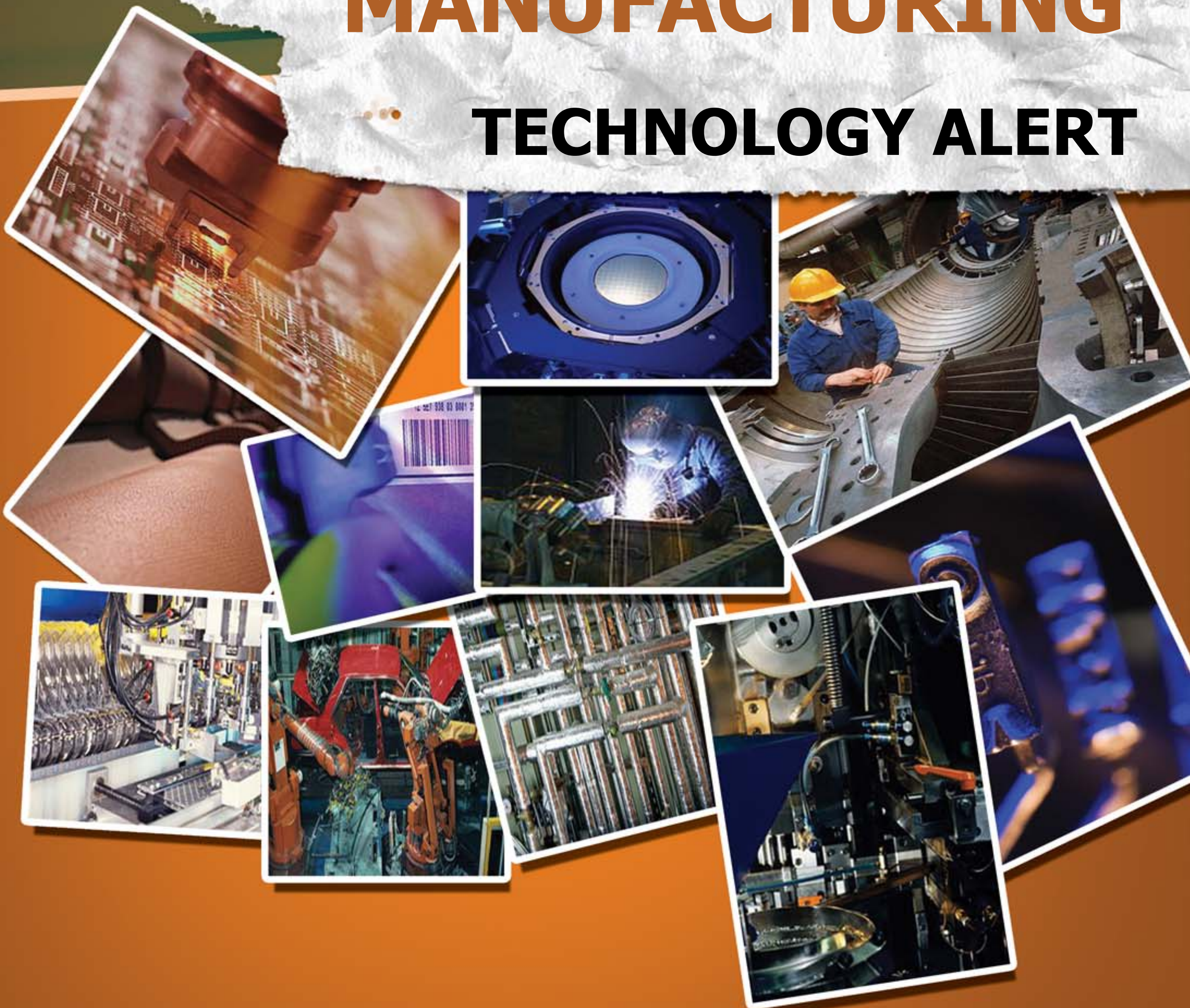
TECHNICAL INSIGHTS

ADVANCED MANUFACTURING

TECHNOLOGY ALERT



10th October 2014

1. ELECTRICAL MOTOR CONSTRUCTED USING CARBON NANOTUBE YARNS IN WINDINGS

Copper has the second highest conductivity among metals at room temperature, which makes it the preferred material for making windings in electrical machines. In spite of such high conductivity exhibited by copper materials, a majority of the losses in the electrical machines occur in copper windings. It is for this reason that joule losses are referred to as copper losses.

One of the ways to upgrade the performance of electrical machines is to have a higher conductivity material in the windings instead of copper. In the past, carbon nanotubes have achieved conductivity much higher than the best metals. Hence, in the future, the carbon nanotubes windings may have double or triple conductivity when compared to the copper windings.

Researchers at the Lappeenranta University of Technology have constructed the world's first electrical motor using carbon nanotube yarns in the windings. The motor uses carbon nanotube yarns spun and converted into an isolated tape and this is achieved by using a spinning technology developed by a Japanese-Dutch company Teijin Aramid in collaboration with Rice University, USA. The test motor has an output power of 40 W, rotates at 15000 rpm and has an efficiency of almost 70 percent. The construction of this motor is considered as a start toward lightweight, efficient electrical drives.

The researchers are of the opinion that though there are opportunities for improvement in electrical machines, there are limits of material physics set by traditional winding materials. Superconductivity is not developing to an extent that it could be applied to electrical machines. However, at this point in time, the carbonic materials appear to be winning the race. Also, carbon is available in plenty whereas copper needs to be mined or recycled by heavy industrial processes.

The researchers explained that by keeping the electrical machine design parameters fixed and by replacing copper with carbon nanotube yarns, the Joule losses in the windings can be halved. As carbon nanotube yarns are lighter than copper and more environmentally friendly, replacing copper with carbon nanotube yarns could reduce the CO2 emissions during operation of the electrical machines. Moreover, the motors can be operated at higher temperatures than the present day motors.

There are a number of electrical machines that are used on a daily basis, such as refrigerators, washing machines, hair dryers, and ventilators. In industries, the number of electrical motors could be enormous; there could be thousands of motors in a single process industry unit. In all these machines, copper windings are used and replacing the copper windings with carbon nanotube yarns could lead to major changes in the industry.

According to the researchers, the research is still in the early stages and increasing production capacity and improving yarn performance will result in major changes in the future.

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2. OPTIMIZATION PROCESS FOR BETTER QUALITY ELECTRICAL STEEL

Transformers are present in many electronic devices. Transformers have a basic structure; they consist of a pair of iron cores with wires of different lengths wrapped around it. These are called the transformer coils. The transformer coils are responsible for generating an oscillating magnetic field and converting this magnetic field into voltage. The energy loss associated with this process can be reduced by making the core with the special type of iron-silicon alloy known as electric steel. The electric steel has a grain oriented structure in its native state, which determines its magnetic properties. In a grain oriented structure, the crystals or grains are arranged in a regular periodic order.

Researchers at the Fraunhofer Institute for Material and Beam Technology, Dresden, Germany have discovered a way to enhance the performance of electrical steel and manufacture it more efficiently using an optimized laser process. The motive behind this research is to integrate the laser processing into the existing production environments to save time and costs.

Talking to *Technical Insights*, Andreas Wetzig, who heads the laser ablation and cutting department said, "The major challenge is to transfer the results we have achieved in the lab into a 24 hours 7 days production environment."

The researchers explained that when certain areas of the material are heated, the size of the domain with the same magnetic orientation reduces, which changes the magnetic structure of steel. As a result, there is lower heat development and reduction in the hysteresis loss of the material. Laser processing is the preferred method for heat treatment. During this process, the steel sheet moves forward at a rate of 100 meters per minute, while a focused laser beam moves across the surface of the material at the rate of 200 meters per second.

The research team at Dresden has optimized this process using galvanometer scanners. Such devices consist of galvanometer-driven mirrors to deflect the laser beam, which in turn, allows the distance between the paths to be controlled flexibly and adapted to different parameters. The optimization process increases the flexibility of the machining process and allows it to adapt to different conditions, such as the quality of the raw material and different production rates. In addition, the researchers have started working on a new type of solid state laser called fiber laser to reduce the hysteresis loss in electric steel. The researchers explained that the fiber laser has better heat absorption characteristics than traditional CO_2 lasers and it reduces hysteresis loss by 15 percent when compared 10 percent that has been achieved until now.

Wetzig added, "We have intellectual properties and it is on the kind of beam deflection."

In terms of applications, Wetzig said, "It is a sort of niche application which is only suitable for treatment of magnetic materials, not necessarily grain-oriented magnetic materials but also nongrain-oriented magnetic materials."

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3. 3D PRINTING METHOD WITH METAL ALLOY INK

Three-dimensional (3D) printing is the process by which a three-dimensional object can be created by the addition of multiple layers of material. It is also referred to as additive manufacturing. The way in which an object is created is exactly opposite to that of subtractive manufacturing. In subtractive manufacturing, a large object is reduced down to the desired size by cutting, grinding and other material removal processes.

One of the challenges in conventional metal 3D printing is that they can be restricted to metals with high melting points; besides, it takes a lot of time to complete the process.

Scientists at the Beijing Key Laboratory of CryoBiomedical Engineering which is a part of the Technical Institute of Physics and Chemistry at the Chinese Academy of Sciences have developed a new 3D printing method with a metal alloy ink, which has a melting point slightly above room temperature. The new liquid phase 3D printing technique can be used for rapid manufacturing of conductive metal objects in different dimensions. The advantage of this process over conventional 3D printing is that it prevents the oxidation of metal ink.

The researchers have developed a four element alloy, Bi35In48.6Sn16Zn0.4, and used it as the printing ink. They have also developed a novel fabrication process. The various steps involved in this process are as follows. The Computer Aided Design (CAD) model of the 3D object is generated and converted into a Stereo Lithography (STL) file. The STL file is imported into an open source software program. This software produces slices of the object as a set of horizontal layers, which in turn, generates tool paths for each layer. The object is printed by dropping the ink into a liquid phase cooling fluid through an injection needle. The fabrication process depends on the type and the properties of the printing ink. Any metal with melting point less than 300 degrees C can be used as printing ink provided the appropriate cooling liquid is available. The ink can be an alloy made from gallium, bismuth, indium or even a mixture of these alloys and nanoparticles.

Liquid phase 3D printing can have the following advantages over conventional metal prototyping techniques. This high-speed manufacturing process of printing metal objects in liquid phase can be used to form three dimensional structures. It is possible to control the temperature field and the flow field of the cooling fluid. Unique 3D metal structures can be realized by regulating the flow velocity and the direction of the cooling fluid. The 3D functional devices, which include supporting structures and conductive devices, can be formed from conductive liquid metal in conjunction with nonmetal materials.

In the future, the speed and the accuracy of 3D printing can be improved by using a combination of a syringe pump array and syringe needle array. The syringe pump array is used to extract the liquid metal solution and the syringe needle array is used to inject the liquid metal ink into the cooling fluid. A computer implemented process is used to control the needle's injection speed and to transform the digital 3D models into printed structures.

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4. PATENT ANALYSIS OF SELECTIVE LASER SINTERING

Additive manufacturing is the process by which digital designs can be converted into three-dimensional objects. Selective laser sintering (SLS), or laser sintering, is one of the technologies used in 3D printing. In this process, three-dimensional objects are formed by fusing together tiny particles of plastic, ceramic or glass using a high-power laser. Similar to the other methods of 3D printing, the process starts with the conversion of the computer-aided design (CAD) file into STL format, which in turn is sent to the selective laser sintering machine. The objects created by using this method are made from powder materials which are dispersed in a thin layer on top of the build platform inside the SLS machine. The laser is controlled by the computer which has the information about the object to be printed. The laser traces the cross section of the object onto the powder and the powder is heated to a temperature just below its boiling point (sintering) or above its boiling point (melting), which fuses the particles in the powder into a solid form. After the initial layer is formed, the platform drops and exposes a new layer of powder which can be used by the laser to trace and fuse together. This process is repeated until the entire object is created.

The main advantage of laser sintering is the durability of the produced part, as well as that a wide variety of powdered materials can be used for the creation of models, patterns and also forms of prototype tooling. The use of powdered materials in the SLS process has several inherent features, including speed and the additive nature of the part building process. There can be little tooling required after the creation of the object and also no supports are required to hold the object while it is being printed.

From the patents that have been exhibited, it can be seen that research is being carried out on the powders which are used in the selective laser sintering process (such as composite powders or POM powder) , the methods used for selective laser sintering and the device used to carry out such methods.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Method for selective laser sintering and system for selective laser sintering suitable for said method	Jun 14, 2012 / WO2012038507 A3	Siemens Aktiengesellschaft	Oliver Hofacker, Martin Schäfer	The invention relates to a method for selective laser sintering and to a device for carrying out such a method. In the method for laser sintering, energy (1 to 6) is applied linearly to a cross-sectional surface (17) of the component to be produced in order to compact the powdery material. According to the invention, in the case of components comprising cross-sectional surfaces (17) that have a curved contour (20), the application of energy can be guided in a line-shaped manner following the curved contour so that the contour (20) of the work piece that develops is continuously replicated. Advantageously, irregularities in the contour, which are caused by the raster predetermined by the laser sintering method, can thus be largely avoided. The device according to the invention for laser sintering according to said method comprises a powder delivery unit which can rotate about a rotational axis located in the interior of an annularly closed cross-section of the work piece to be produced.
Fire retardant polymer nanocomposites for laser sintering	Sep 18, 2008 / WO2008036071 A3	Joseph H Koo, Louis A Pilato, Gerhardt E Wissler	Joseph H Koo, Louis A Pilato, Gerhardt E Wissler	A method and apparatus for forming three dimensional flame retardant objects by laser sintering that includes homogeneously combining, by an extrusion process, certain polymer materials with nanoparticles and using the resultant powder in a laser sintering device to produce freeform parts.
Composite Powders For Laser Sintering	Sep 18, 2014 / US20140264187 A1	Carla Lake, Patrick D. Lake	Carla Lake, Patrick D. Lake	In one aspect, composite powders for laser sintering are described herein. In some embodiments, a composite powder for laser sintering comprises a polymeric matrix and carbon nanofibers disposed in the polymeric matrix. In some embodiments, the polymeric matrix can comprise poly(ether ketone ketone) and the carbon nanofibers can comprise cup-stacked carbon nanotubes.
Polyoxymethylene laser sintering powder, process for its production, and moldings produced from this laser sintering powder	Aug 5, 2014 / US8795833 B2	Basf Se	Claus Dallner, Steffen Funkhauser, Frank Müller, Jürgen Demeter, Mark Völkel	The invention relates to a polyoxymethylene (POM) powder for use in a selective laser sintering process and having the following parameters: Isothermal crystallization time (at 152° C.) >3 min Mn from 22 000 to 25 000 g/mol Mw from 60 000 to 140 000 g/mol Mw/Mn from 3 to 5 MVR from 15 to 70 [cm³/10 min] d50 average particle size 60 µm Particle size from 30 to 130 µm. A process for producing the powder, and also moldings produced from this powder by a selective laser sintering process, are also described.
Implementation method of selective laser sintering process, and fiber implanting apparatus	Jun 19, 2014 / WO2014090110 A1	Yu Jinwen, Yi Ling	Yu Jinwen, Yi Ling	An implementation method of a selective laser sintering process, and a fiber implanting apparatus. The implementation method is as follows: during sintering, implanting, in the sintered power, a fiber layer formed by large-aspect-ratio and sequentially arranged fibers, the fiber layer being wrapped in the sintered formed part after the sintering. Specifically, the fiber layer can be formed by sequentially arranging, with the fiber implanting apparatus, fiber wires (8) or fiber beams in a sintered powder layer (14), or is formed by laying a fiber cloth or fiber mat. In the implementation method, the fiber layer formed by large-aspect-ratio and sequentially arranged fibers is implanted in each sintered layer, and compared with the prior art where short and out-of-order fibers are mixed in the sintered powder, the present invention is greatly improved in the aspect ratio of the fiber, and the fibers are sequentially arranged, thereby greatly improving the strength of the formed part, so that the formed part can be used under the higher strength requirement.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Selective laser sintering at melting temperature	Apr 10, 2001 / US6215093 B1	Fraunhofer-Gesellschaft Zur Foerderung Der Angewandten Forschung E.V.	Wilhelm Meiners, Konrad Wissenbach, Andres Gasser	A method is disclosed for manufacturing a molded body, in accordance with three-dimensional CAD data of a model of a molded body, by depositing layers of a metallic material in powder form. Several layers of powder are successively deposited one on top of the other, whereby each layer of powder is heated to a specific temperature by means of a focused laser beam applied to a given area corresponding to a selected cross-sectional area of the model of the molded body, before deposition of the next layer. The laser beam is guided over each layer of powder in accordance with the CAD cross-sectional data of the selected cross-sectional area of the model in such a way that each layer of powder is fixed to the layer below it. The method is characterized in that the metallic material in powder form is applied in the form of a metallic powder free of binders and fluxing agents, that it is heated by the laser beam to melting temperature, that the energy of the laser beam is chosen in such a way that the layer of metallic powder is fully molten throughout at the point of impact of said laser beam, that the laser beam is guided across the specified area of powder in several runs in such a way that each run of the laser beam partly overlaps the preceding run, and that a protective gas atmosphere is maintained above the interaction zone of the laser beam and the metallic powder.
Chute for laser sintering systems	Sep 18, 2014 / WO2014144319 A1	3D Systems, Inc.	David H. CULLEN, Rafael Enrique HIDALGO	There is provided improved laser sintering systems (10) that increase the powder density and reduce anomalies of the powder layers that are. sintered, that measure the laser power within the build chamber (12) for automatic calibration during a build process, that deposit powder into the build chamber through a chute (20) to minimize dusting, and that scrubs the air and cools the radiant heaters with recirculated scrubbed air. The improvements enable the laser sintering systems to make parts that are of higher and more consistent quality, precision, and strength, while enabling the user of the laser sintering systems to reuse greater proportions of previously used but unsintered powder.
A laser sintering technique for manufacturing items on a movable sintering platform	Feb 13, 2014 / WO2014023657 A1	Siemens Aktiengesellschaft	Jonas Eriksson, Ulf Simmons	The technique presents a laser sintering device and a laser sintering method. The laser sintering device includes a laser source and a sintering platform. The laser source projects a laser beam on a plane, and by changing directions of the laser beam an action area on the plane is defined. The sintering platform provides a sintering area. The sintering platform is arranged in such a way that at least a first region of the sintering area is located within the action area and at least a second region of the sintering area is located outside the action area. The sintering platform is movable such that at least a part of the second region replaces at least a part of the first region within the action area.
Selective laser sintering powder recycle system	Feb 15, 2011 / US7887316 B2	3D Systems, Inc.	Brian David Cox	A method and apparatus for forming three-dimensional objects by laser sintering that includes the use of dense phase pneumatic conveying to internally recycle overflow powder, and to thoroughly blend overflow, recovered and virgin powder to provide a consistent powder feed mix to a laser sintering machine. Overflow powder from the laser sintering machine is recovered and recycled back into the laser sintering machine for reuse. The approach results in a compact and reliable powder recycle system with complete blending and minimum attrition to the handled powder.
Laser sintering of ceramic fibers	Mar 25, 2014 / US8679378 B2	The United States Of America As Represented By The Secretary Of The Air Force	Jonathan Goldstein, Geoff Fair, HeeDong Lee, Hyunjun Kim	A method and system for generating an optical fiber is provided. The method includes creating a green fiber consisting primarily of a ceramic material and sintering the green fiber with a laser by moving the green fiber through a beam of the laser to increase the density of the fiber after sintering. The system for creating a continuous optical fiber includes an extruder, a processing chamber and a laser. The extruder is configured to extrude a ceramic slurry as a green fiber. The processing chamber is configured to receive and process the green fiber. And, the laser is configured to direct a laser spot on the green fiber exiting the processing chamber to sinter the green fiber.

Exhibit 1 depicts patents related to selective laser sintering.

Picture Credit: Frost & Sullivan

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