TECHNICAL INSIGHTS

ADVANCED MANUFACTURING

TECHNOLOGY ALERT

20th November 2015

1. SOFTWARE SUITE FOR 3D PRINTING OF COMPOSITE THERMOPLASTICS

Additive manufacturing has been used for manufacturing and rapid prototyping various objects and components related to different markets, such as automobiles, aerospace, healthcare, personnel items (for example, jewelry), food, and so on. Many key participants are researching and implementing new concepts, materials, software and techniques in the additive manufacturing sector to increase the overall performance and efficiency of the technology. For example, carbon-fiber or carbon nanotube reinforced materials for 3D printing can provide enhanced stiffness and greater thermal resistance.

Arevo Labs, one of the innovative companies in composite additive manufacturing technology and software, has developed a one of a kind scalable robot-based additive manufacturing (RAM) platform for fabricating 3D-printed composite parts. This new platform is the one of the first printing systems that is a combination of fused deposition modeling 3D printing and end-effector technologies with an advanced small standard six-axis robotic system from ABB Robotics, called ABB Robotics IRB 120. The robot is capable of printing components as small as 1000 cubic millimeters and components as large as 8 cubic meters.

The ABB robotics arm is used to control a state-of-the-art advanced thermal management system along with a high-performance carbon fiber thermoplastic filament deposition nozzle. Arevo Labs has developed a new special software suite to control and manage the printing hardware and the robotic arm. At present, this specially designed software is used to manage the ABB Robotics

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IRB 120 but the software is also developed with scalability options and can be adapted to other bigger ABB robotics systems and models.

The software suite consists of CAM software which is used for converting the CAD file consisting of the design model into a set of specific additive deposition instructions. The software suite also uses a highly precise and accurate kinematic simulator which will be used for pre-validating parts, interpret the system from performing complex decomposition instructions and at the same time optimize the parts to construct the path, making it easier for the robotic arm to print the design with ease. The software also at the same time controls all the 6-axis of the robot to obtain high efficiency while printing complex composite thermoplastic parts and components.

The software platform integrates with the ABB Robot Studio stimulation and programming software to easily generate the tools path from the CAD files of the designed component.The newly developed software platform can be applied to an already existing manufacturing workflow process and provide full automation to complete the 3D printing process.

The company strongly believes that the thermoplastic composite parts printed using this innovative software platform will have highly improved aesthetics, strength and components properties when compared to the components printed using other standard and traditional software suites. The software can be used to print 3D surfaces of high quality parts using variable orientations and also eliminates the need for support structures while printing complex parts and components. The software platform allows users to 3D print components with faster post processing time and also decreases the part striation and stepping process, making it easier to print complex structures.

Arevo Labs is currently working on optimizing the software platform for better efficiency and performance. This advanced software platform will be targeted toward the aerospace, automotive and defense industries to precisely and accurately print highly complex composite thermoplastic parts in a faster and cheaper manner.

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2. 3D-PRINTED SENSORS FOR AIRCRAFT MONITORING

Building and maintaining jet engines and aircraft can be very difficult and expensive. Many manufacturing companies, universities, and research groups are implementing new techniques in additive manufacturing technologies to directly print diverse types of three-dimensional functional aircraft parts and components, which saves the overall manufacturing process time and cost.

A group of researchers from Swansea University (UK) have used Optomec aerosol jet technology to 3D print optical creep and strain sensors directly on the compressor blades and engines of jet aircraft for monitoring and maintenance purposes in real time when the jet is flying or standing still.

The research group atomized a conductive nano-silver ink using a mist generator to start the sensor printing process. A virtual impactor was then used to refine the conductive nano-particles. A flow guidance deposition head is used to create an annular flow of sheath gas to collimate the aerosol thus increasing the aerodynamic properties of the resulting material.

Using CNC commands, the flow guidance head is positioned as the substrate remains in a fixed position and the material is patterned on the surface of the jet. To achieve accurate and precise deposition of the material on existing structures and non-planar substrates, a 5mm standoff distance is maintained between the substrate and the deposition head.

The research group subjected the resulting deposited material on the surface of the jet to thermal-post treatment to give the sensor advanced mechanical properties, correct conductivity and at the same time ensure the sensor's adhesion to the substrate. The resulting high-quality film obtained from the above process was thin with near bulk-properties and a high degree of edge definition.

At present, the research team is currently working with nano-silver ink which can withstand a temperature up to 250 degrees C. The team is also developing new nano-platinum ink which will be able to withstand higher temperatures of 1200 degrees C. Sensors developed using this new nano-platinum ink will be able to withstand higher temperatures when compared to the traditional sensors currently used in the aerospace industry which has temperature limitations.

Though these sensors can be used for monitoring low-pressure turbine blades and compressor blades of an aircraft, they cannot be used for monitoring

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high-pressure turbines as these turbines are subjected to very high pressure and temperatures since they are located next to the combustor of the engine, which is subjected to temperatures much greater than those the sensor can withstand.

The 3D printed sensors make it possible for aircraft manufacturers to monitor degree of creep, stress and strain levels in the turbines and different other components of an aircraft in real-time. By using these sensors, preventive and predictive maintenance can be done for the different components which will save time and money and at the same time prevent any accidents from occurring when the aircraft is flying.

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3. METHOD FOR CREATING GRAPHENE INK FOR PRINTED ELECTRONICS

The discovery of graphene, a sheet of pure carbon consisting of a layer of single layer carbon atoms, has given rise to numerous applications in various fields of modern science. Its unique properties that have enabled numerous applications include its incredible flexibility, optical transparency and extraordinary electrical conductivity. There have been various prototypes of graphene demonstrated by various research groups across the world. However, the commercial adoption of graphene is yet to become a reality.

A research study by a group of researchers from the University of Cambridge in the UK along with Novalia, a Cambridge-based technology company, has devised a method to use graphene that could enable the use of graphene in commercial purposes in the near future.

The researchers have found a cost-effective and a high-speed method to use graphene inks in the conventional roll-to-roll printing process. This process uses graphene in inks used for printing newspapers and printed packages for various goods. This new process can include graphene in traditional water-based inks and can be utilized in all commercial printing equipment. This is the first time that graphene has ever employed for commercial high-speed printing. According to the researchers, many companies have produced graphene ink prototypes in their laboratories but none of them have succeeded in producing graphene ink as versatile as this.

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The researchers believe that using graphene for making conductive inks will open up new possibilities in printed and flexible electronics. They also believe that this discovery will enable the creation of electronic systems in new shapes and on new substrates.

This novel method of including graphene in conductive inks was developed in the Nanoscience Centre at the University of Cambridge. The method starts by suspending tiny particles (nanoparticles) of graphene in a mixture of solvents called the 'carrier' mixture. This solution is then added to water-based conductive ink formulations. The ratio of the ingredients used in making the carrier solvent is adjusted to control its properties in order to be easily mixed with water-based conductive inks. The researchers have found that this method works really well with materials apart from graphene-like metals, semiconductors and insulator nanoparticles.

At present, conductive patterns for flexible and printed electronics are printed using inks that have a combination of carbon and other materials. The carbons used in these inks have very poor conductivity and the supporting material commonly used in these inks is silver. As silver is an expensive metal, silver-based conductive ink costs about $1500. The new graphene formulation for conductive inks will reduce the cost of conductive inks by a factor of 25 compared to silver-based inks.

Further, graphene and other constituents used in the new ink are recyclable while silver cannot be recycled. Also, the solvents used in the new formulation are environment friendly and dry up quickly in room temperature. This quick drying feature reduces the printing charges by saving the energy required for ink curing. After drying, the researchers observed that the graphene ink is waterproof and adheres to the surface very well.

The researchers expect the new ink to have a significant impact on the printed and flexible electronics field. In a few years, they anticipate that the new ink will be used to print biosensors, energy harvesting circuits and RFID tags on a large scale.

This research study was funded by grants from the Engineering and Physical Sciences Research Council's Impact Acceleration Account and a Royal Academy of Engineering Research Fellowship. Now, the technology is being commercialized by Cambridge University's commercialization arm called Cambridge Enterprise.

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4. INNOVATIVE TECHNIQUE TO MAKE METALS STRONGER AND MORE DUCTILE

The physical properties of metals enable their use in a broad array of applications. Metals are widely used for applications ranging from the manufacture of submarines to advanced spacecraft and from huge macro objects to various micro and nanostructures required for microelectronics and nanotechnology.

One of the most important physical properties of metals is their strength. Metals can easily replace various types of materials in a host of applications due to its strength. Another significant property of metals is ductility. Ductility is the property of metals that enables them to be drawn into wires and cast into various shapes and lengths.

When metals are drawn out in the form of wires and delicate plates, their strength reduces. A new research study conducted by North Carolina State University and the Chinese Academy of Sciences has found a method to make metals ductile and retain their strength at the same time.

The researchers were able to achieve this feat using titanium metal and they are now working to extend the method to other metals as well. The researchers explained that the strength and ductility of a metal mainly depends on the size of the crystals that form the metal. The metal becomes stronger when the size of the crystal grains is very small. The metal is stronger now as it can stand more force before it starts to deform from its current shape. On the other hand, when the grain size is larger, the metal becomes more ductile but its strength is greatly reduced.

The technique used by the researchers basically manipulates the grain size of the metal crystals in such a way that the metal retains its original strength and ductility without much change.

In order to achieve these two properties, the researchers used an asymmetrical rolling method to process a titanium sheet of 2 millimeter thickness. Asymmetric rolling is a metal processing technique where a sheet of

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metal is processed between 2 rollers; this applies pressure on the metal sheet from both the sides. In asymmetric rolling, one of the rollers rotates at very high speed compared to the other roller. This process makes the metal sheet thinner. As the rollers rotate at different speeds, the rolling process also introduces a sheer strain on the metal sheet.

This strain in the metal makes it stronger and more ductile at the same time. During the asymmetric rolling process, the crystal structure on the side of the metal sheet that is being rolled by the faster roller gets distorted and breaks down the crystalline structure to form smaller crystal grains in the metal sheet.

As the smaller grains start forming, the rolling process is repeated until the sheet becomes 0.3 millimeters in thickness. The sheet is then exposed to a heat of 475 degrees C for 5 minutes. The applied heat allows some small crystals to fuse and become large crystals. Further, the heat helps the large and small crystals to align in a particular order. The new crystal structure that results from the crystal realignment has a patchwork of perfectly aligned large crystal grains. Each large grain is tightly surrounded by smaller crystal grains.

This new crystal structure makes the metal sheet strong due to the large presence of small crystal grains, which will also stop the free movement of large crystal grains. At the same time, the presence of large crystal grains will make the metal ductile. Hence, the metal sheet can be drawn into different forms like wires and filaments with more strength than before.

A notable feature of this new method is that it has been followed in industries for several years for different applications. The researchers opine that the existence of the asymmetric rolling technique in industries will help scale up this technique faster than usual.

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5. PATENT ANALYSIS OF MACHINE VISION INSPECTION SYSTEMS

Machine vision is a technology that enables a computer to "see". This technology encompasses equipment and methods that capture images of the environment it is placed in and uses the images as data for processing. A typical

machine vision system consists of one to many video and image capturing devices, analog-to-digital converters and signal processing units.

Machine vision is an enabling technology that has revolutionized the industrial sector through its immense capabilities in automatic inspection, analysis, and recognition applications. The technology has served key manufacturing industries/application areas, such as electronics and semiconductor manufacturing, automotive manufacturing, vision guided robotics, aerospace, and so on. Machine vision inspection is a popular application of machine vision and is widely used in various industries, such as manufacturing, construction and transportation. In these sectors, machine vision has grown tremendously .At present, machine vision inspection systems possess capabilities to inspect complex environments with high accuracy and automatically trigger corrective actions.

The exhibit below showcases some of the interesting patents for machine vision inspection systems in 2015 (January till date). One of the interesting patents is filed by Kan Hui (CN 104432498) for a machine vision inspection system to inspect cigarette appearance in a cigarette making machine. The machine vision-based visual cigarette appearance inspection technology includes an optical image-forming unit, an image pre-processing unit, and a control and image analyzing unit. Another interesting patent is filed by Anhui Keming 3D Technology Co. Ltd. (CN 104535587) for an inspection system to inspect printed circuit board assembly (PCBA) solder joints. This inspection system inspects the position and quality of solder joints on PCBAs.

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Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Programmable digital machine vision inspection system	September 10, 2015/ US 20150254833	Tyco Electronics (Shanghai) Co., Ltd.	Yingcong Deng	A programmable digital machine vision inspection system is disclosed having a programmable automatic feeding system that supplies elements to be inspected, a programmable robot system, a programmable inspection system, a qualified product receiving container, and an unqualified product receiving container. The programmable robot system has a first vision system with an inspection area, and a robot that grips the supplied element and moves the gripped element to and from the inspection area. The programmable inspection system has a second vision system that identifies features of the elements in the inspection area, and determines whether the element is a qualified product based on the identified features. The qualified product receiving container receives identified qualified products from the robot, and the unqualified product receiving container that receives identified unqualified products from the robot.
Machine vision inspection system and method for obtaining image with extended depth of field	June 4, 2015/ JP 2015104136	Mitsutoyo Corp	Bryll Robert Kamil	PROBLEM TO BE SOLVED: To provide a machine vision inspection system and method for obtaining an image with extended depth of field. SOLUTION: A method operates an imaging system of a machine vision inspection system to provide an extended depth of field (EDOF) image. The method comprises: (a) placing a work-piece in a field of view; (b) periodically modulating a focus position of the imaging system without macroscopically adjusting spacing between elements in the imaging system, over the plurality of focus positions along a focus axis direction within a focus range including work-piece surface height; (c) exposing a first preliminary image during image integration time while modulating the focus position within the focus range; and (d) processing the first preliminary image to remove blurred image contribution occurring in the focus range during the image integration time to provide an EDOF image having larger depth of field than that provided by the imaging system at a single focal position. COPYRIGHT: (C)2015,JPO&INPIT
Inspection apparatus, method, and computer program product for machine vision inspection	May 28, 2015/ US 20150146964	Industrial Technology Research Institute	Chung-Li Tai	A method for vision machine inspection comprises providing depth information of a target acquired by an image capturing system, determining real-time three-dimensional information of a target object in a predetermined inspecting area based on depth information of at least one real-time image of the target. The method further comprises projecting color pixel information of a real-time color image of the target object to a three-dimensional virtual model based on the real-time three-dimensional information. The real-time color image may be acquired by a color camera system. The method further comprises generating a color three-dimensional virtual model. The color three-dimensional virtual model may comprise the color pixel information.
Machine vision-based steel rail surface inspection system	May 27, 2015 /CN 104655631	Wang Jian	Wang Jian	The invention discloses a machine vision-based steel rail surface inspection system, and belongs to the technical field of automatic control. The machine vision-based steel rail surface inspection system is characterized by comprising an ARM controller (1), a signal conversion module (2), an auxiliary light source A (3), a power supply module (4), a bus interface circuit (5), a data transmission interface (6), an auxiliary power supply B (7), an image pre-processing module (8), a CCD line-scan digital camera (9), a to-be-inspected steel rail (10), an upper computer (11), a display module (12), an alarm module (13), a keyboard input module (14) and a defect characteristic database (15). Compared with the prior art, the machine vision-based steel rail surface inspection system has the advantages of simple system structure, convenience in assembling and debugging, high system reliability, high measurement accuracy, low power consumption and the like, and is easy to popularize and convenient to maintain.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
System and method for controlling a tracking autofocus (TAF) sensor in a machine vision inspection system	April 23, 2015/ JP 2015078982	Mitsutoyo Corp	Northrup Ryan	PROBLEM TO BE SOLVED: To provide a system and a method for controlling a tracking autofocus (TAF) sensor in a machine vision inspection system. SOLUTION: A method is provided for controlling a tracking autofocus (TAF) portion 1000 of the machine vision inspection system. The TAF portion 1000 automatically adjusts a focus position of an imaging portion to focus at a Z height corresponding to a current surface height of a workpiece. The TAF portion 1000 comprises a TAF enable/disable portion 1000J that provides TAF enable and disable operations. The TAF disable operations comprise a first set of TAF automatic interrupt operations that are automatically triggered by user-initiated operations that include changing the Z height, and the TAF disable operations may further comprise automatic interrupt operations that are automatically triggered on the basis of at least one respective TAF Z height surface tracking characteristic exceeding a previously set TAF disable limit for that respective TAF Z height surface tracking characteristic. COPYRIGHT: (C)2015,JPO&INPIT
PCBA solder joint inspection method based on machine vision	April 22, 2015/ CN 104535587	Anhui Keming 3D Technology Co. Ltd.	Lyu Yuelin	The invention provides a PCBA solder joint inspection method based on machine vision. The solder joint position and quality are judged by virtue of image acquisition and analysis. The method specifically comprises the following steps: S1, presetting detection parameters, wherein the detection parameters comprise the solder joint standard coordinates and solder joint standard parameters which are in one-to-one correspondence; S2, photographing to-be-detected PCBA, thereby obtaining a PCBA image; S3, analyzing the PCBA image, and extracting the coordinate and surface parameters of the to-be-detected solder joint; S4, comparing the coordinates of the detected solder joint with the solder joint standard coordinates to and judge whether the solder joint position is accurate; and S5, comparing the solder joint surface parameters with the solder joint standard parameters according to the solder joint coordinates and the solder joint standard coordinates to judge whether the solder joint quality is qualified. According to the method disclosed by the invention, the solder joint detection is performed by utilizing the machine vision technology, the problems that the solder joints are high in intensity and difficult to distinguish, detection leakage is easily caused and the like are effectively solved, the solder joint detection accuracy is guaranteed, the detection efficiency is improved, and the labor cost is reduced.
System and method for controlling a tracking autofocus (TAF) sensor in a machine vision inspection system	April 16, 2015/ US 20150103156	Mitutoyo Corporation	Ryan Northrup	A method is provided for controlling a Tracking AutoFocus (TAF) portion of a machine vision inspection system including an imaging portion, a movable workpiece stage, a control portion, and graphical user interface (GUI). The TAF portion automatically adjusts a focus position of the imaging portion to focus at a Z height corresponding to a current surface height of the workpiece. The method includes providing the TAF portion, and providing TAF enable and disable operations, wherein: the TAF disable operations comprise a first set of TAF automatic interrupt operations that are automatically triggered by user-initiated operations that include changing the Z height, and the TAF disable operations may further comprise automatic interrupt operations that are automatically triggered based on at least one respective TAF Z height surface tracking characteristic exceeding a previously set TAF disable limit for that respective TAF Z height surface tracking characteristic.

Title	Publication Date/ Publication Number	Assignee	Inventor	Abstract
Machine-vision-based visual cigarette appearance inspection device of cigarette making machine	March 25, 2015/ CN 104432498	Kan Hui	Kan Hui	The invention discloses a machine-vision-based visual cigarette appearance inspection device of a cigarette making machine. The machine-vision-based visual cigarette appearance inspection device comprises an optical image-forming unit, an image pre-processing unit, a control and image analyzing unit and a trigger signal unit, wherein the optical image-forming unit comprises a camera component A and a camera component B which are respectively positioned on the two side surfaces of a transmission drum wheel of the cigarette making machine; the image pre-processing unit comprises a PCI image acquisition card with a CAMLINK interface; the control and image analyzing unit mainly comprises an industrial computer; the trigger signal unit mainly comprises FPGAs; the optical image-forming unit, the image pre-processing unit, and the control and image analyzing are connected one by one; and the trigger signal unit is simultaneously connected to the optical image-forming unit, the image pre-processing unit, and the control and image analyzing unit. Cigarette images acquired by the device include images of a tipping paper filter tip part, so that complete finished product cigarettes can be inspected.
Automobile white body machine vision inspection system design method	February 25, 2015/ CN 104374315	Tianjin Biaoshiqi Science and Technology Development Co., Ltd.	Cheng Ming	A machine vision system which is developed from the 80s of the twentieth century is used for realizing the vision function of a person through a machine to form acknowledgement to objects in the world. Due to the advantages of high precision, high speed, good repeatability and no fatigue and the like, the machine vision system can well improve product quality and the automation degree, and the machine vision system plays an irreplaceable role in the occasions where manual operations are not suitable or high-risk fields. White body inspection is divided into casual inspection according to frequencies and all inspection; according to inspection measures, white body inspection can be divided into manual inspection and inspection through other direction inspection tools, or the machine vision inspection system is used for inspecting key quality factors of a white body, wherein a left door opening, a right door opening, a front windshield opening and a rear windshield opening are main inspection portions of the white body. Machine vision inspection is adopted abroad to monitor white body quality of cars in the 80s, and is widely applied.
Focus height repeatability improvement in a machine vision inspection system	January 15, 2015/ US 20150015696	Mitutoyo Corporation	Delaney Mark Lawrence	A method improves focus height repeatability in a machine vision inspection system. A region of interest is defined within a field of view imaged by a camera portion, wherein an aligned edge feature in the region of interest may introduce a focus height sensitivity that varies depending on the aligned edge feature offset relative to the image pixels. A first set of focus-determining operations determines a focus height for the region of interest, and comprise at least one of: (a) operations that reduce the sensitivity of the focus height determination to the offset of the aligned edge feature relative to the image pixels; and (b) operations that adjust the offset of the aligned edge feature relative to the image pixels according to a predetermined offset repeatability criteria, such that the image data used in the focus height determination fulfills the offset repeatability criteria.

Exhibit 1 lists some of the patents related to machine vision inspection systems.

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