substrate, the second substrate comprising a second metal having a second connecting surface formed at least one second connection; the at least one first and the at least one second connecting structure connecting structure pressed together, so that the connection surface of the contact surface in one or more locally deformed and shear, the overall effect is reached in the bonding surface between the first metal and a second metal to form a metal-to-metal binding. Overlapping at the connecting surface effectively removes surface impurities, without heat input in the case of connection between the surface generated conveniently close contact. Vacuum sealing means may comprise pharmaceutical ingredients, biosensors, or MEMS devices.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Multifunction hydraulic head suitable for being applied to machines for bending and forming metallic sheets	June 27, 2005/US 20090282886 A1	Luigi Patuzzi	Finn-Power Oy	A multifunction hydraulic head for use with forming and bending machines for sheet metal and/or metal profiles is equipped with carriages (**15**) that slide horizontally on guide and shift shafts. Each carriage (**15**) of the said machine is equipped with a bracket (**17**) that is integral with the respective carriage, the bracket supporting the interchangeable work assemblies (**18, 19, 20, 21**) which include a mobile matrix (**22, 24, 26, 28**) and a fixed pressing unit (**23, 25, 27, 29**); furthermore, the sheet metal (**11**) is inserted between the matrices and the pressing unit of the installed unit, to be spot processed by the said work assemblies in accordance with the desired shape.
Liquid phase diffusion bonding method of metal machine part and such metal machine part	June 2, 2004/US 7804039 B2	Yasushi Hasegawa, Ryuichi Honma, Yutaka Takagi	Fukuju Industry Corporation Ltd, Nippon Steel Corporation	A liquid phase diffusion bonding method for a metal machine part superior in the quality of the joint and the productivity enabling the bonding time to be shortened, achieving homogenization of the bonding structure and improving the tensile strength, fatigue strength, and joint quality and reliability. This liquid phase diffusion bonding method of a metal machine part is characterized interposing an amorphous alloy foil for liquid phase diffusion bonding at bevel faces of metal materials, performing primary bonding by melt bonding said amorphous alloy foil and said metal material by resistance welding to form a joint, then performing secondary bonding by liquid phase diffusion bonding by reheating said joint to at least the melting point of said amorphous alloy foil, then holding it there to complete the solidification process of said joint.
Method for producing an insulating pack for an insulating part	December 23, 1998/US 6352787 B1	Evelyn Zwick, Alexander Wildhaber	Rieter Automotive (International)Ag	The invention relates to a method for producing an insulating pack (**10**), according to which a stack (**9**) of metallic lamellae is cold-welded simultaneously along a predefined contour and separated from a remaining area. The insulating pack produced according to the invention preferably has a plurality of knobbed and/or perforated aluminium foils (**12, 14, 16**) and at least one stretch film (**18**) and is characterized by a narrow welding seam (**20**) extending along the edge. The insulating pack can be used as an insulating part on its own or loosely inserted into an additional supporting or covering layer. Such insulating parts can be configured in an acoustically active manner and are used in the motor industry, machine industry and/or electronic or computer industry. Means for carrying out the method provided for in the invention provide for the use of a cutting blade with two cutting flanks. A preferred version of the cutting blade has cutting flanks inclined at different angles and can be configured as a rotary blade.

Exhibit 1 depicts patents related to cold pressure welding.

Picture credit: Frost & Sullivan

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