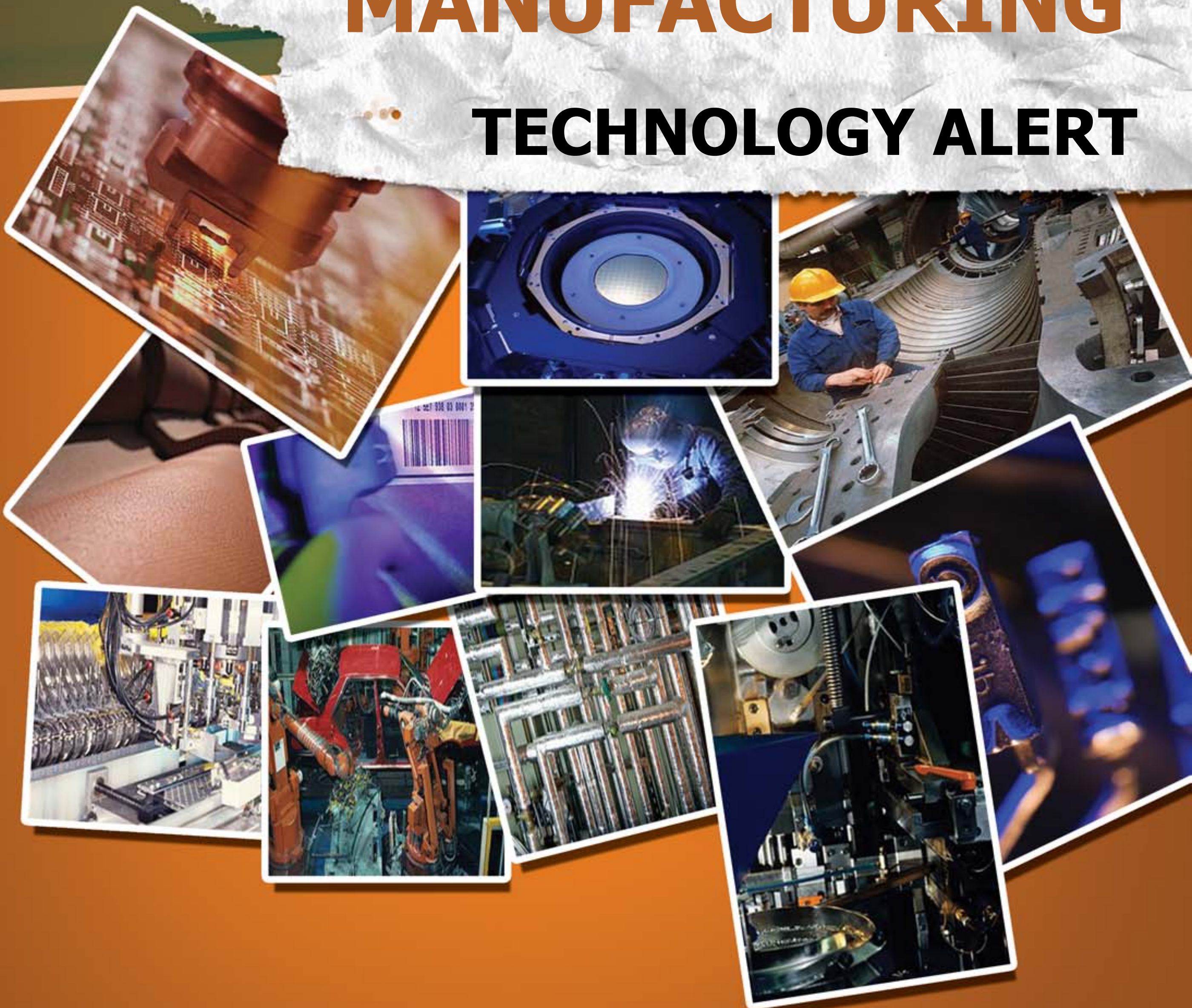
TECHNICAL INSIGHTS

ADVANCED MANUFACTURING

TECHNOLOGY ALERT



28th November 2014

1. HIGH-POWER SPINDLE RAISES PRODUCTIVITY OF LARGE PART MACHINING

One reason that Makino of Mason, Ohio, has maintained its leadership in advanced computer-numerically-controlled machining centers is that its designers have improved proven solutions to create next-generation CNC machining centers. A case in point is the Makino a81nx horizontal machining center for producing large parts. The a81nx is designed to enhance the capacity, productivity, and reliability of its highly successful predecessor the a81 machining platform.

For example, the size of large parts can limit the space of the work zone and hamper cutting processes. Makino engineers addressed this by extending the Y-axis of the a81nx by 100 millimeters. This lengthens the full-axis travels along the X, Y, and Z axes to 900 mm, 900mm, and 1,020 mm, or 35.4 inches, 35.4 inches, and 40.2 inches, respectively. Extended Y-axis travel is a boon for making automotive parts such as cylinder heads and engine blocks whose critical mating surfaces must have feed-on/feed-off milling passes to optimize sealing.

Because large machine parts typically possess multiple features in a range of sizes, CNC machining centers must be able to bring diverse tool types and sizes to bear quickly. Makino developed a robust automatic tool changer that can swiftly deploy tools that are larger in diameter, longer, and heavier to fashion the features found in larger parts.

The Ohio company has equipped its new horizontal machining center with a 10,000 revolution per minute spindle that provides 305 Newton meters of torque and 45 kilowatts of extended duty-rated power, or 26 kW of continuous output to raise speed and productivity. The a81nx duty-rated power levels are 25% greater than the a81 machining center to significantly cut spindle acceleration and deceleration times. Makino reports that this will save the time taken for the tapping process by 20 to 30%.

For manufacturers of hard metal parts, Makino provides an optional 8,000 rpm, high-torque spindle configuration for the a81nx. This high-torque spindle has 553 Nm of duty-rated torque and 37 kW of continuous output, delivering 19% more continuous power compared to the previous generation Makino high torque spindle. Such power can cut the most difficult metals to machine, such as titanium.

The Makino design team also equipped the a81nx with a novel GI servo control mode to reduce the time needed to pocket aluminum billets. A new chain-type automatic tool-change magazine holds up to 80 tools to reduce the time needed to search for the required tool.

The a81nx is designed to provide greater rigidity and reliability than its predecessors. Makino engineers achieved this by enhancing the build qualities of the new horizontal machining center's bed, column and table castings. Specifically, they increased the step height between the front and rear X-axis linear guide to impart more strength and raise acceleration. Makino uses roller-type linear motion guides to give the a81nx more stiffness and reliability in higher load capacities. Makino makes the a81nx B-axis table available in two configurations: index and numeric-controlled rotary. The index table features a larger curvic coupling diameter within the table, and the NC rotary table uses a three-roller-type bearing. Both innovations enhance rigidity.

Mindful that tool changes are made literally millions of times during the life of a machining center, Makino's engineers focused on making their nx-Series machines' automated tool changers as reliable as possible. This includes a high-speed, servo-driven ball screw to actuate the tool changer's shutter door to improve responsiveness, and facilitate setup and maintenance. Another benefit of the servo axis is minimizing exposure of the automated tool changer to the work envelope. A taper-cleaning air-blow station and tool-seat detection capability keeps tools clean and seated properly in the spindle.

While many of the a81nx functions are automated, human operators operate the advanced machining center and handle the large parts, so ergonomics was a key design consideration. The Makino horizontal machining center has an L-shaped door to improve accessibility to its spindle, provide greater visibility for inspection of the tool and the part it is working, and prevent coolant drip at the doorway. Engineers located the preventive maintenance features of the a81nx at the back of the machine to simplify access.

Makino designers equipped the safety-guard door on the automatic pallet changer of the a81nx with an adjustable height for the operation panel so that it can be adjusted to meet the level of the operator's work platform. There is also a wider automatic pallet change stocker that supports the loading of large fixtures and workpieces, and chip cleaning.

All a81nx magazines feature a tool-loading station to aid the physical challenges of manually handling large and heavy tools. Makino makes a touch-type human machine interface panel available on all 80-tool and larger capacity automatic tool changers to simplify operator management of tool data at the magazine.

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2. IRRADIATION IN MANUFACTURING AND PROCESSING OF FOOD

Exposure of food products to controlled doses of ionizing radiation has been a long-accepted commercial practice around the globe (50 countries), but is controversial because many consumers fear (incorrectly) that such irradiated food becomes radioactive (glowing in the dark?) and toxic to ingest. The irradiation benefits include elimination of pathogens (disease-causing micro-organisms), destruction and sterilization of resident insects (such as fruit flies and their larvae), considerable extension of shelf life, reduction of sprouting, delay of ripening, enhanced re-hydration, and higher juice yield from fruits. The process is also known as cold sterilization. The most widely used form of radiation is the gamma ray, a highly energetic and deep-penetrating form of electromagnetic radiation. Electron beams (beta radiation, with shallow penetration) and x-rays have also been used. A key source of gamma rays is the cobalt (Co) 60 isotope, also used in the medical community for radiology therapies and sterilization.

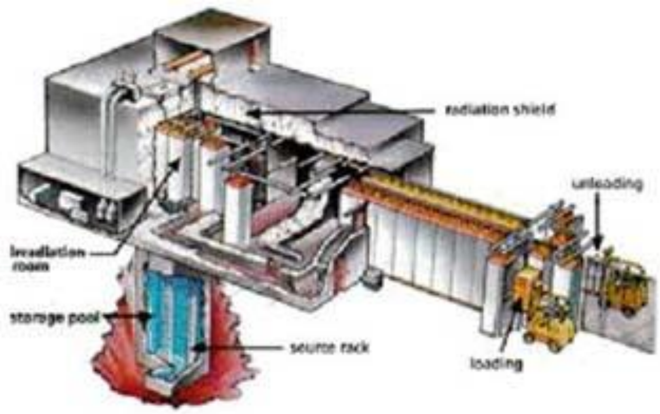

Exhibit 1 depicts an irradiation system for food sterilization.

Picture Credit: http://thealignedindustries.com/process/

Radiation exposure (which is a function of time exposed, and dosage level-- low/medium/high) does alter the chemistry of many foods in ways that differ from traditional heating or sterilization, thus nutritional value and sensory qualities of the food (such as taste and appearance) may be modified. The population of free radicals in the food will increase, but that is not considered particularly dangerous. Traditional food processing via cooking, salting, smoking, and extended storage (resulting in spoilage) have much more dramatic effects on food products than irradiation. Dried/ground spices and herbs that are irradiated have very little nutritional or taste degradation, but enjoy nearly unlimited shelf life when stored properly.

Although there is a global annual production of irradiated foodstuffs around 500,000 metric tons, according to industry sources, there is not tremendous demand-pull from consumers. The US meat industry was shipping a good deal of irradiated products in the early 2000s, but more recently, the industry has cut back considerably—people are not asking for this product, despite the benefits, and apparently don't object to a shorter shelf life. And the meat industry did not want to take chances with the risky image of irradiation.

This food processing technology, unfortunately, can lead to public hysteria and irrational behaviors. For example, after many cat deaths in Australia were attributed to a brand of irradiated cat food, this brand of product was recalled and banned from the market. Subsequent pathology analysis, however, showed that all the cat deaths were traceable to one lot of bad cat food. All other brands of irradiated cat food on the market yielded no such ill effects, so how could gamma ray treatment, in general, cause cat fatalities?

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3. ELECTRIC RESISTANCE HEATING FOR MANUFACTURING OPERATIONS

Factory process designers have various alternative methods to bring heat to a manufacturing work piece or fluid medium, directly and indirectly, usually powered by electricity or fossil fuels. Any item needing indirect electric heat can be exposed to a set of electric resistance wires in close proximity (a toaster or toaster oven). For instant electric resistance heating, manufacturers pass a substantial current directly through the work piece. The power loss P (in W or kW) = I^2R: current (amps) squared x resistance (ohms). This is the Joule heating effect. Power generated or dissipated over time represents energy, such as heat energy (measured as Joules or kWh, or BTUs-British Thermal Units, where 1 kWh = 3413 BTU) transferred to a workpiece. A Joule represents the energy of 1 amp of current passing through 1 ohm of resistance for 1 second.

Relatively poor conductors, such as steel, readily lend themselves to direct resistance heating. One industrial application is heat treating, or hardening, of carbon steel: the manufacturer can use direct-resistance heating to heat steel to cherry red, hold (or apply soak time), then quench in water or oil. Many electric resistant heaters have a heating element wire of fairly high resistance (such as 80% nickel-Ni, plus 20% chrome-Cr) sheathed in a grounded protective metal, such as a stainless steel jacket, with an insulating ceramic in between (such as magnesium oxide powder).

Programmable low-voltage thermostats are a standard practice in industrial applications for electric resistance heating. The thermostat controls (via low voltage and current signals) a remotely operated relay carrying and switching the heavy current and high voltage on and off. The power levels of electric resistance heaters are substantial, ranging from low single kW levels to hundreds of kW

Exhibit 2 depicts an electric resistance immersion heater for fluid processing.

Picture Credit: http://www.wattco.com/immersion-heaters.html

One key advantage of electric resistance heating is that there is no waste; all the energy input converts to heat. Another is the inherent cleanliness; there are zero emissions at the point of use. One drawback is that the cost of electric energy (per kWh) is generally higher than many commercial fossil fuels, in terms of US dollars (or other currencies) per 1000 BTUs. So, factory operating costs could run at a premium, depending on local power rates. Offsetting that is avoidance of emissions control costs.

To summarize the manufacturing plant uses, electric resistant heating can be used for: space heating, water boiling, fluid processing, hardening of metals via heat treating, and various drying processes. The space heating could be configured as an electric furnace, a baseboard heater (with tube/fin layout), a wall or ceiling-mounted heater, an infrared hot quartz emitter/heater (as for outdoor gatherings of employees), and a portable spot heater, with or without forced air for circulation.

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4. PATENT ANALYSIS OF EVAPORATIVE PATTERN CASTING

Evaporative pattern casting is a casting process in which the pattern is made from a material that will evaporate when the molten metal is poured into the molding cavity. There are two major evaporative pattern casting processes--lost-foam casting and full-mold casting. The main difference between the two casting processes is that lost-foam casting uses unbonded sand whereas full-mold casting uses bonded sand.

A recent patent in evaporative pattern casting, US8733421 B2, was assigned to Honda Motor Co. Ltd.; it pertains to the evaporative pattern casting process. Many patents have been filed for the lost-foam casting process. Examples include General Motor Corporation's patent on lost foam casting without fold defects (US6189598 B1) and GM Global Technology Operations' patent on lost foam casting apparatus and method for creating hollow gating (US7150307 B1

). Robert Bosch GmbH has filed a patent on a new method to manufacture an electric machine by the lost foam casting process (US8424186 B2).

The advantages of the lost foam casting process are that the complex components can be produced as one part whereas other manufacturing processes would require the production of one or more parts that have to be assembled. There is more design flexibility, as the foam is easy to manipulate and carve. Complex shapes can be produced without the need for cores and also no draft paper is required as the pattern is not removed prior to casting.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Evaporative pattern casting process	May 27, 2014 / US8733421 B2	Honda Motor Co., Ltd.	Fumio Hirai, Osami Ito, Hiroyuki Yamada, Hiroshi Ichikawa, Hidetaka Hokazono, Tomohiko Yamamoto, Kosuke Murai	An evaporative pattern casting process includes forming a mold by burying a pattern made of resin foam in casting sand, pouring molten metal into the mold, and evaporating the pattern with the molten metal and thereby casting a product. In the evaporative pattern casting process, casting time during founding is set according to a modulus (pattern volume÷pattern surface area) of the pattern. Accordingly, the casting time in the evaporative pattern casting process is accurately set with high precision.
Method of generating CAD data for evaporative pattern having frame structure	Jun 24, 2014 / US8762112 B2	Toyota Jidosha Kabushiki Kaisha	Hiroshi Imakawa, Kozue Kato	A method for generating CAD data appropriate for designing an evaporative pattern having a frame structure is provided. The method includes, allocating, generating joint shape data, and extracting rod body data. Rod data includes rod body data representing a shape of a rod body and terminal data representing a shape of a rod terminal disposed at an end of the rod body. In the allocating, a plurality of the rods is allocated so that the rod terminals overlap each other in a 3-dimensional space in computer. In the generating, the joint shape data is generated by merging the terminal data of the plurality of rod terminals overlapped. In the extracting, the rod body data is extracted from the rod data of the rods allocated in the 3-dimensional space. The joint shape data and the rod body data obtained by such processes correspond to the CAD data of the evaporative pattern.
Lost foam casting without fold defects	Feb 20, 2001 / US6189598 B1	General Motors Corporation	George D. Chandley, Qi Zhao	Fold defects are reduced or eliminated in lost foam castings by contacting a destructible polymeric pattern surface proximate to which deleterious fold defects comprising unbonded seams are prone to form in the solidifying molten metal with a material that reduces or eliminates fold defects in the casting proximate the pattern surface. The material can comprise a silicone layer that is anti-sticking relative to a gas permeable refractory layer on the pattern or foundry sand directly contacting the pattern surface depending on casting configuration. The pattern is cleaned prior to contact with the material. Lower melt casting temperatures can be used with concomitant improvements in casting microstructure (e.g. finer dendritic arm spacing) and mechanical properties.
Apparatus and improved method for lost foam casting of metal articles using external pressure	Apr 26, 2005 / US6883580 B1	Brunswick Corporation	Raymond J. Donahue, Terrance M. Cleary	An apparatus and method to delay the application of pressure on a molten metal front to equalize a pressure gradient present at the molten metal front during pressurized lost foam casting processes, or other pressurized casting processes. A pressure equalization member is placed over a pouring cup to divert the direct application of pressure to molten metal present in the pouring cup. The pressure equalization member allows for increased pressurization rates in such processes, facilitating interdendritic feeding while reducing microporosity and metal penetration defects.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Lost foam casting apparatus and method for creating hollow gating	Dec 19, 2006 / US7150307 B1	Gm Global Technology Operations, Inc.	David D. Goettsch	A method and apparatus is disclosed for forming a metal casting sprue for a lost foam casting process, the sprue formed in sand for receiving molten metal and directing the molten metal to a foam pattern in a mold cavity, wherein the sprue formation is facilitated by an insert having a plurality of apertures formed therein, the apertures facilitating an application of a coating to sand surrounding the insert prior to removal of the insert from the sand, and wherein the sprue facilitates a minimization of production costs and an optimization of material properties of the resultant casting.
Container-filling device for lost-foam casting systems	Jun 15, 2004 / US6749004 B1	Fata Aluminum Division Of Fata Group S.P.A.	Alfredo Dal Pan	The device, which can be used for filling containers in a lost-foam casting system, includes in a singe operational combination: supporting devices for containers with associated vibration devices to set the containers into vibration; a sand-feeding device, such as a hopper, for feeding dosed quantities of sand into the container; and a positioning device that make it possible to locate foam models into containers and sustaining them both while the sand is being fed into the containers and while the containers are being vibrated, thus avoiding the risks of malpositioning and/or breakage. Preferably, both the sand feeding hopper and model-positioning device on the same equipment capable of moving between a raised position in which the hopper may be loaded with the sand, while the foam models are being transferred by the positioning device, by a robot for example, and a lowered position, in which the models are inserted into the containers, after which the latter can be filled with sand.
Full mold casting process and device for a differential case with cast-in bolt holes	May 10, 2005 / US6889742 B1	Torque-Traction Technologies, Inc.	William Glen Jensen, Michael J Catalano	A peripheral flange formed on a differential case for mounting a ring gear and the peripheral flange is provided with a plurality of cast-in bolt holes for bolting up the ring gear to the differential case using the lost foam casting process for making the differential case. A method of making a gear case eliminates the process of machining of the bolt holes in the differential case casting, thus reducing cost of manufacturing the differential case.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Evaporative pattern, method of forming an evaporative pattern, and method of forming a metal mold by using an evaporative pattern	Mar 25, 2014 / US8678071 B2	Toyota Jidosha Kabushiki Kaisha	Hirotake Sueta, Kiyoshi Kameyama, Atsushi Takemoto, Tatsuya Watarai, Hitoshi Akimoto, Masaki Yamashita	A lightweight metal mold having a necessary rigidity is realized. Firstly, an original pattern of an evaporative pattern is formed by machining an evaporative material block. The original pattern includes a three-dimensional mesh structure including a plurality of bar-shaped parts and connecting points that connect ends of the bar-shaped parts and are distributed in a three-dimensional space, and a plurality of block parts having fixed relative positional relationship by being fixed to the three-dimensional mesh structure. Then, at least a portion of at least one or more of the bar-shaped parts composing the original pattern is removed, and replaced with a tube member. Then, a full-mold casting is performed by using the evaporative pattern having the replaced tube member. Positional relationship of the block parts in which surfaces, etc. necessary for the metal mold are formed is fixed by the three-dimensional mesh structure, and the necessary rigidity is secured. The metal mold is made lighter by using the three-dimensional mesh structure. Due to the replacement with the tube member, an amount of gas generated upon the full-mold casting is suppressed, and a decrease in casting quality is prevented.
Method for the production of a lost-foam casting model for a light metal cylinder liner	Feb 6, 2007 / US7172011 B2	Mahle Gmbh	Karlheinz Bing, Frank Winger	A light metal cylinder liner with a surface which facilitates the connection with the surrounding cast material may be produced. The cylinder liner is produced by a lost-foam method with a form for production of the cast foam model having a structured surface with height variations of 0.8 to 5 mm. The structured surface is, for example, grooves or longitudinal elevations.
Method for manufacturing an electric machine by a lostfoam casting process, and electric machine for a hybrid vehicle	Apr 23, 2013 / US8424186 B2	Robert Bosch Gmbh	Denis Kern, Andreas Herzberger	A method for manufacturing an electric machine, made up of a housing, a stator accommodated in the housing, which is formed from a stator body and stator windings, a rotor, which is supported in the housing so as to be rotatable about a rotor axis, and a bearing support fastened on the housing, includes a housing foam part manufactured from at least three individual foam parts and a housing cast blank manufactured using the housing foam part in accordance with a lost foam casting method. Individual foam parts are made up of a center disk having an essentially hollow-cylindrical design and forming an intermediate piece of a housing foam part, an annular disk having an essentially hollow-cylindrical design and forming another intermediate piece of the housing foam part, and a bearing support disk having an essentially cup-shaped design and forming an end of the housing foam part.

Exhibit 3 depicts patents related to metal injection molding.

Picture Credit:Frost & SUllivan

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