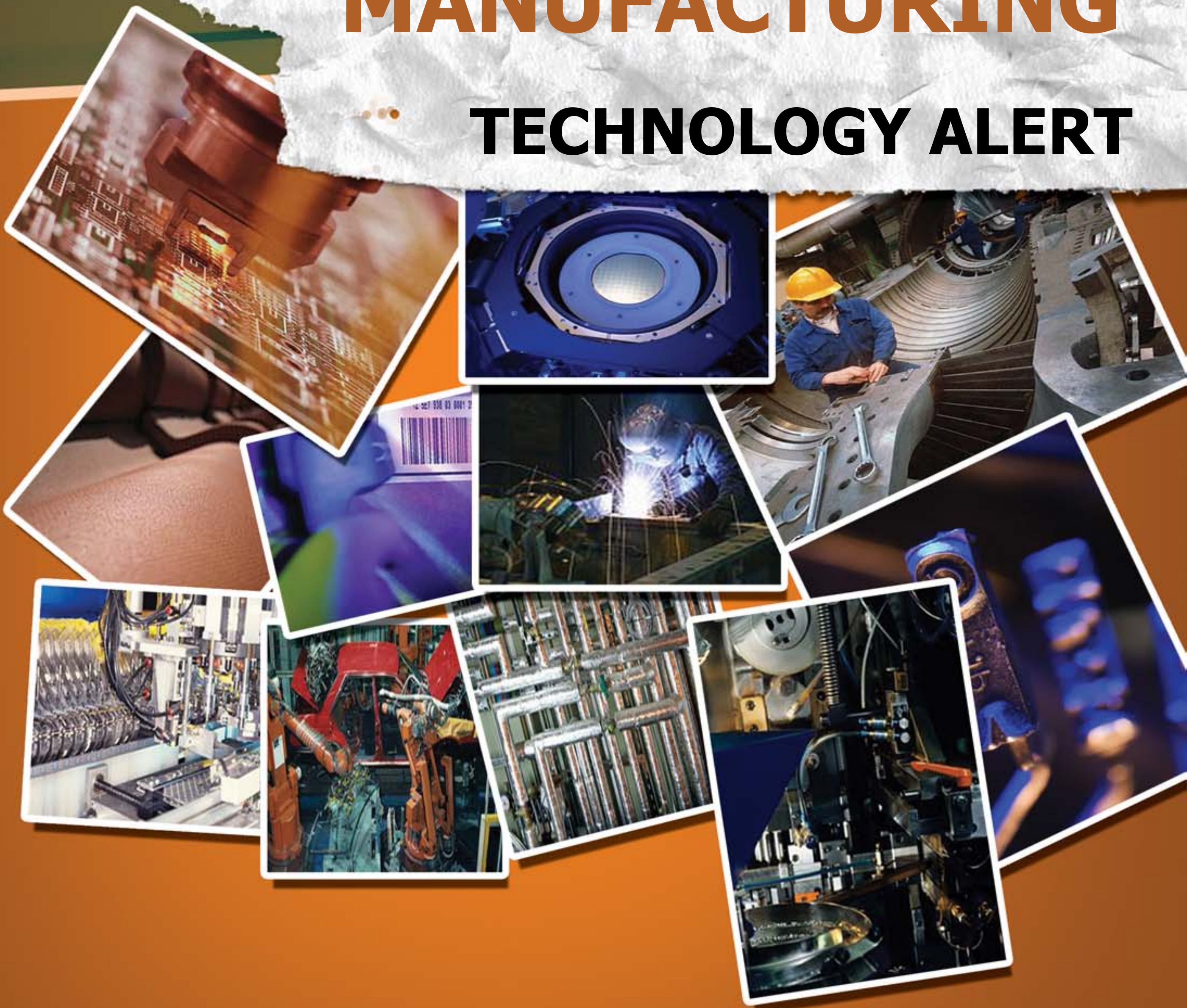
TECHNICAL INSIGHTS

ADVANCED MANUFACTURING

TECHNOLOGY ALERT



08th August 2014

1. LASER CUTTING MACHINES FOR METAL FABRICATION

Lasers electrically excite a lasing material (laser gain medium), which (via stimulated emission) amplifies the light of a specific wavelength that passes through the gain medium. Often, an optical cavity consisting of a pair of mirrors at each end of the gain medium is used to reflect light from the lasing medium back into itself. The light strength is increased as it bounces between the two mirrors. A laser produces monochromatic light in a selected wavelength; and the light emitted is coherent, which means that the light waves help each other propagate in a parallel fashion (instead of interfering with each other in incoherent light) with fixed phase relationships.

When focused by optics and of sufficient power, lasers can cut, drill, and engrave metallic and non-metallic materials. Laser cutting machines began as a novelty for drilling holes in diamond dies at Western Electric in 1965. They have grown to become a part of mainstream metalworking and materials fabrication processes, with ever increasing power ratings (now up to 6kW or so). The coherent light can be pulsed with intervals as short as femtoseconds, (10-15 sec) up to continuous wave (CW) with no pulsing. The laser beam, can melt, vaporize, burn away metals, and with gas jet assist can blow away the melt.

Various laser types are in commercial use: CO_2 (carbon dioxide), solid-state lasers, which can use, for example, a neodymium (Nd) dopant in a solid-state laser crystal, or a neodymium doped yttrium-aluminum-garnet crystal (Nd-YAG); and semiconductor lasers that use laser diodes. Fiber lasers (which can be considered a special type of solid-state laser that uses optical fiber doped with rare earth elements as the active gain medium) have been gaining momentum in the marketplace for applications such as materials processing. Best practice with the CO_2 laser is to pump it by RF excitation of the contained gas. RF resonators have external electrodes. Active cooling of the laser generator and external optics is mandatory, and the need becomes more urgent as the laser power edges into the kW (killiowatt) class. The workpiece can move relative to fixed optics, or the optics can rapidly fly over a fixed workpiece via linear actuators, as see in gantry-type machines.

Certain advantages have been found for this manufacturing technology compared to cruder alternatives such as sawing, oxygen-acetylene welder cutting torches, plasma torches and EDM (electro-discharge machining): fairly quick cutting, able to be precisely guided by computer numerical control (CNC), leaves a clean and fine edge condition (no deburring required), presents much less thermal impact on the workpiece due to a small heat-affected zone (HAZ), higher precision (with beam-widths focused down to 0.001 inch and kerf widths of only 0.004 inch) and reduced contamination of the workpiece. One of the limitations of laser cutting is the thickness of materials being cut. Heavy metal plate requires too much laser power with a high capital cost, and so plasma cutters are a wiser choice in those situations. Another consideration is the relatively high power consumption of laser cutters, which reportedly have an efficiency range of only 5% to 45%, thus producing much waste heat to manage.

Key suppliers of industrial laser cutting machines include Coherent, along with Rofin-Sinar Technologies, Trumpf, Cincinnati Incorporated, plus others. Industry uses laser cutters to generate shapes from flat sheet feedstock as well as to cut pipe and structural materials. If not cutting in from the edge, the machine has to first pierce a hole into the material with high-power laser pulses.

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2. BENEFITS OF CRYOGENIC MACHINING TECHNOLOGY

Researchers have long been interested in active super-cooling of tools that are cutting metals. Cryogenic-assisted machining is an advanced technique to deal with difficult materials, such as nickel-based superalloys. Such machining conditions involve extreme heat generation at the cutting tool/workpiece interface that accelerates tool wear, and slows down cutting velocities in order to yield an acceptable part. Such phenomena raise costs.

Technical Insights' staff have experience in working in machine shops and are well familiar with standard practices of flooding the metal machining site (as for drilling, milling, turning) with water-based or oil-based coolant. That is messy, creates a coolant disposal problem and raises environmental risks. Why not cool the tools with a direct infusion of clean liquid nitrogen (LN_2)? This cryogenic liquid is cooled to -321 degrees F, and is produced by the distillation/separation of liquefied air. Liquefied oxygen (LOX, around 20% of air) is the other byproduct of liquid air distillation. Nitrogen makes up around 78% of air, is nontoxic, not a greenhouse gas, and requires no pumping or disposal (unlike aqueous cutting fluids). With cryogenic coolant, no other aqueous coolant or cutting fluid is required and the boiled-off nitrogen gas is safely dissipated into the air.

Researchers have found that the internal microstructure provides improvements for cutting tools (yielding better mechanical properties), especially high-speed steel (HSS) drills, with exposure to cryogenic cooling. The microstructure upgrade translates to longer tool life. In comparative machining tests, cryogenic cooling extended tool life 10X or more before a need for re-sharpening, compared to conventional cutting tools with traditional aqueous cooling fluid. In fact, milling tests on Udimet 720 nickel-based superalloy made by US-based Special Metals Corporation, showed that the maximum cutting velocity could be raised from 10 m/minute to 120 m/minute (12x) with cryogenic assist.

In the early stages of R&D, the LN_2 fluid was sprayed externally at the tool/workpiece interface, but much of it evaporated before arrival at the hot spot where the tool was removing metal. This cryogenic-assist approach was too costly and unworkable. When tool specialists finally found a way to deliver the cryogen internally through the tool, success was achieved. As a side benefit of this machining technology, the surface quality of the cryogenically machined workpiece improves via reduced residual stresses, reduced burr formation, reduced abrasion from heat-softened cutting tools, and diminished grain boundary distortion (surface distortion). So, application of cryogenic fluid not only improved the cutting tool, but also the metal workpiece at the cutting zone, by reducing cutting temperature and adjusting the coefficient of friction. This translates to higher productivity and reduced machining costs. That said, cryogenic-assisted machining has some barriers that block its widespread acceptance, such as lack of ready access to large quantities of LN_2 at attractive prices, and the complexity of the apparatus.

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3. NOVEL INSPECTION SYSTEM FOR MANUFACTURING INDUSTRIES

In a manufacturing industry, work pieces and other components are subjected to various rigorous inspection techniques before being shipped out of the production plant. The inspection process is given high importance since even the minutest fracture or impact point of the work piece and other components could result in drastically reducing their durability. In automotive and aerospace industries in particular, the inspection techniques play a key role in achieving safety and aesthetics of the components that are being manufactured. In order to check the quality of a component, image processing methods are commonly employed by the manufacturers. In this method, multiple cameras are employed to take pictures of component surfaces from various angles, which are then analyzed by a software program. The drawback seen with this conventional inspection method is that, it is sometimes difficult to inspect the material substance since every material has its own unique surface structure. Most of these inspection systems that are currently available in the market are configured for specific materials and dimensions. To overcome the above mentioned drawback, researchers from a research institute in Germany have developed a novel inspection system with significantly high accuracy and capabilities.

A group of researchers from the Fraunhofer Institute for Industrial Mathematics ITWM, Germany, have developed a novel inspection system called Modular Algorithms for Surface InspeCtion (MASC). This inspection system is said to be adapted on a customer-specific basis and integrated into the production process. Some of the other capabilities of this novel system are that it can be used for a diverse range of material such as metals, leather, textiles, or paper; and covers a size range from tiny components for medical technology to entire sheets of ceiling panels for automobiles. Using this system, the surface of the work piece is first illuminated and scanned using multiple cameras that are set at a wide range of angles. These cameras help in picking up the impact points or fractures that are only visible at all the different points of the component surface. For the analysis of the images that are captured by these cameras, researchers have developed mathematical evaluation algorithms and have also built a comprehensive software library.

According to the researchers, the basic version of this analysis software comprises of more than 300 algorithms that could be combined in different combinations for carrying out various inspections processes depending on the component and the task that is to be performed. When the system identifies a defect, the production process is automatically stopped and the machine operator is notified of the defect. It is also said that, these algorithms help in eliminating flaws that could be incorrectly determined by the inspection system. Once the testing parameters are set, this novel inspection is integrated into the production process by the customer. The system could be directly installed into the assembly line or could be done with the help of robots. This novel inspection system is expected to be commercially available for wide scale adoption by 2018.

Some of the advantages of this novel system are that it can be easily integrated into the production line of the customer and it has significantly high level of accuracy. Due to the above mentioned capabilities and advantages this novel system is expected to be adopted on a large scale by a wide range of manufacturing sectors for the quality inspection of their products and components.

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4. PATENT ANALYSIS OF ULTRASONIC WELDING MACHINES

Ultrasonic welding process is a type of solid state welding where ultrasonic waves of high frequency are employed to join two materials together. In this process, the work pieces are held under high pressure when the ultrasonic waves are made to pass through them. The average amount of frequency used in this process range from 20 kHz. Based on the requirement and the type of materials that are welded, the frequency range varies from as low as 10 kHz to a maximum of 170 kHz. This process is based on molecular movement where a combination of both pressure and high vibration is employed. The metallic bonding between the work pieces are achieved in the solid state where there is no heat, high pressure and filler rod is employed. The work pieces are first degreased, this is done in order to prevent the oxides from being split when high frequency of ultrasonic waves are applied. The work pieces are then clamped between the tip of the sonotrode and the anvil. The tip of the anvil is usually made of high speed steel (HSS), since HSS has high wear resistance. The welding machine used in this process consists of a frequency converter, which is used to convert the line frequency to electric power of high frequency. This high-powered electric frequency is then converted into high frequency ultrasonic energy using a transducer. A coupler is employed to bridge the gap between the welding tip and the transducer, the high frequency energy is applied on to the surface of the work piece through the welding tip. Some of the advantages of this welding method are that, since there is no heat, filler rod used, the failure in the welded joint are significantly reduced. Since this process produces minimum deformation on the surface of the work piece, no surface finish is required. The other advantages are, different cross sectional materials can be welded and very thin materials can also be welded. This type of welding process is employed on a large scale in the electronics industry and in the welding of nuclear equipment.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Ultrasonic welding tip, ultrasonic welding machine, and method for producing battery	December 03, 2012/ WO 2013105361 A1	Hitachi Maxell, Ltd.,	Ueno Tomohiro	In the present invention a plurality of protrusions are formed at a machined surface (11) of a tip (10) contacted to a member to be welded during ultrasonic welding. When the machined surface is seen head-on, at least one of the protrusions disposed at the outermost periphery of the plurality of protrusions is a chamfered protrusion (120) that has been chamfered in a manner so as to have, on the peripheral contour line (121), an arc (121r) of radius R satisfying R ≥ A/6, where A is the outer dimension in one direction thereof. As a result, it is possible to reduce the occurrence as a result of ultrasonic welding of breakage of a foil that is the member to be welded.
Ultrasonic welding equipment with mechanical arms	September 25, 2012/CN 202781836 U	Required Connaught Machinery (Dongguan) Co., Ltd.	Lv Huiqing	The utility model relates to the technical field of ultrasonic welding equipment, in particular to ultrasonic welding equipment with mechanical arms. The ultrasonic welding equipment with the mechanical arms structurally comprises a machine frame, an operation frame, six-spindle joint mechanical arms, a controller used for controlling the six-spindle joint mechanical arm, and a plurality of welding seats with ultrasonic welding heads placed. The operation frame, the six-spindle joint mechanical arms, the controller and the welding seats are fixedly connected with the machine frame. Products are arranged on the operation frame. The six-spindle joint mechanical arms grasp the ultrasonic welding heads from the welding seats to the operation frame to weld the products. The plurality of the welding seats with the ultrasonic welding heads placed are arranged, the welding heads placed on the welding seats are different from each other, when the welding heads need to be replaced, the six-spindle joint mechanical arms grasp the corresponding welding heads in a replaceable mode to carry out relative welding operation, trouble in the process of manual replacing operation is avoided, and work efficiency is improved.
Ultrasonic welding machine with robot	September 21, 2012/ CN 202781834 U	Precision Machinery Co., Ltd. Suzhou Kai Erbo	Su Wei	The utility model relates to an ultrasonic welding machine with a robot. The ultrasonic welding machine comprises a working table base, a working table, a robot, an ultrasonic welding head, a servo drive device and an index plate; the index plate is arranged on the working table base and controlled to rotate by the servo drive device; the working table is arranged on the index plate and capable of rotating together with the index plate; the robot is arranged at one side of the working table; and the ultrasonic welding head is arranged on the robot and capable of working in a working region of the working table under the control of the robot. According to the ultrasonic welding machine with the robot, the scheme is as follows: the high-precision robot with a six-shaft linkage mechanism is adopted; and the robot can work at any position in the working region of the working table; at the same time, the index plate is controlled to rotate by the servo drive device, so that the rotation of the working table is realized; a plurality of welding stations can be arranged on the working table as required; and the robot can arrange a set of welding process at each welding station. Due to the scheme, the ultrasonic welding machine has the advantages of being good in applicability, high in production efficiency and easy and convenient to operate.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Ultrasonic welding machine for plastic welding	July 10, 2012/CN 202702624 U	Lee Shun Plastic Products Co., Ltd. of Tianjin	Douhua Li	The utility model provides an ultrasonic welding machine for plastic welding; and the ultrasonic welding machine comprises a frame, wherein a mounting panel is arranged on a frame; an ultrasonic welding device and a locating fixture transmission device are also arranged on the frame; the ultrasonic welding device comprises an ultrasonic generating device, an ultrasonic welding head and a temperature control system; the ultrasonic generating device is connected with the temperature control system by a controller; the ultrasonic welding device further comprises a counter; and an input end of the counter is connected with a switching circuit of the ultrasonic generating device and is electrically connected with the controller. The ultrasonic welding machine for plastic welding, provided by the utility model, has the advantages of simple structure, convenience for maintaining, low machining cost, high production efficiency and so on.
Ultrasonic welding machine and method of assembling the ultrasonic welding machine	August 31, 2011/US 20130048698 A1	Lg Chem, Ltd.	Alex Khakhalev	An ultrasonic welding machine and method are provided. The machine includes a base portion having a first aperture that defines first internal threads. The machine further includes an electrically non-conductive member disposed on the base portion having a second aperture that is aligned with the first aperture. The machine further includes an anvil portion disposed on the electrically non-conductive member having a third aperture that is aligned with the second aperture. The machine further includes a first bolt disposed through the third aperture and the second aperture that is threadably received in the first internal threads, and the first bolt and the anvil portion are electrically isolated from the base portion.
Ultrasonic welding machine and method of aligning an ultrasonic welding horn relative to an anvil	August 19, 2011/US 20130042959 A1	Lg Chem, Ltd.	Alex Khakhalev, Lee Nelson Cole, Eric Hicks	An ultrasonic welding machine and method are provided. The machine includes an ultrasonic welding horn operably coupled to a housing. The machine further includes an anvil operably coupled to the housing. The machine further includes a removable collar assembly that is coupled around a portion of an outer surface of the ultrasonic welding horn. The removable collar assembly has at least first and second set screws that contact the housing such that when at least one of the first and second set screws are moved inwardly toward the housing, the removable collar assembly rotates the ultrasonic welding horn to align the ultrasonic welding horn relative to the anvil.
Omega ultrasonic welding machine	April 19, 2011/WO 2011128118 A8	Ultrasonics Steckmann Gmbh	Helge Steckmann, Irina Karpel	The aim of the invention is to provide an omega ultrasonic welding machine (1) for welding a number of metal workpieces (16), said welding machine connecting a solar collector to an absorbing sheet (2) and to a pipeline system (4), which conducts liquid when used, by means of an ultrasonic welding process such that the active surface of the solar collector is not deformed, destroyed, or otherwise damaged. This is achieved in that in addition to a first sonotrode (8a), at least one further sonotrode (8b) is provided on a track that runs parallel to the track of the first sonotrode (8a).

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Ultrasonic welding machine and control method thereof	September 26, 2008/ CN 101683645 A	Horse open type	Shanghai Furong Industrial Heating Equipment Co., Ltd.	The invention relates to an ultrasonic welding machine and a control method thereof. The ultrasonic welding machine comprises an energy converter, an oscillator, a driver, a sensor and a control module. The control method comprises the following steps: firstly, outputting drive frequency to the driver by using the oscillator to enable the driver to drive the energy converter; secondly, sensing a working current value of the energy converter by using the sensor; thirdly, computing whether the working current value is more than a preset threshold or not by using the control module, and providinga comparison result, when the working current value is more than the preset threshold, performing the sweep frequency by using the control module, sequentially scanning a plurality of frequency bandsby using preset scanning time in the sweep frequency step to obtain a normal drive frequency value; fourthly, driving the energy converter according to the normal drive frequency value to enable theworking current value to be less than or equal to the preset threshold; and fifthly, adjusting the oscillator by using the control module to enable the frequency value of the oscillator to be equal tothe normal drive frequency value.
Ultrasonic spot welding machine for back cover lock	June 17, 2008/CN 101318258 B	Wei speed up (Kunshan) Co., Ltd. Security Systems	ZHU Ya Qun, Zhu Yong, Cai Jingwen	The invention discloses a back cover lock supersonic spot welding machine which comprises a horizontal base, a longitudinal stent and a horizontal mechanical bottom plate; the stent is fixed on the base which is horizontally positioned on the mechanical bottom plate in a sliding way; an supersonic welding torch is longitudinally positioned on the facade of the stent in a sliding way; the base is fixedly provided with a processing seat which is provided with a placing space for the back cover lock when in processing; the processing seat is arranged below the supersonic welding torch which can just be welded to a welding point of the back cover lock arranged at the processing seat; a pressurized block is articulated with the processing seat and forms a notch toward one side of the supersonic welding torch; the notch of the pressurized block is just used for the insertion the welding head of the supersonic welding torch; the pressurized block can just be pressed on the back cover lock; the welding machine is also provided with a preloading cylinder; a piston of the preloading cylinder is pivotally connected with the opposite side of the articulation position of the pressurized block;the facade of the stent is provided with a detection cylinder; the piston end part of the detection cylinder can just pull an actuating rod of a micro-switch on the back cover lock; the embodiment ofthe invention can reduce the working hours obviously and guarantee the product quality.
Ultrasonic wave metal welding machine tool head component	March 17, 2004/CN 2706270 Y	Zhenjiang City days Electromechanical Co., Ltd.	Tu I mark	The utility model belongs to a welding device which relates to an ultrasonic wave metal welding machine tool head component. The ultrasonic wave metal welding machine tool head component comprises a tool head body and a polygonal welding disc. Each side of the polygonal welding disc is respectively provided with a set of welding joints, and the welding disc is fixed with the front end of the tool head body by a center bolt. The utility model has the advantages of convenient manufacture, easy replacement and long service life.

Exhibit 1 depicts patents related to ultrasonic welding machines.

Picture Credit: Frost & Sullivan

From the patents presented in Exhibit 1, it can be seen that the companies are carrying out research in order to automate this type of welding process. This would help in employing this type of welding in various industries without having to compromise on the production rate and efficiency.

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