TECHNICAL INSIGHTS

ADVANCED MANUFACTURING

TECHNOLOGY ALERT

21st November 2014

1. AUTOMATING SURFACE ROUGHNESS TESTING INCREASES MACHINE TOOL EFFICIENCY

Part surface roughness is an important testing parameter of many parts created on machine tools. Unlike other measurements that can be automated, checking a part’s surface roughness typically requires that the work piece be manually clamped or removed from the machine for external inspection. Both approaches interrupt automated production and can incur errors. Blum-Novotest GmbH in Grünkraut-Gullen, Germany, developed its TC64-RG Surface Roughness Gauge to automatically measure the work piece surfaces in machine tools to enhance their productivity.

Blum-Novotest has specialized in developing advanced measurement and testing technology for the machine tool, aviation, and automotive industries since its founding in 1968. Today, the German company's manufacturing facilities near Ravensburg and Willich, Germany, are supported by sales and service subsidiaries in the US, China, England, France, India, Italy, Japan, Singapore, South Korea, Taiwan, and Thailand.

The harshness of the machine tool environment has restrained the development of automated surface roughness measurement for many years. There was also the challenge of high production manufacturers who demanded fast measurements that would also be precise and reliable. The Blum-Novotest design team used its DIGILOG technology, introduced in 2010, to develop the TC64-RG. Like its predecessors, the new Blum-Novotest surface roughness probe has IP68 protection and is impervious to coolants. The TC64-RG can measure milled, turned, or ground surfaces to within a single micron accuracy in seconds, then use that information to analyze the Ra, Rz, and Rmax parameters of surface roughness. The gauge can display these roughness values on its Graphical User Interface, document them for later study, or output them as a status value.

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Blum-Novotest has reported the TC64-RG has been used to measure automotive connecting rods, cylinder bores, and impellers. Such parts must achieve a precise, predetermined roughness value in order to store lubricant in the part surface. Some manufacturers have used the new gauge to measure the surface roughness of aviation turbine blades and automotive transmission housings. The TC64-RG can also test free-form surfaces in contrast to external measurement devices.

At the heart of the TC64-RG is a wear-free optoelectronic measurement sensor. Blum-Novotest equips its roughness gauge with its patented shark360 measurement mechanism, two interlocking face gears. This integrated technology permits the probe to move in a defined deflection direction while simultaneously maintaining a desirable constant deflection force. Thus, the face gear will resist any torsion that may occur and prevent it from compromising the accuracy of the measurement.

The Blum-Novotest surface roughness gauge transmits data using BRC, the company's proprietary radio communication technology, proven in field installations of other Blum products. Rather than replacing traditional roughness measurement technologies, the German firm has positioned the TC64-RG as a way to help spot surface defects and automate part approval in as short a time as possible, thereby shortening the duration to achieve a return on investment.

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2. ELECTRIC INDUCTION HEATING AND MELTING TECHNOLOGY

A well accepted means to heat and melt conductive metals is via the induction process. That is, a large powerful electromagnetic coil(s) in proximity to a metal work piece can induce strong eddy currents to surge throughout the target material, which stimulates I2R ohmic (resistive) heating of the metal. The eddy currents can also be harnessed to stir metal melts that need good alloy addition mixing.

In a simple form, household electric range smooth cooktops can have internal apparatus that can indirectly and inductively heat a metallic pot, kettle, or frying pan from beneath, thus cooking the contents, or boil liquids. Inductive cooking can happen faster than with traditional electric ranges that have resistive stovetop elements (typically 80% nickel and 20% chrome) with an insulating sheath. Induction heating is considered clean and energy efficient.

A key to success in stimulating powerful internal eddy currents is to feed the copper electromagnetic coils (often liquid cooled) with relatively low voltage at rather high current levels and elevated AC frequencies (such as 400 to 500 kHz, rather than standard 50 Hz to 60 Hz line power). See the exhibit of a typical induction heater with a glowing work piece. The industrial uses are well known: metal hardening/heat treatment, brazing, metal melting (with induction furnaces), heating-to-fit (enlarging a work piece to accommodate and shrink fit a smaller diameter object), and indirect cooking of food. Plastics can be processed as well, if loaded with ferromagnetic particles.

Exhibit 1 depicts an induction heater at work.

Picture Credit: http://www.mindchallenger.com/inductionheater/

One established manufacturing use of induction heating is the vacuum induction melting (VIM) coreless electric furnace for oxygen-sensitive specialty metals (such as titanium, specialty steels--as for aircraft landing gear, nickel-based superalloys, shape-memory nickel-titanium alloys [trade name: Nitinol], and cobalt alloys). The first prototype VIM demonstration was in the US back in 1920 by E. F. Northrup. Germany (Heraeus, under the leadership of scientist Wilhelm Rohn) continued development, and by the late 1920s the English and Swedish had medium-frequency VIM furnaces in operation.

VIM is now common for safety-critical aerospace and nuclear engineering applications. By virtue of the high-frequency AC power provided to the induction coils, a rapidly fluctuating magnetic field is created. The changing magnetic fields, operating in the presence of conductors, induces current flow. One slight risk of the VIM process is carbon contamination of the melt, especially with melting of Nitinol. Power supply size can range from 10 kW to 42 MW. The largest induction furnaces can handle 65 to 100 metric tons of melt.

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3. MANUFACTURING OF FOOD PRODUCTS VIA 3D PRINTING

Three-dimensional (3D) printing (or additive manufacturing) of edible food seems far-fetched, yet a number of such food products have already been demonstrated on an experimental basis. However, volume commercial 3D production of food remains in the future. Many of the 3D printed foods, so far, are sugar-laced confections (see exhibit). However, non-sweet entrees (such as pasta and pizza) have received R&D effort. Kitchen taste tests show that all are edible, but some items (like layered pizza) proved disappointing and needed much more work.

Exhibit 2 depicts a logo 3D-printed with sweet Nutella spread.

Picture Credit: http://www.businessinsider.com/3d-printed-foods-2014-9?op=1

Major US universities, including Cornell in New York and MIT in Massachusetts, are doing research in this field, developing 3D printers dedicated to foods. In addition, a number of pre-commercial projects have been funded by large food companies, such as Barilla (pasta) and Hershey's (chocolate). Mondelez International 3D-printed an imitation Oreo cookie with a choice of 12 filling flavors plus either a chocolate or vanilla base wafer in 2 minutes flat.

Testers say it tasted like an Oreo but did not hold up well structurally (easy to crumble). Mondelez used a machine created by MAYA Design, incorporating a Delta Bot 3D printer. These machines can be loaded with cartridges of flavored pastes, and the controlling computer takes it from there.

The pictured printed Nutella logo (this popular spread from Europe is made from cocoa powder, hazelnuts, sugar, palm oil, and skim milk) was engineered by a startup company, Structur3D. This company will offer next month an add-on to 3D printers, known as Discov3y ($349) to enable such food creations.

3D Systems, a giant in additive manufacturing equipment, announced earlier this year the availability of the countertop-size ChefJet printer, based on color jet printing technology and kitchen-ready for consumers to produce and experiment with edible products. The company will have a digital cookbook with a series of designs and a variety of edible materials to use. The printer prices will be fairly high for home use: a monochrome version just under $5,000 and a larger full-color printer just under $10,000.

Barilla wants to 3D print pasta at restaurants, up to 20 pieces every 2 minutes. The pasta shapes could be customized for each diner. Barilla's pre-filled pasta cartridges would feed into the printer. The machine is being co-developed with the company TNO in Eindhoven, Netherlands, and the pasta has been tested in some Eindhoven restaurants. No word on how diners liked the results. In 2013, NASA engaged an engineer to build a 3D food printer, and a crude pizza was shown after cooking the multi-layer concoction on a heated surface. Pizza ingredients included cream cheese and tomato ketchup (not exactly appetizing, compared to traditional pizza).

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4. PATENT ANALYSIS OF METAL INJECTION MOLDING

Metal injection molding is a metal working process in which finely powdered metal is mixed with binder material of measurable amount to comprise a feedstock which will be handled by plastic processing equipment through a process known as injection mold forming. Complex parts can be shaped in a single operation and in high volume through this molding process.

A recent patent in metal injection molding, US8846206 B2, is assigned to Siemens Energy, Inc., which pertains to an injection molded component.

Companies are working on using metal injection molding for various medical applications. Examples include Medtronic's patent on metal injection molded titanium alloy housing for implantable medical devices and Advanced Cardiovascular System's patent on metal injection molded tubing for drug eluting stents.

Companies are also focusing on using metal injection molding for various purposes. For example, Pratt and Whitney Canada Corp.'s patent on a new method to manufacture a metal injection molded combustor swirler and Magna International's patent on a new method to manufacture a hinge assembly using the metal injection molding process and die highlight this trend.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Multi-component composition metal injection molding	Nov 26, 2013 / US8591804 B2	Cool Polymers, Inc.	Kevin A. McCullough, James D. Miller	A method of metal injection molding on an injection molding machine having a heated barrel with an increasing temperature gradient is disclosed. A first step includes providing a metal alloy feedstock including a first component having a first melting point and a second component having a second melting point that is higher than the first melting point, the first melting point and the second melting point selected to match the temperature gradient of the heated barrel of the injection molding machine. A second step includes feeding the metal alloy feedstock into the injection molding machine. A third step includes melting the metal alloy feedstock within the heated barrel of the injection molding machine. A fourth step includes maintaining the percentage of solids to liquids in the metal alloy feedstock of the first component and second component within a processable range of about 5% to about 30%.
Metal injection molded putter	Aug 14, 2012 / US8241145 B2	Cobra Golf Incorporated	Robert D. Hirsch, Peter L. Soracco	The present invention relates to a method for forming golf club head using metal injection molding and the resulting golf club head. The method of the invention allows for a lower volume of powdered metal than current metal injection molding processes thereby decreasing overall production cost.
Metal injection molded titanium alloy housing for implantable medical devices	Sep 21, 2010 / US7801613 B2	Medtronic, Inc.	Bernard Li, Reginald D. Robinson, John E. Kast	The housing of an implantable medical device is made of a titanium alloy that provides improved electrical performance, mechanical strength, and reduced MRI heating. The titanium alloy housing includes portions formed by metal injection molding and welded together. Wall thickness of at least a portion of one major face of the housing is reduced by chemical etching a metal injected molded housing portion.
Metal injection molded tubing for drug eluting stents	Nov 6, 2012 / US8303642 B1	Advanced Cardiovascular Systems, Inc.	James M. Carlson	An intravascular stent is formed by utilizing the process of metal injection molding (MIM) applied to metal powder, ceramic powder and ceramic metal composite powder. The devices may have longitudinal/circumferential channels and/or depots molded into the tubing thereof to enable such devices to act as a functional drug delivery vehicle having adequate drug reservoir capability.
Golf club head with metal injection molded sole	Nov 23, 2010 / US7837577 B2	Callaway Golf Company	D. Clayton Evans	A wood-type golf club head (**20**) with a main body (**22**) and a metal injection molded sole portion (**26**) is disclosed herein. The main body (**26**) has a face portion (**30**), a crown portion (**24**) a ribbon portion (**28**) and a bottom opening (**31**). The metal injection molded sole portion (**26**) is preferably brazed to the main body (**22**). The metal injection molded sole portion (**26**) preferably has a mass ranging from 45 grams to 110 grams. The metal injection molded sole portion (**26**) is preferably from 50 weight percent to 35 weight percent of the total mass of the wood-type golf club head (**20**).
Method of manufacturing a metal injection moulded combustor swirler	May 25, 2010 / US7721436 B2	Pratt & Whitney Canada Corp.	Lev Alexander Prociw, Harris Shafique, Aleksander Kojovic	A combustor swirler for a gas turbine engine and method of manufacturing by metal injection molding an inner component and an outer cylindrical component. Indentations are molded in one of the inner and outer components and sealed by the engagement of the components together to form a series of fluid flow passages. The inner and outer components are molded with interlocking features for ensuring proper alignment of the components during assembly.

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injection molding, cooling green body in continuous furnace, removing binder, then sintering	Jun 8, 2010 / US7731894 B2	Umarex Sportwaffen Gmbh & Co. Kg	Wulf-Heinz Pflaumer, Franz Wonisch, Daniel Rieger	A method for producing a breech slide of a firearm in a metal injection molding process. The process includes the following steps: a green body is injected in an injection mold. The green body is cooled. The binder is removed from the green body to form a brown body. Then the brown body is sintered.
Feeding system for semi-solid metal injection	Dec 11, 2012 / US8327914 B2	National Research Council Of Canada	Chang-Qing Zheng, Florentin Laplume	A semi-solid metal alloy injection feed system for reduced inclusion injection molding comprises a substantially closed injection chamber for containing a billet of semi-solid metal alloy, and thrusting the billet through the injection chamber into a mold, wherein the injection chamber has a first section defined by a wall with an inner contour for mating with a bearing surface for reciprocating motion of the bearing surface within the first section, along a center axis of the injection chamber; and the injection chamber has an outlet in fluid communication with the mold, the outlet provided at an opening in the injection chamber that is offset with respect to the center axis, and is disposed at an angle of 90° to 125° from the center axis. There is no neck or throttling between the chamber and the outlet. A butt end trap is preferably formed that requires inclusions that are principally on a bottom side of the injector to travel a relatively long ways to enter the outlet.
Method of manufacturing a hinge assembly utilizing a metal injection molding process and a die	May 8, 2012 / US8171606 B2	Magna International Inc.	Christopher John Kuntze, Steve Giles, Daniel V. Beckley, Jason Fulcher, Ben Reginella, Timothy F. O'Brien	A THIXOMOLDING™ process and a die are utilized to fabricate a hinge assembly for moving a step on a motor vehicle between a stowed position and a deployed position. The hinge assembly includes a rail bracket fixedly secured to the vehicle and including inner and outer bushings insert molded therein. A step bracket includes inner and outer bushings insert molded therein. The step is fixedly secured to the step bracket. An inner arm includes upper and lower pivot shafts insert molded therein. The upper and lower pivot shafts protrude from the inner arm and are pivotally disposed in the inner bushings of the rail and step brackets, respectively. An outer arm includes upper and lower pivot shafts insert molded therein. The upper and lower pivot shafts protrude from the outer arm and are pivotally disposed in the outer bushings of the rail and step brackets, respectively.
Injection molded component	Sep 30, 2014 / US8846206 B2	Siemens Energy, Inc.	Allister W. James, Douglas J. Arrell	An intermediate component includes a first wall member, a leachable material layer, and a precursor wall member. The first wall member has an outer surface and first connecting structure. The leachable material layer is provided on the first wall member outer surface. The precursor wall member is formed adjacent to the leachable material layer from a metal powder mixed with a binder material, and includes second connecting structure.

Exhibit 3 depicts patents related to metal injection molding.

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