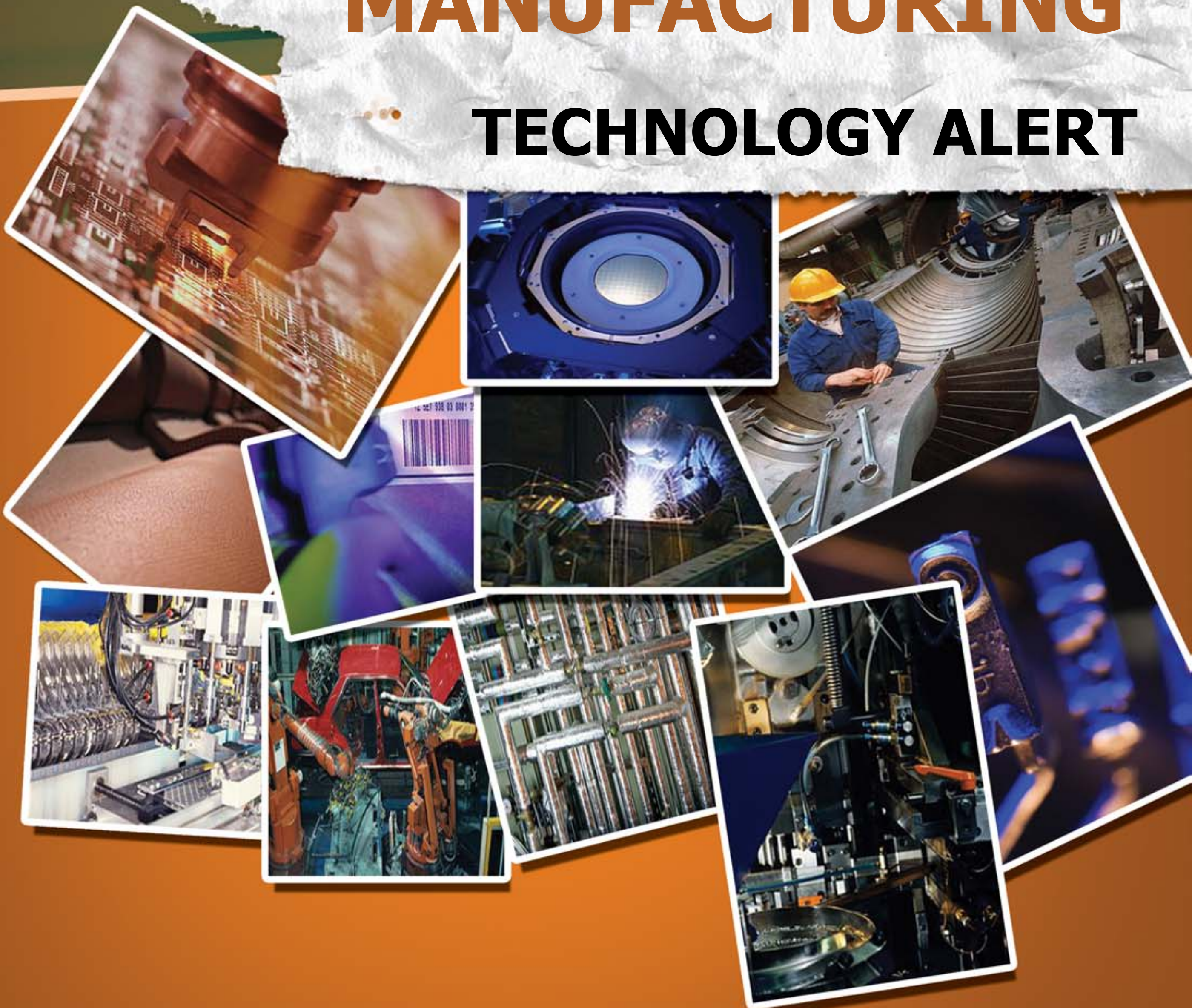
TECHNICAL INSIGHTS

ADVANCED MANUFACTURING

TECHNOLOGY ALERT



06th February 2015

1. BEVERAGE BOTTLING AND CANNING TECHNOLOGY

The last critical stage in beverage manufacturing is the bottling or canning of fluids for sale (such as beer, water, fruit juices, wine, soda, and much more). The exterior appearance of the container is a key part of the marketing or selling effort, setting the theme and image. The liquid product usually has to be well-sealed from air and light, specifically ultraviolet (UV) radiation, to enable sufficient shelf life.

The container often serves as a pressure vessel to contain carbonated beverages (which absorb dissolved CO_2 under high pressure). The existence of this internal pressure allows beer brewers and soda canners to use a slightly thinner and weaker aluminum (Al) can material, and have the same crush resistance. A refrigerated can of Coca-Cola soda at 40 degrees F reportedly has an internal pressure of 207 MPa, or 17 psi, but the pressure goes up sharply with storage temperature: at 75 degrees F the can's internal pressure rises to 380 MPa, or 55 psi. If the product is pasteurized (beer bottles are spray hot-water heated to 140 degrees F for 2 to 3 minutes) in the containers, the internal pressure will spike much higher.

Bottled champagne (sparkling wine) could contain even more pressure than beer, which can propel a released closure (cork) at high velocity. The human bottle opener should be positioned well clear of this flying projectile, which could damage an eye on impact.

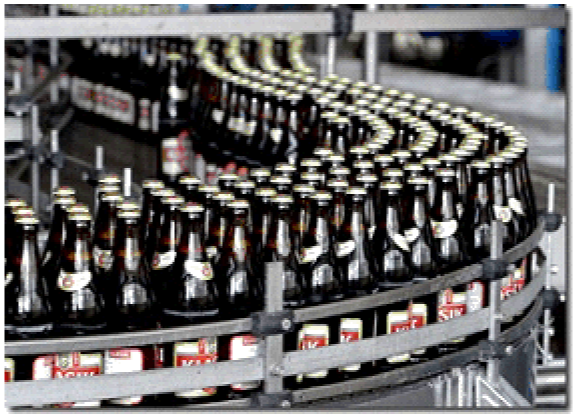


Exhibit 1 depicts a typical beer bottling line.

Picture Credit :http://blog.industrysoftware.automation. siemens.com/blog/tag/plant-simulation/

In order to boost the speed, efficiency, and reliability of bottling/canning lines, designers of such lines (which may be consulting engineering firms) are turning more and more to sophisticated simulation software tools, such as the Tecnomatix Plant Simulation program from Siemens PLM Software. Plant owners have to get the design right, in advance, because the cost of bottling line downtime (to sort out teething problems and defects in layouts) is rather high. Tecnomatix allows manufacturing simulation and validation before any construction is done. Digital models of the bottling plant layout are rendered so that "what-if" experiments can be run, as well as bottleneck analysis. Siemens claims such benefits as: reduction in initial investment of 6%, increased system productivity of up to 20%, reduced throughput time up to 60%, plus reduction in energy consumption (one of the built-in tools is "energy consumption simulation and analysis").

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2. CHALLENGES IN MACHINING OF PLASTICS

Frequently in the course of manufacturing plastic parts, injection or vacuum molding is not quite sufficient and machining (precise material removal) is required to meet specifications, so as to provide secondary operations such as drilled cross-holes (see exhibit). An alternative to the subtractive machining process is to build up a plastic part layer-by-layer with 3D printing, also known as additive manufacturing. However, that process is relatively slow and not well-suited to mass production of plastic parts. Computer numerical control (CNC) machines for drilling, milling, sawing/cut-off, and turning work well with volume plastic parts. They offer speed, accuracy, and repeatability not seen in manual machining.

Machining of plastic is fussy and thermally sensitive (especially thermoplastic resins (including nylon, acrylic, and polyvinyl chloride—PVC), as opposed to thermosetting resins (such as epoxy). That is, the plastic workpiece could soften, deform, or melt from the friction and force of tool contact. In addition, overstressed plastic could release toxic thermal decomposition gases. So, the plastic must be cooled properly by pressurized air, or clean water impingement. Unreinforced plastics can be machined with standard high speed steel (HSS) tools. Reinforced plastics (such as those loaded with abrasive fiberglass) will need extra-hard carbide-tip cutting tools, in order to extend tool life between sharpening events with diamond-face grinders. Carbide is a reference to cemented carbides, such as tungsten carbide (WC), wherein the hard ceramic carbide particles are sintered together with a cobalt (Co) or nickel (Ni) metal matrix representing up to 10% of the composite mass.

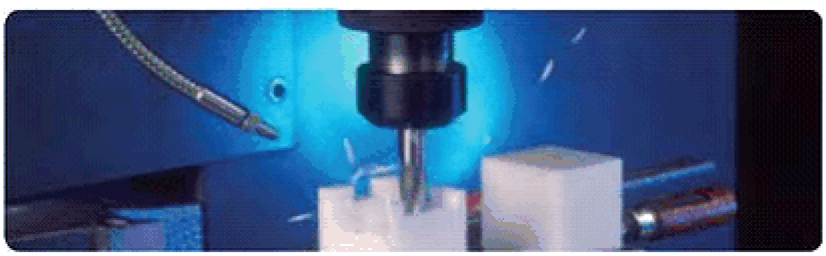

Exhibit 2 depicts machining of nylon plastic parts.

Picture Credit : http://www.millerplastics.com/machining/

The machinist has to be aware of what resin is being machined, as each type needs adjustment, for best results. For example, there are optimal drill point angles, rake angles, cutting speeds (ft per minute) and feed rates (mils removed per cutting tool revolution) for each resin. Some tough higher-temperature plastics (such as thermoplastic PEEK—polyetheretherketone) in thicker sections and diameters actually need pre-heating (at say 250 degrees C) before machining, to obtain best results. Some demanding plastics can stress crack when coolants are applied incorrectly.

For optimal accuracy, it is recommended to start with stress-relieved plastic workpieces. If not the case, hidden stresses can release during machining, deforming the workpiece. Because many plastics exhibit coefficients of thermal expansion higher than metals, it is further recommended to machine plastics in a temperature-controlled (that is, air conditioned) plant environment.

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3. MANUFACTURING COMPOSITE WINDMILL BLADES

With the expansion of global wind turbine installations to harness 'free' and clean electric power devoid of carbon emissions, it has become critical to get blade manufacturing right. The objectives include: long-term durability, efficiency, minimal sound emissions, and tolerance of extreme operating conditions. Videos are available to show what happens to a windmill out of control in a 'runaway' condition, as in a hurricane. The windmills eventually start to throw off their blades, which is a dangerous situation. The windmill operator is supposed to 'feather' all of the blades and turn their edges into the wind to minimize the driving force. The same strategy is applied when a multi-engine propeller aircraft loses engine power in flight: the pilot or flight engineer has to immediately feather the target propeller and stop its rotation to preclude the huge drag of a 'windmilling' unpowered propeller.

The standard construction method today involves hand layup of fiberglass textiles (woven from E-glass) impregnated with a resin such as polyester or epoxy. A strong solid core, or metal spar (many are made of aero-grade 6-4 titanium alloy--exhibiting the strength of steel with half of the weight), carries the wind loading transverse and twisting forces as well as the considerable longitudinal centrifugal forces of a spinning blade. In more advanced and more expensive blade designs today, light carbon fiber reinforcement substitutes for the relatively heavy fiberglass. Such blades generally use the thermosetting epoxy resin. The entire blade assembly is usually cured and thermoset in a steam-fired autoclave. As a result, the finished wind turbine can safely spin much faster, generating more power.

Exhibit 3 depicts Gamesa 62.5 meter 5 MW wind turbine blades installed near Spain's Canary Islands.

Picture Credit: http://www.offshorewind.biz/2013/04/10/gamesa-begins-transporting-largest-wind-turbine-blade-ever-built-in-spain/

It is interesting that wind farms tend to generate most of their daily power at night, when electric power demand is lowest. So, energy storage technologies can complement and help facilitate wind power. These MW-class blades emit with each revolution a high-amplitude 'whooshing' sound loaded with lots of low-frequency energy.

There is considerable art in getting the fiber layup angles just right, as well as the ply thickness. These details have been scientifically investigated to see which layup configurations produce best results. After the long blades are laid up and cured, a slick polymeric gel-coat (usually white in color) is applied to resist weather as well as solar attack, and provide a low-friction surface to the passing wind.

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4. PATENT ANALYSIS OF SELECTIVE LASER MELTING PROCESS

Selective laser melting (SLM) is a type of additive manufacturing process using which complex components are generated directly using powdered metal on the base of computer aided design (CAD) files. The selective laser melting process is commonly employed for manufacturing tools that are used in plastic injection molding and die casting. Some of the common materials that are used in this process are high-quality steel, alloys based on aluminum, titanium, and nickel with grains of powder ranging from 10 ìm and 60 ìm in size. The layer thickness of the material that is used for producing the parts ranges between 20 ìm and 50 ìm. Using this process, the accuracy of the components manufactured is in the range of ±50 ìm and the parts that are generated have a homogenous structure with a density of almost 100%.

One of the latest patents for the selective laser melting process has been filed by individual researchers Gerald J. Bruck, Ahmed Kamel. Some of the other key innovators for this manufacturing process are Alstol Technology Ltd, Siemens AG and Airbus Operations GmbH.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Selective laser melting / sintering using powdered flux	January 31, 2013/ US 20130136868 A1	Gerald J. Bruck, Ahmed Kamel	Gerald J. Bruck, Ahmed Kamel	An additive manufacturing process (**110**) wherein a powder (**116**) including a superalloy material and flux is selectively melted in layers with a laser beam (**124**) to form a superalloy component (**126**). The flux performs a cleaning function to react with contaminants to float them to the surface of the melt to form a slag. The flux also provides a shielding function, thereby eliminating the need for an inert cover gas. The powder may be a mixture of alloy and flux particles, or it may be formed of composite alloy/flux particles.

Selective laser melting (SLM) atmosphere protection system	January 23, 2013/ CN 103071796 A	Xi'an Platinum Lite Laser Forming Technology Co., Ltd.	Huang Weidong, Xue Lei, Yang Donghui, Zhao Xiaoming	The invention relates to a selective laser melting (SLM) atmosphere protection system comprising a metal sealed cabin body of which the inside is provided with a selective laser melting (SLM) forming operation mechanism, wherein the inside of the metal sealed cabin body is also provided with a temperature-controlled air conditioner, the temperature-controlled air conditioner is connected with a central control system outside the metal sealed cabin in a controlling way, the central control system is connected with an upper computer with a human-computer interface in a communicating way, an inert gas container in which inert gas exists is communicated with the metal sealed cabin body by an inert gas pipeline, an air-inlet electromagnetic valve connected with the central control system in a controlling way is arranged on the inert gas pipeline, an oxygen purifier is provided with two pipelines communicated with the metal sealed cabin body, a first valve is arranged on one pipeline, and a second valve, a circulating fan and a molecular sieve on the part of the other pipeline, which extends into the metal sealed cabin body, are arranged on the other pipeline. The addition of the technological parameter of the oxygen content with strict control in the forming process is avoided, and the influence of the oxygen content, which is caused to the performance of components, is prevented; and moreover, the inert gas can not be excessively consumed, and the production cost is lowered.
Large-format selective laser melting (SLM) equipment of multi-galvanometer	January 23, 2013/ CN 103071797 A	Xi'an Platinum Lite Laser Forming Technology Co., Ltd.	Yang Donghui, Zhao Xiaoming	The invention relates to large-format selective laser melting (SLM) equipment of a multi- galvanometer, which comprises an SLM forming table, wherein the SLM forming table is divided into four uniform forming areas, respective separate galvanometer systems are respectively arranged above the forming areas, galvanometer components in all of the galvanometer systems are respectively in control connection with respective corresponding galvanometer motion controllers, all of the galvanometer motion controllers are in control connection with a central controller, so as to form parts which cannot be manufactured by the traditional SLM equipment, and additionally, the processing efficiency of the parts is increased.

Method for manufacturing a component by selective laser melting	July 20, 2011/ US 20130199013 A1	Andreas Graichen	Andreas Graichen	A method of manufacturing a component by selective laser melting and to provide heat treatment to the component is provided. The method includes building a heat treatment device adapted to provide a heat treatment to the component as part of the same selective laser melting for manufacturing the component and providing a heat treatment to the component by the heat treatment device.
Process for producing a 3-dimensional component by selective laser melting (SLM)	January 20, 2011/ US 8610027 B2	Alstom Technology Ltd	Simone HÖVEL, Alexander Stankowski, Lukas Rickenbacher	A process produces a 3-dimensional component (16) by selective laser melting (SLM), in which the component (16) is formed on a foundation with a surface, e.g., a platform (10) or a support, which in particular is a component of the same type which has already been produced previously, by successively melting layers of a first metal powder to form a sequence of stacked layers. The process is substantially simplified and made more flexible by virtue of the fact that the separation of the finished component (16) from the surface of the platform (10) or the support thereof is simplified by providing a separating layer (11) between the component (16) and the platform (10) or the support, this separating layer making it possible to separate the finished component (16) from the platform (10) or the support without damaging the finished component (16).
Method to apply multiple materials with selective laser melting on a 3d article	October 15, 2010/ CA 2717834 A1	Alstom Technology Ltd., Simone Hovel, Alexander Stankowski, Lukas Rickenbacher	Simone Hovel, Alexander Stankowski, Lukas Rickenbacher	Disclosed is a method for manufacturing an article (1), particularly a prototype of a product or component, a tool prototype or spare part, by using selected laser melting. Specifically, for the application onto the article (1) of a layer (13) or portion of a second metallic material, which is different from the material of the first metallic powder (4), a tape (12), sheet (14), foil or three-dimensional pre-form (18) of a second material is applied to the article (1) and is heated by means of a focused laser or electron beam (6) to a specified temperature such that the tape (12), sheet (14), foil or pre-form, respectively, are molten by the or electron laser beam (6), wherein the focused beam (6) is applied to a given area corresponding to a selected cross-sectional area of the model of the article (1) under formation of a new layer or part made of second material integral with the article (1).

A method for manufacturing a component by selective laser melting	August 5, 2010/ EP 2415552 A1	Siemens Aktiengesellschaft	Andreas Graichen	The present invention provides a simple method of manufacturing a component (43) by selective laser melting and to provide heat treatment to the component (43). The underlying idea is to building a heat treatment device (42) which provides a heat treatment to the component as part of the same selective laser melting process for manufacturing the component (43).
Method for producing a component through selective laser melting and process chamber suitable therefor	June 17, 2009/ EP 2291260 A1	Siemens Aktiengesellschaft	Martin Schäfer, Christian Doye, Sven Pyritz, Uwe Pyritz	The invention relates to a method for producing a component through selective laser melting and to a process chamber (11) for carrying out the method. According to the invention, the selective laser melting by way of a laser (17) is also used for producing coating areas (25) of the component (14) being produced, said coating areas having a composition that differs from the composition of the powder (16). This is accomplished by intermittently introducing a reactive gas (27) that reacts with the powder material or that produces a material on the component (14) from precursors present in the reactive gas. In the process chamber according to the invention, an additional feed line (28a, 28b) is provided for introducing reactive gas, said feed line permitting the feeding of the reactive gas if possible close to the laser (17).
Support for a manufacturable in selective laser melting process aircraft structural component	August 28, 2008/ DE 102008044759 B4	Airbus Operations GmbH	Christoph Klahn , Rüdy Gysemberg , Olaf Rehme	Elongated support (20) for a heavy-duty structural component (2), said support (20) is adapted to receive (20) acting bending forces transverse to a longitudinal direction of the support, wherein the support (20) comprises: a an elongated cavity (28) of the support (20) at least partially surrounding wall (26); a reinforcing structure (36, 38), said reinforcing structure (36, 38) within the cavity (28) and is arranged transversely to the longitudinal direction in order to increase the bending stiffness, wherein the reinforcement structure (36, 38) is formed integrally with the wall (26), wherein both the wall (26) and the reinforcing structure (36, 38) are formed from a fusible material.
Direct manufacturing method of selective laser melting of customized tongue-side orthodontic support	May 19, 2008/ WO 2009105922 A1	South China University Of Technology (Scut)	Yongqiang Yang, Shufan Wang	The invention provides a direct manufacturing method of selective laser melting of customized tongue-side orthodontic support grooves. The method includes the following steps: measuring the data of the dentition and obtaining the three dimensional CAD models of the teeth; designing the bottom board of the individual support groove which contacts with the tooth surface according to the characteristic of the tooth, and determining the

grooves				trenches of the support grooves according to the ideal placement position of respective support groove; introducing the designed models into the selective laser melting machine to directly manufacture the supports grooves of required materials. The method can achieve customized manufacture with high precision according to the individual difference, the support grooves can stick well to the surface of the teeth, and the support grooves are formed directly in one step, which saves working procedures, time and cost; the applicable range is wide and the manufacture materials are various; different materials can be used in one direct forming process to satisfy the performance requirements of the different parts of the support groove.

Exhibit 4 depicts patents related to the selective laser melting process.

Picture Credit: Frost & Sullivan

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