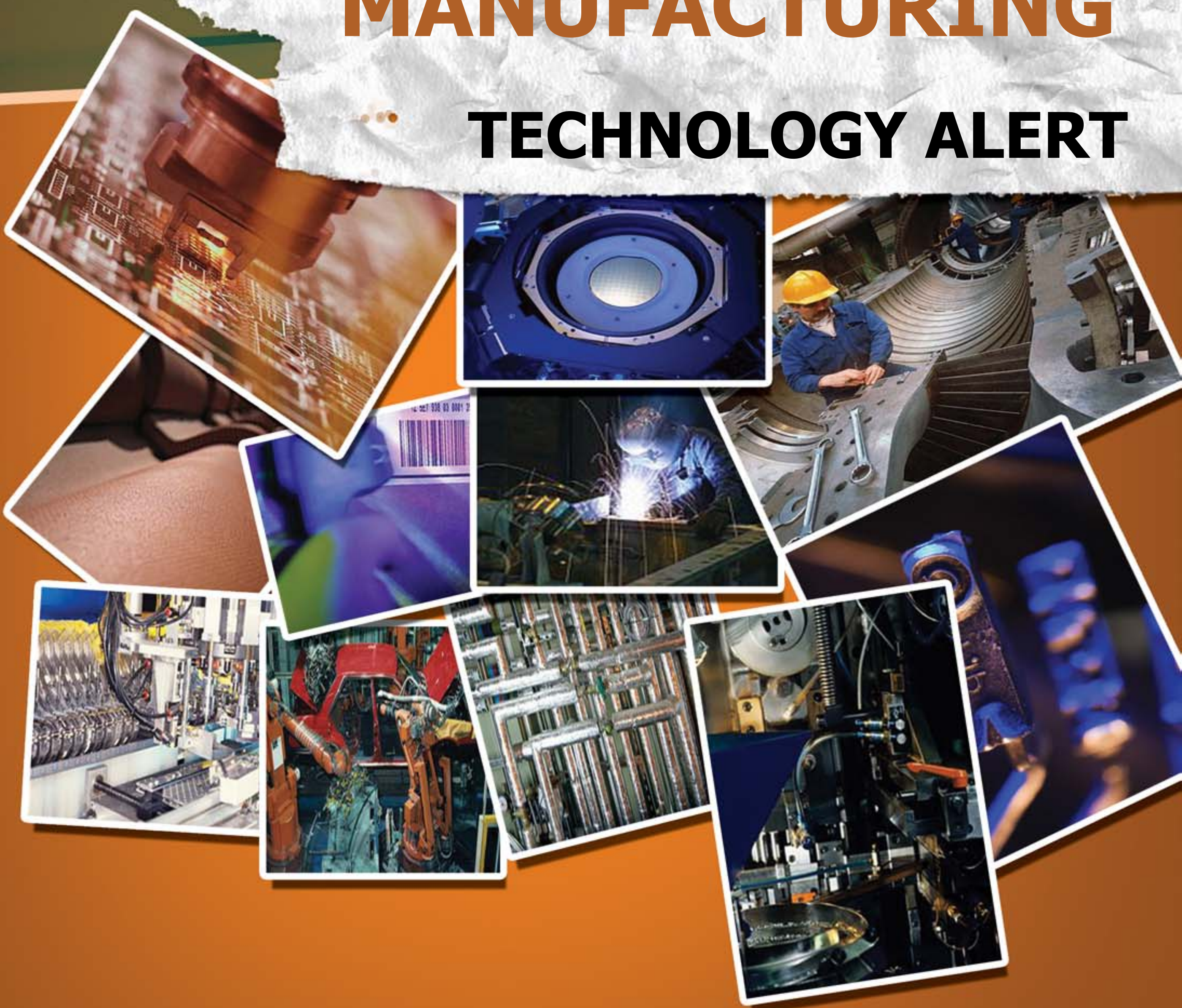
TECHNICAL INSIGHTS

ADVANCED MANUFACTURING

TECHNOLOGY ALERT



02nd January 2015

1. DEVELOPMENTS IN METAL-CUTTING FLUIDS

Cutting fluids are essential to remove the considerable frictional heat generated at the tool/workpiece interface, to extend the life of cutting tool edges, and also to lubricate the cutting tool to prevent adhesion to the machined metal. Industrial-grade metal machining (with large feeds and speeds) makes the need for cutting fluids more acute (Please refer Exhibit 1). Another function of such fluids is to minimize rust on machine parts and tool holders. The available varieties of cutting fluids are many, including: water-based fluids, oil-based fluids, oil/water emulsions, gels, pastes, solid waxes, aerosol mists, compressed air, and more. The oils can be mineral-based (from petroleum stock) or man-made synthetics. Plain water was reportedly the first coolant/cutting fluid applied in machine shops back in the 19^{th} century.

Exhibit 1 depicts cutting fluid at work.

Picture Credit: http://www.nederman.com/problems-we-solve/production-recycling/coolant-and-cutting-fluid

Some metals, such as brass and cast iron, are recommended to be machined dry, with no cutting fluid. So-called free-machining brass contains small amounts of lead to facilitate dry metal-cutting operations. Grey cast iron contains so much carbon graphite in flake form (around 4% of the mass) that this substance proves sufficient for lubrication. Liquid coolants/cutting fluids may contain petroleum distillates, animal fats, plant oils, water, and more. The cutting fluids containing organic ingredients can become rancid over time and smell bad if not replaced regularly.

The means for cutting fluid application are several: flooding, spraying, misting, dripping, smearing up against a moving bandsaw blade (like a wax in a consumable cardboard tube), and brushing. Misting is not so good for machine operators. A more modern method of aerosol delivery has emerged: MQL (minimum quantity of lubricant). In that case, the aerosol is delivered through or around the cutting tool insert. The method is so effective that machinists perceive it to be almost dry machining.

The cutting fluid application techniques can result in a lot of splattering, so enclosures are recommended to contain the mess. Ambient air has low-thermal conductivity, thus is not an effective coolant, so can be tolerated only for light cuts. The lubrication function is quite beneficial, by reducing the coefficient of friction at the tool/workpiece interface, so that less heat is generated. Another benefit is the prevention of chips from welding onto cutting tool surfaces.

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2. TORCH CUTTING TECHNOLOGY

Technical Insights has previously written about various methods of metal work piece cutting on the factory floor via mechanical means (such as saws--bandsaw, hack saw, abrasive cut-off wheel, toothed cold cut-off saws), as well as laser beams, EDM--electrodischarge machining, EB--electron beams, and water-jet cutting. Sometimes a welding torch is the preferred method of cutting, as with really thick steel plate, that could take a long time to cut with other methods.

Oxygen (Oxy)-fuel cutting/welding torches (which can be fueled by propane gas, acetylene gas, natural gas, propylene gas, hydrogen gas or liquid fuels) (Please refer Exhibit 2) will do the job, as well as electric-energized welding and cutting torches (such as plasma arc). It must be understood that, in trade for beneficial speed and ability of rather hot torches to cut through virtually any material, a considerable amount of heat will be introduced to the work piece, which can damage the temper or heat treatment properties, and perhaps burn the metal.

Exhibit 2 depicts an oxy-fuel cutting torch in action.

Picture Credit: http://oxypetrol.com/

The portability of oxy-fuel torches (which require two tanks--for fuel and oxygen), with no need for an electric power connection, is an advantage. However, higher-tech electric powered torches are gaining market share. In the oxy-fuel torch, initially, the metal is heated cherry red, then an oxygen valve (oxygen-blast trigger) is opened, initiating a burning and melting of the metal, continuing the heating process via exothermic combustion. The oxy-fuel torch process generates iron oxide in the cutting kerf, which melts at half the temperature of steel, and flows away. Nonetheless, some oxide slag remains that needs to be tapped or ground off. One higher-performance oxy-fuel torch, the equal-pressure injector torch, projects oxygen out of the torch middle, dragging fuel with it, leveraging the venture effect.

Plasma torches can be manipulated by robots or automated with CNC (computer numerical control), which allows more intricate and demanding cut patterns. The technology is limited to two-dimensional (2D) patterns. Although very effective with thin sheet metal, the largest CNC plasma torches can cut steel up to around 150 mm (almost 6 inches) thick. Striking the plasma arc needs special techniques, such as the high frequency start or blow back (starting with a short circuit). A gas (such as air or inert gas), is blown through a nozzle, and an electric arc is struck through the flowing gas, directing superheated plasma to a metal work piece, which is immediately melted.

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3. CENTERLESS GRINDING TECHNOLOGY

An important manufacturing process for machining and mass production of many cylindrical metal work pieces that are hardened/heat-treated is centerless grinding. No spindle is used to secure the round work pieces, which are cradled between two revolving wheels and sitting on a work rest pedestal or blade (which the machine operator can raise or lower). One wheel is the regulating wheel (smaller diameter) and the other wheel is the grinding wheel (larger diameter, please refer Exhibit 3). The relative surface speed of the two wheels determines the rate of metal removal. Both wheels are revolving in the same direction, such as counterclockwise (viewed from the end of work piece, as seen in Exhibit 3).

The regulating wheel moves to apply lateral pressure to the work piece, forcing it into the grinding wheel. The grinding wheel (also movable laterally) tends to apply a force that impels the work piece down into the support blade/pedestal. The regulating wheel has a rubberized abrasive surface to trap or keep the work piece in place. The round work piece turns at the speed of the regulating wheel, whereas the grinding wheel presents a higher tangential velocity at contact with the work piece.

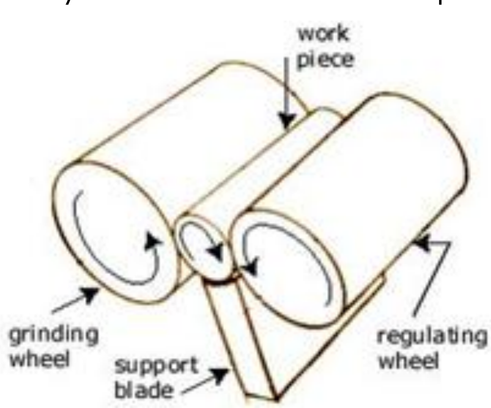

Exhibit 3 depicts the centerless grinder layout.

Picture Credit: http://cybermediaservicesdigitalmag.com/biospectrumasia/ centerless-grinder

Again, grinding is only considered for hardened work pieces (and there are many of them produced, for example the hardened steel rollers used to carry the load in anti-friction roller bearings). The centerless grinding rate of metal removal is modest compared to turning centers or lathes. As with turning centers, centerless grinders may have CNC control, to automate, expedite, and boost the precision of grinding operations.

Grinding wheels can be switched out to choose particular wheel sizes and grit ratings. They are bonded abrasive wheels containing such ceramics as aluminum oxide, or zirconium oxide, or silicon carbide, or blends of these ceramics. Diamond dressing tools are used to true-up the cutting face. Spinning RPM limits must be observed or the wheel will disintegrate, throwing chunks all over the machine shop.

Through-feed machines have the regulating wheel mounted slightly off axis (away from the plane of the grinding wheel) so that work pieces will self-feed through the machine. This eliminates a feeding mechanism, but the work pieces must be perfectly cylindrical. For tapered work pieces, the metal is axially fed into the machine up against a rest stop, ground, then ejected in the opposite direction. For fancy shapes, such as hourglass work pieces, they are manually loaded, then the regulating wheel moves into place. The shapes will be ruined by any axial movement, so must be locked in place.

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4. PATENT ANALYSIS OF FORGING

Forging is a manufacturing process, which involves controlled deformation of a metal into a specific shape by compressive forces. The forging process is better than casting; and the parts formed using the forging process have denser microstructures, defined grain patterns, and less porosity. The forgeability of a metal or an alloy depends on the forgeability rating. The factors involved in forging a metal/alloy are the material's composition, crystal structure, and mechanical properties; and all these factors are considered within the temperature range. The forgeability rating is high for wide temperature ranges.

A latest patent in forging process, US8857236 B2, is assigned to Showa Denko K.K. and pertains to a forging device that is capable of producing a high-quality article while simplifying the structure.

Many patents have been filed for the forging process by Showa Denko K.K, and Kobe Steel Ltd. Many companies are working on forging methods. Some examples include Kobe Steel Ltd.'s patent (US8057737 B2) on a new manufacturing method for forging steel. Also, Seiko Epson Corporation has a patent (US7127929 B2) on a forging work method.

Title	Publication Date/ Publication Number	Assignee	Inventor	Abstract
Forging device	14 Oct 2014 / US8857236 B2	Showa Denko K.K.	Daisuke Endo, Tomoo Uchida	A forging device capable of producing a high-quality forged article while simplifying the structure is provided. The forging device of the present invention includes a punch **1**, a die **2** having a shaping hole **22** and a helical blade portion **23** formed on an inner peripheral surface of the shaping hole, a back pressure generation mechanism **15**, and a back pressure transmission mechanism. The back pressure transmission mechanism includes a rotation-side transmission member having a back pressure plate **40** and a non-rotation-side transmission member. The back pressure plate **40** is arranged in the shaping hole **22** in a fitted manner. When a forging material W**1** is driven into the shaping hole **22** and the back pressure plate **40** is pressed downward by the metallic material, the back pressure plate **40** is guided by the blade portion **23** of the shaping hole **22** and thereby descends while rotating about the axis and a back pressure by the back pressure generation mechanism **15** is applied to the metallic material via the back pressure transmission mechanism.
Forging method, closed forging mold and tripod uniform motion universal joint	15 Jan 2013 / US8353778 B2	Ntn Corporation	Jiahua Miao, Akira Sera, Shunsuke Makino	A forging method and a full-enclosed forging die contribute to the alleviation of an enclosing force applied to dies and in which a relatively small enclosing apparatus can be used even with respect to larger-sized products. A tripod type constant velocity universal joint is formed with a tripod member molded with the full-enclosed forging die. The full-enclosed forging die includes openable / closable dies and punches for pressing a material between the dies. From the forging die, the tripod member including a boss portion and shaft portions protruded radially from the boss portion is molded.

Forming of metallic glass by rapid capacitor discharge forging	24 Dec 2013 / US8613814 B2	California Institute Of Technology	Georg Kaltenboeck, Joseph P. Schramm, Marios D. Demetriou, William L. Johnson	A forging apparatus and method of uniformly heating, rheologically softening, and thermoplastically forming metallic glasses rapidly into a net shape using a rapid capacitor discharge forming (RCDF) tool are provided. The RCDF method utilizes the discharge of electrical energy stored in a capacitor to uniformly and rapidly heat a sample or charge of metallic glass alloy to a predetermined "process temperature" between the glass transition temperature of the amorphous material and the equilibrium melting point of the alloy in a time scale of several milliseconds or less. Once the sample is uniformly heated such that the entire sample block has a sufficiently low process viscosity it may be shaped into high quality amorphous bulk articles via forging in a time frame of less than 1 second.
Aluminum alloy forging member and process for producing the same	10 Apr 2012 / US8152940 B2	Kobe Steel, Ltd.	Manabu Nakai, Yoshiya Inagaki, Atsumi Fukuda	The present invention provides an aluminum alloy forging material having enhanced strength, toughness, and corrosion resistance, and a method of producing the material. An aluminum alloy forging material 1 produced with specified components under specified conditions has an arm portion 2 including a relatively narrow and thick peripheral rib 3 and a thin and relatively wide central web 4 having a thickness of 10 mm or less and having a substantially H-shaped sectional form. In a width-direction section of a maximum stress producing site of the rib 3 a, the density of crystals observed in the structure of a sectional portion 7 where the maximum stress is produced, the spacing of grain boundary precipitates and the size and density of dispersed particles observed in the structure of a sectional portion 8 including a parting line, the recrystallization ratio observed in each of the sectional portions 7 and 8 of the rib, and the recrystallization ratio observed in a sectional portion 9 of the web 4 a adjacent to the sectional structure of the rib 3 a in the width direction are defined for enhancing the strength, toughness, and corrosion resistance of the aluminum alloy forging material.
Method for producing shaped article of aluminum alloy, shaped aluminum alloy article and production system	9 Sep 2014 / US8828157 B2	Showa Denko K.K.	Yasuo Okamoto	A method for producing an aluminum-alloy shaped product, includes a step of forging a continuously cast rod of aluminum alloy serving as a forging material, in which the aluminum alloy contains Si in an amount of 10.5 to 13.5 mass %, Fe in an amount of 0.15 to 0.65 mass %, Cu in an amount of 2.5 to 5.5 mass % and Mg in an amount of 0.3 to 1.5 mass %, and heat treatment and heating steps including a step of subjecting the forging material to pre-heat treatment, a step of heating the forging material during a course of forging of the forging material and a step of subjecting a shaped product to post-heat treatment, the pre-heat treatment including treatment of maintaining the forging material at a temperature of −10 to 480° C. for two to six hours.

Forging steel and its manufacturing method, and forged parts	15 Nov 2011 / US8057737 B2	Kobe Steel, Ltd.	Tetsushi Deura, Motohiro Nagao, Atsushi Tomioka, Shogo Fukaya	A forging steel has a dissolved Mg concentration within the range of 0.04-5 ppm by mass and a dissolved Al concentration within the range of 50-500 ppm.
Forging work method	31 Oct 2006 / US7127929 B2	Seiko Epson Corporation	Fujio Akahane, Nagamitsu Takashima, Kazushige Hakeda, Ryoji Uesugi, Akiharu Kurebayashi	A metallic plate member is provided. A first punch is operable to perform a first forging work to mold a first member in the plate member. The first member has a first function. A second punch is operable to perform a second forging work to mold a second member in the plate member. The second member including at least one kind of positioning member. The first forging work and the second forging work are performed at a single stage.
Forging device and method therefor	1 Oct 2002 / US6457342 B2	Kabushiki Kaisha Kobe Seiko Sho	Masanori Tanahashi, Yoshinori Ogata	A forging device and a method therefor that enables improve forging precision of a work and lengthen life of dies of a forging device, by efficiently heating the work chiefly made of aluminum in one heating furnace, wherein the device has: a heating furnace for heating works W while moving the works W along the movement path; an intermediate processing means, disposed in the midst of the movement path in a heating furnace, for intermediately forming works W; an intermediate conveyance means for conveying works W from the heating furnace to the intermediate processing means; and a final processing means for making the intermediate conveyance means convey the intermediately formed works W to the heating furnace, reheating the conveyed the works W, and finally processing to form the works W.
Forging method forged product and forging apparatus	9 Dec 2008 / US7461533 B2	Showa Denko K.K.	Atsushi Otaki, Hidemitsu Hamano	A forging apparatus 1A includes a swaging apparatus 2 equipped with a fixing die 10, a guide 20 having an insertion passage 22 for inserting and holding a bar-shaped raw material 5 in a buckling preventing state, and a punch 30. The raw material 5 is fixed to the fixing die 10 with the one end portion of the raw material protruded. The one end portion of the raw material 5 is inserted into the insertion passage 22 of the guide 20. Thereafter, while pressing the raw material 5 with the punch 30 in the axial direction, in a state in which an entire peripheral surface of the exposed portion 8 of the raw material 5 exposed between the guide 20 and the fixing die 10 is not restrained, the guide 20 is moved in a direction opposite to the moving direction of the punch 30 so that a length of the exposed portion 8 of the raw material 5 becomes a budding limit length or less at a cross-sectional area of the exposed portion 8 of the raw material 5.

				Thus, the one end portion of the raw material 5 is subject to swaging processing.
Forging machine having rollers between a support and a slide body of a die assembly	8 Sep 2009 / US7584641 B2	Fwu Kuang Enterprises Co., Ltd.	Yun-Te Chang	A forging machine includes a support having two sidewalls, and two track plates attached respectively to the sidewalls. A slide body of a die assembly is mounted slidably inside the support between the sidewalls. Two first rolling devices are respectively mounted on the track plates near the front of the support to contact the slide body. Two second rolling devices are mounted respectively on the sidewalls above the track plates and near the rear of the support to contact the slide body. Due to the first and second rolling devices contacting the slide body near the front and rear of the support, the slide body can slide stably in the support without positional deviation.

Exhibit 4 depicts patents related to forging.

Picture Credit: Frost & Sullivan

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