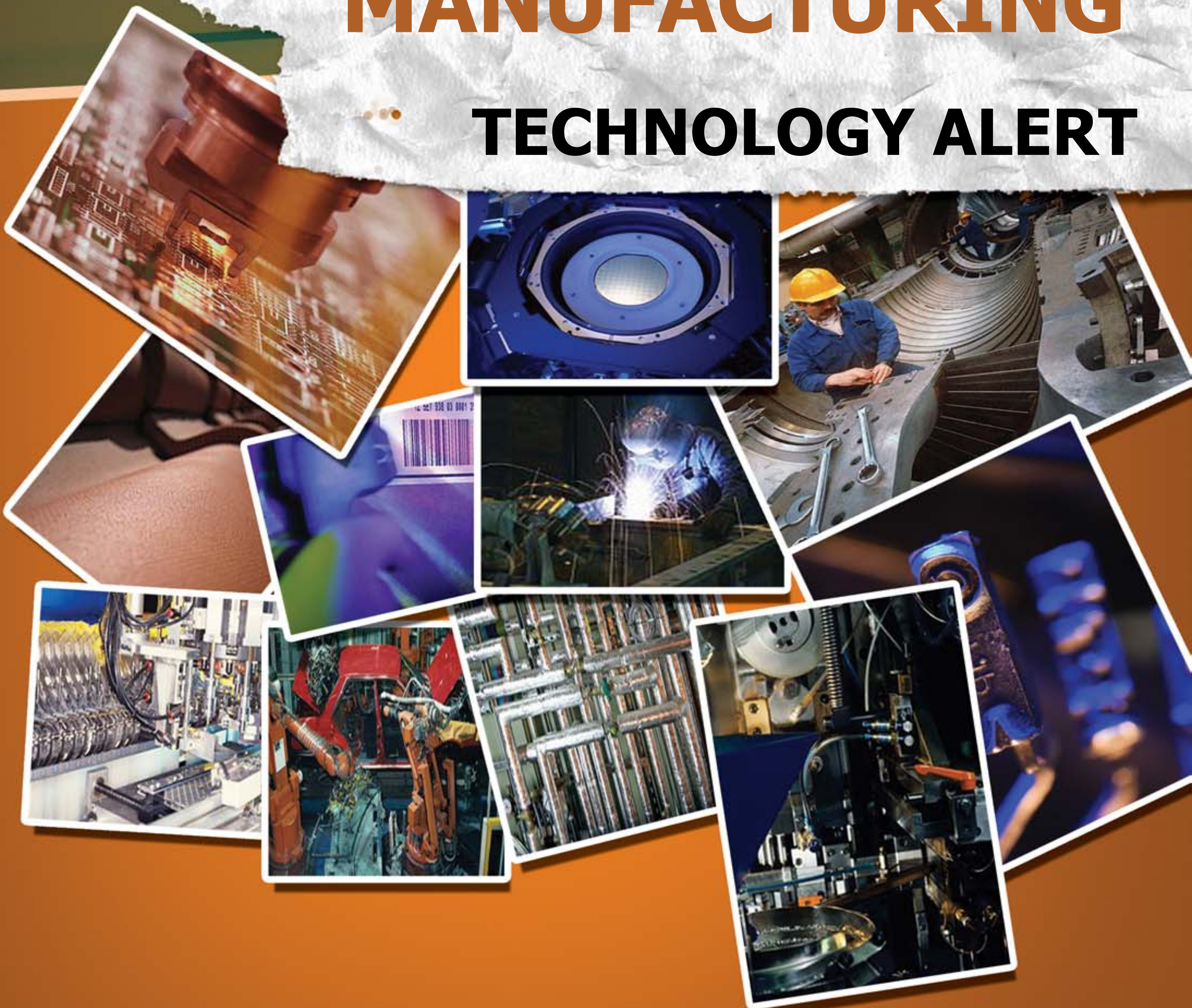
TECHNICAL INSIGHTS

ADVANCED MANUFACTURING

TECHNOLOGY ALERT



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1. ADVANCEMENTS IN ORGANIC SEMICONDUCTORS

It has been challenging to design organic semiconductor materials capable of high charge carrier mobility (the ability to conduct a charge) and high luminescence (the ability to emit light). Presently, organic semiconductor materials that exhibit high luminescence have low charge carrier mobility; and organic materials exhibiting high charge carrier mobility have low luminescence. The ability to create organic semiconductor materials capable of both high luminescence and high charge carrier mobility in a single material can enable development of innovative optoelectronic devices, such as organic light-emitting transistors (OLETs), OLET-based displays, or OLET-based electrical pumping lasers.

An OLET is a type of transistor that emits light. Through combining electrical switching and light emission, OLETs have potential for greater efficiency compared to organic light-emitting diodes (OLEDs). Organic light-emitting transistors could pave the way toward nanoscale light sources and highly integrated organic optoelectronics.

In a development that that could overcome the traditional trade-off in organic semiconductor materials between the ability to emit light and to conduct a charge, researchers from China and the UK have crafted an innovative organic semiconductor, composed of 2,6-diphenylanthracene (DPA), which exhibits both high luminescence and high charge carrier mobility.

It has been challenging to design an organic semiconductor with both high mobility and high luminescence because these attributes tend to require opposite types of molecular structures. To achieve high mobility, the molecules must be densely packed together; however, fluorescence quenching (a process that decreases the fluorescence intensity of a certain substance) results from densely packed molecules. Fluorescence takes place when an electron falls to its ground state and emits a photon. On the other hand, densely packed molecules tend to have strong intermolecular interactions that prevent electrons from transitioning to their ground states, which thwarts photon emission.

In designing the novel organic semiconductor compound, DPA, the researchers utilized densely packed molecules to provide high mobility; however, the molecules were packed together in a way that also could considerably reduce fluorescence quenching.

The innovative molecular arrangement is termed "herringbone packing," which entails a zig-zag pattern that provides weaker intermolecular interactions than other types of arrangements, although the molecules are still very close together. Due to the weaker interactions, the electrons are able to transition to the ground state, allowing the molecule to exhibit high luminescence as well as high mobility.

As noted in "High mobility emissive organic semiconductor," published in Nature Communications (1 December 2015), DPA crystals were produced by PVT (physical vapor transport) under ultraviolet light. Fabrication of the device is based individual micrometer-sized single crystal employing an organic ribbon mask technique on an n-doped substrate containing a 300 nm silicon dioxide and OTS (octadecyltrichlorosilane) monolayer.

The researchers fabricated OLEDs from the DPA organic semiconductor that exhibited bright blue luminescence, and organic field effect transistors (OFETs) that exhibited DPA’s good charge transport characteristics. Moreover, to demonstrate the opportunities for the new material in organic optoelectronic devices, the researchers devised an OLED array composed of the DPA material driven by an OFET fabricated with DPA.

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2. IMPROVED CONTROL IN PHOTONIC SINTERING

Photonic sintering is a low-thermal exposure sintering method to sinter or fuse nanoparticles (which measure between 1 nanometer to up to a few hundred nanometers) to form functional thin films. In contrast to thermal sintering, which uses sintering furnaces, photonic sintering uses pulses light (a xenon flash lamp) to provide a high intensity, short duration pulse of light to the deposited nanoparticles. The incidence of such large-area broad-spectrum light onto deposited nanoparticles, results in heat generation in the nanoparticles and their densification. Photonic sintering can provide rapid densification of nanoparticle inks over large-area substrates under ambient conditions.

Due to the ability of photonic sintering to provide rapid, scalable functionality and operation under ambient conditions, there is significant interest in using this process for nanoparticle sintering in key emerging or expanding applications, such RFID (radio frequency identification) tags, flexible electronics (which involves incorporating electronic devices on flexible substrates), solar cells, and sensors (such as wearable biosensors, chemical or gas sensors, or pressure sensors). However, there is a key need to understand the physics involved in the photonic sintering process. Key issues that merit investigation include, for example, the effects of nanoparticle size on densification and the temperature of the deposited nanomaterial and substrate.

Supported by a four-year, $1.5 million National Science Foundation Scalable Nanomanufacturing Grant, focused on surmounting the scientific barriers to industry-level production of nanomaterials, researchers at Oregon State University (OSU) have achieved key insights into the physics of photonic sintering. Such knowledge has promise to lead to advancements in products such as solar cells, flexible electronics, or sensors that could be printed onto a sheet of flexible materials such as paper or plastic.

The OSU researchers found that prior approaches to comprehending and controlling photonic sintering were predicated on an imperfect perception of the fundamental physics involved in this process. The flawed understanding has resulted in overestimating the product quality and process efficiency associated with photonic sintering. Based on their expanded knowledge of the physics of photonic sintering, the researchers conceive that they can exploit photonic sintering to devise high-quality products at considerably lower temperatures, at least twice as fast with tenfold greater energy efficiency.

Previously, temperature change and the degree of fusion in photonic sintering were considered to not be related. The OSU researchers, however, discovered that his relationship is very important. For example, both the temperature and nanoparticle densification are found to be very dependent on the nanoparticle size. Removing constraints on production temperatures, speed and cost, can enable the creation of innovative high-tech products printed onto inexpensive substrates, such as paper or plastic.

The investigation has opportunities to lead to precise control of temperature with smaller nanoparticles. Such capability can increase the speed of the photonic sintering process and enable high-quality production at temperatures at least two times lower than previously. Moreover, the researchers identified an inherent self-damping effect that strongly impacts the desired quality of the finished film. The researchers should be able to create production processes for nanotech products that are rapid and inexpensive, without loss of quality. Lower temperature processing is a key attribute. To reduce costs, it is desirable to pint the nanotech products on such materials as paper or plastic, which would melt or burn at higher temperature. The researchers envision products such as solar cells, gas sensors, RFID tags, flexible electronics, as well as biomedical sensors and innovative sensors for environmental applications.

In the next step in migrating the technology toward commercial production, the OSU researchers will work with two manufacturers in private industry to create a laboratory-based proof-of-concept facility.

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3. WELDING TECHNIQUE SAVES ENERGY, CREATES STRONGER BONDS

Conventional welding technology can have difficulty in welding alternative metals, as the microstructures of such materials can be weakened by high heat and re-solidification.

Resistance spot welding is a common welding technique used in such applications as automotive manufacturing (to weld the sheet metal to form a car). In resistance spot welding, contacting metal surfaces are joined by the heat derived from resistance to electrical current. The work pieces are held together under pressure by electrodes, which concentrate the welding current into a small spot and clamps the sheets together. The large current through the spot melts the metal and forms the weld. The amount of heat (energy) generated to the spot is determined by the resistance between the electrodes and the current's magnitude and duration.

Resistance spot welding has limitations, such as generation of high currents can consume much energy, and the melted portions of metal may not be as strong as they previously were. For example, spot welding of aluminum alloys requires higher welding current due to their considerably higher thermal conductivity and electrical conductivity.

Under the leadership of Glenn Daehn, professor of materials science and engineering, researchers at the Ohio State University have developed and garnered patents on an innovative welding technique--vaporized foil actuator (VFA) welding-that can consume 80% less energy that the common resistance spot welding technique and yet crate bonds or welds that are 50% stronger.

The VPA process uses electrically driven rapid vaporization of thin conductors to produce short-duration pressure pulses of high magnitude. Electrical energy stored in a capacitor bank is released through a switched circuit that contains a thin metal conductor. The metal conductor is able to be heated above its energy of sublimation before it has time to melt, when the energy deposition rate into the conductor is very high. This occurs when the current in the circuit reaches its maximum very quickly. The metal conductor vaporizes directly into a gas that expands rapidly, propelled by the extra energy deposited above the energy of sublimation. The pressure pulse from the expanding gas can be used to drive the work pieces for applications such as forming, shearing, tube expansion, and collision welding.

In the VFA process, a high-voltage capacitor bank creates a very short electrical pulse inside a thin piece of aluminum foil. The foil vaporizes within milliseconds, and a burst of hot gas, traveling at speeds approaching thousands of miles per hour, pushes two pieces of metal together. Since the different bonded metal pieces do not melt, there is no seam of weakened metal between them. The process uses a reduced amount of energy because the electrical pulse is very short and the energy needed to vaporize the foil is less than the energy that would be required to melt the metal parts. Via the VPA welding technique, materials are shaped and bonded together at the same time, and can become stronger. The ability to simultaneously shape metal parts and weld them together can increase manufacturing efficiency.

The VPA welding approach has promise in the auto industry, which is increasingly focused on providing vehicles that combine traditional heavy steel parts with lighter, alternative metals to reduce the car's weight.

The Ohio State researchers have successfully bonded different combinations of copper, aluminum, magnesium, iron, nickel, and titanium. Furthermore, they have succeeded in creating strong bonds between commercial steel and aluminum alloys; and the high-strength steel and aluminum join together with weld regions that are stronger than the base metals.

The researchers have welcomed collaborations with manufacturers to further develop and license the technology.

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4. ENHANCED PEROVSKITE-BASED LIGHT-EMITTING DIODES

A light-emitting diode (LED) consists of a semiconductor chip doped with impurities to create a p-n junction. The p-n semiconductor diode generates light when electrical energy is applied to it. The LED, a semiconductor light source, uses the principal of electroluminescence, which pertains to the emission of light from a semiconductor due to the effect of an electric field.

Light-emitting diodes are essentially efficient, durable, and long lasting lighting devices. The technology has improved considerably since the 1960s when the first LEDs appeared on the market. Applications for LEDs include a wide range of status indicators and displays: traffic lights, exit signs, vehicle brake lights, other forms of automotive lighting, lamps/light bulbs, backlighting of LCD televisions; remote controls, light sources for sensors (such as motion sensors), and so on.

With reduced costs and higher performance, LED lighting has potential to reduce electricity consumption. According to the US Department of Energy, residential LEDs, especially ENERGY STAR rated products, use at least 75% less energy, and last 25 times longer, than incandescent lighting.

However, contemporary LEDs tend to be more expensive than incandescent light bulbs; and an LED lamp generates a much smaller amount of luminous flux (total amount of light generated) than an incandescent bulb. Moreover, the LED's lamp light output varies with temperature.

Researchers at Florida State University have developed an innovative LED solution that leverages an organic-inorganic hybrid material with promise to enable less expensive, brighter, mass produced lights and displays.

Using synthetic chemistry to fine-tune the material properties and device engineering to control the device architectures, the researchers enhanced the capabilities of perovskites to create a high-performance LED.

Perovskites are calcium titanium oxide minerals composed of the same type of crystal structure as calcium titanium oxide. Perovskite materials have such key attributes as excellent charge carrier mobility and the possibility of a tunable optical bandgap. Organic-inorganic hybrid perovskites have a very high color purity and are attractive as, for example, low-cost LED emitters. However, their low luminescent efficiency has been a key limitation.

The Florida State researchers devised an innovative approach to address key issues and achieve a high-performance LED, which was able to glow exceptionally bright. Their LED was able to achieve a luminescence of about 10,000 candelas per square meter at a driving voltage of 12V. candelas are the unit of measurement for luminescence. By comparison, LEDs glowing at about 400 candelas per square meter can provide sufficient brightness for computer screens. The outstanding brightness of the LEDs created by the researchers is attributed, to a considerable degree, to the inherent high luminescent efficiency of the surface-treated, very crystalline nanomaterial.

Furthermore, the material, and the resulting LED device, can be produced quickly. In addition, in contrast to bare perovskites that can be unstable in humid air, the nanostructured perovskites show very high stability in the ambient environment owing to the designed surface chemistry. This chemical stability can reduce the need for a sophisticated infrastructure to manufacture LEDs based on such materials.

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5. AEROSPACE OPPORTUNITIES FOR COMPOSITES MANUFACTURING

Key opportunities exist in aerospace for composite materials, which enable parts comprised of at least two component materials with different properties. Composites manufacturing enables parts that have superior properties compared to those that use a single material.

For example, the Boeing 787 Dreamliner is composed of more composites than metal. The 787 makes greater use of composites in its airfracme and primary structure.

Composites, such as carbon fiber and fiber glass, can be easily molded into complex shapes. Composites are excellent for handling tension, but not as efficient for handling compression loads. The 787 uses carbon fiber composite materials in the airframe and primary structure (including the fuselage and wing).

Applications for composites in aircraft include fan blades and fan cases in jet engines, doors, aircraft interiors, and spacecraft satellites. Furthermore, thermoplastic composites can benefit parts that require greater impact resistance, including the wing leading edge, the cockpit fiber, movable ribs and spars.

Keen interest exists in better understanding how composite structures react in emergency landing situations. In contrast to metals, which deform and absorb energy in a crash, composites tend to flex and to not deform as much. The flexing capability helps maintain the survivable volume of the fuselage, however, it can cause higher loads to transfer onto the seats, which has potential to injure passengers or other parts of the aircraft.

This issue can be mitigated by engineering a fuselage design that includes specially designed crash absorbers to reduce the peak forces on the seats and transfer such forces to dedicated load paths around the survivable space in the cabin. The interior design reduces the possibility that passengers will be injured, while the load paths prevent the engine from damage.

Nanotechnology applied to composites can help enable aircraft or spacecraft structures to have improved properties, such as laminate strength, toughness, electrical and thermal conductivity. For example, the Massachusetts Institute of Technology has focused on aligned carbon nanotubes (CNTs) as a reinforcement phase in a polymer matrix associated with fibrous laminated aero composites. This work on enhanced hybrid composites prompted research into aligned-CNT polymer nanocomposites (A-PNCs). The A-CNTs can have opportunities in applications such as thermal interfaces and structural elements.

The hybrid composite has aligned CNTs as a second fiber at the nanoscale. The main fiber, at the nanoscale, is a traditional advanced fiber. The high-strength CNT nanofibers improve the composite's toughness, which can help avoid internal damage.

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6. PATENT ANALYSIS OF COLD-FORMING PROCESS

Cold-forming is a process for forging shapes and tools from metals at a relatively low temperature. The temperature ranges from room temperature to a few tens of degrees higher. Cold-forming is a high-speed process, where the speed is one of the factors that determines the shape and size of the metal in desired form.

In the cold-forming process, the metal is forced into a die by pressing beyond its elastic limit. Since the metal crosses its elastic limit, the metal conforms to the shape of the die and remains in the same shape. However, the metal is not strained beyond its tensile strength during the forming process because crossing the tensile strength of the metal would lead to fractures in the metal structure formed.

Cold-forming is widely used in the steel industry because the elastic limit of steel is quite low. Cold-forming is used in various applications where steel needs to be forged into different shapes and sizes based on the application it is used in.

One of the interesting patents filed (US 20150183204), which is assigned to Unitika Ltd., pertains to a production method and use of a polyester film for the cold-forming process. Another interesting patent (US 20150266083), assigned to Illinois Tool Works Inc., pertains to a method and apparatus used for cold-forming thread rolling dies (including a method for roll forming the face pattern onto a pattern forming die).

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
COLD FORMING AND HEAT TREATMENT PROCESS FOR TUBULARS	December 23, 2015 / WO/2015/195722	VETCO GRAY INC.	CHEN, Jianqiang	A method for forming an elongated tubular member for use with hydrocarbon production includes forming a blank member of a steel material having an outer diameter equal to a first outer diameter. The blank member is mounted on a rotating mandrel. A tubular member is formed by engaging a rotary disk with an outer surface of the blank member and moving the rotary disk in a first axial direction, lengthening the blank member in a second axial direction and reducing the outer diameter of the blank member until the outer diameter of a central portion of the blank member is equal to a second outer diameter and the outer diameter of end portions of the blank member is equal to a third outer diameter. The tubular member is heat treated to reduce a residual stress. A mechanical connection is formed in each of the end portions.
COLD PRESS FORMING METHOD	December 23, 2015 / WO/2015/194401	JFE STEEL CORPORATION	SATO, Kentaro	A cold press forming method of one embodiment of the present invention includes a first press forming step in which a first formed component (7) having a hat-shaped cross-section part (8) is formed by draw forming in a cross-section orthogonal to the longitudinal direction with a cross-section depth of 10-30 mm in the longitudinal direction; a trimming step in which the first formed component (7) is trimmed to obtain a trimming component; and a second press forming step in which a portion of a top plate in the hat-shaped cross-section part of the trimming component is pressed with a pad, and a second formed component (9) is formed by foam forming, the second formed component including a product-shaped part (12) having a hat-shaped cross-section part (10), a step-shaped part (31) that is continuous with the outside of an area corresponding to a vertical side of a T shape in a connected T shape, and an inclined surface part (33) that is continuous with the outside of the step-shaped part (31) and rises diagonally upwards.
COLD FORMED PRODUCT AND METHOD FOR MAKING	December 10, 2015/ US 20150352627	Amanda Bent-Bolt Company	Mike HOOD	Described is a method of making a cold formed product. The method includes the steps of forming a rod in diameter of annealed steel. At least a portion of the rod is positioned in a cavity and end portion of the rod is impacted to form a bulge in the rod in the cavity. The bulge is cold formed with a die to form an opening through the rod at the bulge surrounded by a upset portion. The opening and upset portion supporting a fastener positioned through the opening.
PACKAGING MATERIAL FOR COLD FORMING AND PRESS-THROUGH PACK FORMED USING SAME	October 22, 2015 / US 20150298879	UNITIKA LTD.	Kazunari Nanjo	The packaging material for cold forming of the present invention includes a polyamide resin film biaxially stretched by a tenter method and an aluminum foil provided on one surface of the polyamide resin film and integrated with the polyamide resin film. The distortion of the polyamide resin film caused by applying thereto a tension corresponding to the tensile break tension of the aluminum foil is 20% or more and 45% or less. Herewith, it is possible to provide a packaging material for cold forming excellent in cold formability, capable of suppressing the breakage of the aluminum foil during the cold forming in the case where the polyamide resin film biaxially stretched by the tenter method is used.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
COLD-FORMED STEEL ABOVE GROUND TORNADO SHELTER	October 1, 2015 / US 20150275502	Ping Guo	Ping Guo	A tornado shelter which meetts the structural performance criteria of ICC, FEMA, ASCE, AISI, and ACI, produced from trapezoidal cold-formed steel panels.
METHOD AND APPARATUS FOR COLD FORMING THREAD ROLLING DIES	September 24, 2015 / US 20150266083	ILLINOIS TOOL WORKS INC.	Kenneth R. LeVey	A method is disclosed for roll forming the face pattern onto a pattern forming die having a pattern receiving face, using an initial, and subsequent, pattern forming tool, each with a generally cylindrical pattern defining surface, by relatively and sequentially reciprocating and rotating the pattern defining surfaces and the pattern receiving face while engaging them and urging them to impress the pattern of the pattern defining surfaces into the pattern receiving face of the forming die blank. An apparatus for performing the process is disclosed which includes a platen for the pattern forming die, initial and subsequent pattern forming tools each having a generally cylindrical pattern defining surface, a drive mechanism for relatively and sequentially reciprocating and rotating the pattern defining surfaces and the pattern receiving face of the forming die blank, and relative movement mechanism for engaging the surfaces to impress the pattern of the pattern defining surfaces of the pattern forming tools into the pattern receiving face of the forming die blank.
COLD-ROLLED STEEL SHEET AND METHOD FOR MANUFACTURING SAME, AND HOT-STAMP FORMED BODY	August 13, 2015 / US 20150225830	NIPPON STEEL & SUMITOMO METAL CORPORATION	Toshiki Nonaka	A cold-rolled steel sheet has a predetermined chemical composition, in which a structure before and after a hot-stamping includes ferrite: 30 area % to 90 area %, martensite: 0 area % or more and less than 20 area %, pearlite: 0 area % to 10 area %, retained austenite: 5 volume % to 20 volume %, and rest structure: bainite, a hardness of the retained austenite measured with a nano indenter before and after the hot-stamping satisfies relations of H2/H1<1.1 and σHM<20, and a relation of TS×El>20000 MPa.% is satisfied.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Cold bend forming production line	July 29, 2015 / CN 104808637	Weifang Highfull Machinery Co., Ltd.	Cui Yanliang	The invention relates to a cold bend forming production line. The cold bend forming production line comprises a levelling machine and a servo feeder, a uncoiling and feeding buffering area is arranged between the levelling machine and the servo feeder, and an uncoiling and feeding buffering position sensor is arranged at the bottom of the uncoiling and feeding buffering area and lower than a plate between the levelling machine and the servo feeder. The cold bend forming production line has the advantages that according to running statuses of the uncoiling and feeding buffering position sensor, a feeding and forming buffering position sensor, the levelling machine, the servo feeder and a plate forming machine, a CPU (central processing unit) controls equipment to start and stop automatically, so that plates can be prevented from being too long or too short, and safety of a motor and other mechanical mechanisms can be protected; cold bend forming production line runs at low speed when the plate gets close to the cutting position, so that position error caused by inertia of high-speed running of the equipment can be reduced, a tracking cutting mode is adopted during cutting, and production speed is increased.
POLYESTER FILM FOR COLD FORMING AND METHOD FOR PRODUCING SAME	July 2, 2015 / US 20150183204	UNITIKA LTD.	Kazunari Nanjo	A polyester film for cold forming including polybutylene terephthalate (PBT) and polyethylene terephthalate (PET), wherein a mass ratio (PBT/PET) between PET and PET is 30/70 to 80/20.
Small modulus straight gear cold heading extrusion forming process and mold	June 17, 2015 / CN 104707930	XI'AN UNIVERSITY OF ARCHITECTURE AND TECHNOLOGY	YANG CHENG	The invention discloses a small modulus straight gear cold heading extrusion forming process and mold. A cylindrical blank subjected to phosphorization saponification treatment is put into a mold cavity of the forming mold consisting of a toothed concave mold and a lower toothed mold; an upper toothed mold is pressed down to enable a blank material to flow into a tooth cavity of the toothed concave mold; when a part of the blank material is extruded into a splitting cavity of the tooth top to form a pre-forged piece with tooth top trimming, the upper toothed mold stops extrusion and moves upwards and the blank material is withdrawn from the toothed concave mold; at the moment, the toothed concave mold has upward friction to the blank material, the upper angle part of the forged piece can be filled, the lower toothed mold pushes the pre-forged piece upwards outside the toothed concave mold under the action of a lower jacking rod, a final forged piece is obtained under the action of a standard inner toothed cavity at the upper part of the toothed concave mold, the toothed concave mold has downward friction to the blank material, and the lower angle part of the forged piece can be filled. The small modulus straight gear cold heading extrusion forming process is simple and reliable in procedure and easy to achieve.

Exhibit 1 shows the patent activity related to the cold-forming process during the last 7 months (June 2015 to December, 2015).

Picture Credit: Frost & Sullivan

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