

3D PORTABLE DOCUMENT FILE FOR A SYSTEM FOR MANUFACTURING A COMPONENT

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 63/609,144 filed December 12, 2023, entitled “3D Portable Document File For 3D Printing System,” which is incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

[0002] This application is directed to the field of manufacturing systems and, more particularly, to documents that contain encrypted information for directing a manufacturing system such as a 3D printer to make a particular part.

BACKGROUND OF THE INVENTION

[0003] Rapid prototyping and/or 3D printing technology has progressed significantly in the last decade. 3D printing refers to a set of processes, which can vary extensively, for the extrusion of materials into a three-dimensional space in order to create a three-dimensional physical object. 3D printing is also known as additive manufacturing. 3D printers

today can utilize plastic materials and/or composite materials, such as nylon or carbon fiber, and even metals. These materials offer great integrity and strength in printed components. As such, modern 3D printing technology has been used for printing industrial-use parts.

[0004] 3D printing has employed computer files to store information about the printed components. The computer files are employed by the printer to form the component. Such files typically have information on the component such as size and shape. Numerous different types of files are in use. Often the files have to be converted to a format that is understood by a particular printer. Furthermore, several files may be required for a single component.

[0005] Generally, a technical data package (TDP) is a set of electronic files, that describes a product or item. These files typically include 3D models, product manufacturing information, bills of material (BOMs), and any other necessary data to produce a product. The packages are tools for sharing 3d printer profile data such as material selection, layer height, infill percentage, flow rates etc. Therefore, there is a need in the art for an easy-to-use 3D file system that provides information to the printing system without adding complexity to the system.

SUMMARY OF THE INVENTION

[0006] In accordance with the present invention, a system for manufacturing a component is provided. An exemplary system is a 3D printing system comprising a 3D printer including a modular electronics unit. The modular electronics unit has a processor configured to adjust print operating parameters of the printing system. The modular

electronics unit also has a memory, and a communications device connected to the processor. A computer file includes information needed to manufacture the component. The computer file is preferably in PDF format and includes meta data representing quality data generated by the 3D printer.

[0007] The 3D printer includes a 3D print quality evaluation system, and the computer file includes metadata representing quality data generated by the 3D print quality evaluation system. The 3D printer also includes sensors for measuring scoring metrics including warping, bobbling, and ripples. A camera is provided on the 3D printer, and the quality data is images of the printer and print chamber before, during and after printing. Environmental sensors are employed to collect data, and the quality data includes temperature, pressure, humidity, volatile organic compounds, shock, vibration, air quality, air chemical composition, or particulate matter in air.

[0008] The computer file includes metadata representing manufacturing instructions, settings, or requirements. The 3D printing system includes a slicer system wherein the meta data includes the slicer system configuration print settings and wherein the print settings include printing speed or filament size.

[0009] The printer is preferably constructed with a nozzle, a bed, and a print chamber. The manufacturing instructions include temperature of the nozzle, temperature of the bed, temperature of the print chamber, speed of the printing and flow rate of the printing material. The printer is also constructed with a firmware module in the memory, a fan, a light and a motor. The manufacturing instructions preferably include a 3D printer firmware configuration setting: fan speed, lighting, micro stepping instructions, amounts and timing of motor currents, acceleration of the

nozzle, mechanical control system parameters, and power system parameters. The manufacturing instructions include a configuration of a quality control or quality assurance system to alter scoring/data collection methodologies and updating model parameters such as mathematical function parameters, machine learning parameters or weight parameters.

[0010] The metadata includes hours of uptime, hours of printing time, age of various components such as electrical systems, hot end nozzles, fans, or heaters and is stored as text, image, video etc. Data may or may not be visible to end users and the data may be stored various formats such as an xml, json, html, css, csv, excel or word document file embedded within the PDF file. Information is preferably stored in a relational/key-value/object database embedded within the computer file. The metadata also includes user inputted feedback such as the usage and usability of the 3D printer; ease of use; user interface design and user experience; hardware, firmware and software functionality; the quality of the 3D printer; part quality history; the quality of the 3D printed part; the environmental conditions; the internal conditions of the printer; the electrical conditions before, during and after the print. The metadata also includes power related metrics such as power, voltage, current, power source, or generator status. The metadata also includes process documentation such as: a list outlining execution of all manufacturing steps, verification of completion and quality assurance of manufacturing steps, data regarding the environmental and internal conditions of the 3D printer, or data regarding the electrical conditions before, during, and after the print including power, voltage, current, power source, generator, or battery.

[0011] Preferably the metadata includes a secure technical data package including 3d shape data and profile data. The packages are

digital files for manufacturing that can be sold. The 3d shape data and profile data (the metadata) are encrypted and embedded in the metadata or in the image data on the computer file. These critical 3D data and profile data are only decryptable at the endpoint- the 3D printer or manufacturing machine itself or a decryption device at the manufacturing endpoint.

[0012] A method of printing a 3D object is also disclosed. The method uses a 3D printing system comprising a 3D printer. The 3D printer includes a modular electronics unit having a processor configured to adjust print operating parameters of the printing system. The method comprises embedding metadata into 3D PDF print files.

[0013] Additional objects, features and advantages of the invention will become more readily apparent from the following detailed description of preferred embodiments of the invention when taken in conjunction with the drawings wherein like reference numerals refer to corresponding parts in the different views.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Figure 1 is an upper perspective view of a top-opening embodiment of a manufacturing system in accordance with the present invention.

[0015] Figure 2 is an upper perspective view of the manufacturing system of Figure 1 in which the lid, door and door plate of the enclosure have been removed to show a 3D printer housed within the body of the enclosure.

[0016] Figure 3 is an upper perspective view of the 3D printer of Figures 1 and 2 which has been removed from the enclosure.

[0017] Figure 4 is a schematic view of a suspension system of a 3D printing system in accordance with the present invention.

[0018] Figure 5 is a schematic view of the controller in a 3D printing system in accordance with the present invention.

[0019] Figure 6 is a schematic view of the control of a 3D printing system in accordance with the present invention.

[0020] Figure 7 is a block diagram representing intelligent software to detect flaws and to alert users about flaws.

[0021] Figure 8 is a block diagram for an approach to analyze, learn and improve quality as well as provide a scorecard-based quality report.

[0022] Figure 9 is an example of a scorecard-based quality report.

[0023] Figure 10 is a block diagram of a pay by print system that is integrated with quality control.

[0024] Figure 11 is a schematic view of a computer file.

DETAILED DESCRIPTION OF THE INVENTION

[0025] Detailed embodiments of the present invention are disclosed herein. However, it is to be understood that the disclosed embodiments are merely exemplary of the invention that may be embodied in various and alternative forms. The figures are not necessarily to scale, and some features may be exaggerated or minimized to show particular details. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a representative basis for teaching one skilled in the art to employ the present invention.

[0026] As used in this specification and the appended claims, the singular forms “a”, “an” and “the” include plural referents unless the content clearly dictates otherwise. As used in this specification and the

appended claims, the term “or” is generally employed in its sense including “and/or” unless the content clearly dictates otherwise.

[0027] In the description of embodiments disclosed herein, any reference to direction or orientation is merely intended for convenience of description and is not intended in any way to limit the scope of the present invention. Relative terms such as “lower,” “upper,” “horizontal,” “vertical,” “above,” “below,” “up,” “down,” “front,” “back,” “top” and “bottom”, as well as derivatives thereof (e.g., “horizontally,” “downwardly,” “upwardly,” etc.), should be construed to refer to the orientation as then described or as shown in the drawing under discussion. These relative terms are for convenience of description only and do not require that the apparatus be constructed or operated in a particular orientation. Terms such as “attached,” “affixed,” “connected,” “coupled,” “interconnected,” and similar refer to a relationship wherein structures are secured or attached to one another either directly or indirectly through intervening structures, as well as both movable or rigid attachments or relationships, unless expressly described otherwise.

[0028] Figure 1 shows a system for manufacturing components which is preferably a 3D printing system 1 in accordance with the present invention. The 3D printing system includes a hermetically sealed enclosure 4 defining a sealed chamber (not separately labeled). As shown, enclosure 4 has a body 5 that is attached to a lid 7 via hinges (not separately labeled). Enclosure 4 is water resistant and made of materials that are impact resistant. Preferably, the enclosure 4 is made of plastic materials and can be sealed for waterproofing and dustproofing purposes. Handles 11 that are attached to the exterior of body 5 grant portability to the 3D printing system while exterior bumpers 13 on body 5 help ruggedize the 3D printing system (one handle 11 is shown in Figure 1,

another handle 11 is located opposite but not shown). Preferably, the exterior bumpers are made of a rubber or plastic material.

[0029] Lid 7 includes a lid plate 15 on its underside to which various elements are mounted: a user interface 17, an electronics housing 19 and a filament case 30. As shown in Figure 1, user interface 17 includes a touchscreen display monitor unit (not separately labeled). However, other user interfaces could be employed with the 3D printing system of the present invention. Preferably, the user interface is watertight and airtight. Electronics housing 19 is described in more detail below with the discussion of Figures 4 and 6 and operates based on information stored in a PDF file, as discussed with regard to Figure 11. Filament case 30 is used to store 3D printing filament(s). One type of 3D printing process, called fused deposition modeling (FDM), relies on heating a ductile filament material to near its melting point and continuously depositing the heated material in layers to create a physical object. As the layers cool, the continuous filament fuses to provide structural integrity. FDM can be used to print plastic and composite materials (e.g., nylon or carbon fiber). However, the 3D printing system of the present invention is not limited to being used for FDM printing. Also, the filament case can be of other geometric shapes and sizes than shown in Figure 1.

[0030] As shown in Figures 1 and 2, enclosure 4 of 3D printing system 1 is openable at a top portion 38 of body 5. In use, lid 17 is moved from top portion 38 to reveal a door plate 39 and a door 41. Door 41 is preferably attached to door plate 39 via hinges (not separately labeled) and preferably includes a transparent section 42 which allows the user to view beneath the door. Whether or not the door is transparent users could use a camera view beneath the door. Together, door plate 39

and door 41 cover a 3D printer. Manifolds 45 and 46 reside upon and in door plate 39 and facilitate air movement (e.g., for fume management).

[0031] As further shown in Figure 3, 3D printer 51 includes a bed plate 107 upon which a 3D object is printed (e.g., by fused deposition modeling). The vertical position of bed plate 107 is adjusted by stepper motors 112 and 113 which drive the rotation of threaded screw shafts 115 and 116, respectively. Threaded screw shafts 115 and 116 are rotated within ballscrew nuts 118 and 119, respectively, which are attached to bed plate 107. Stepper motors 112 and 113, positioned upon upper mounting plate 58, are joined to upper portions of threaded screw shafts 115 and 116 via clamps such as clamp 121.

[0032] Figure 4 gives an overview of a suspension system 228 employed by a 3D printing system of the present invention. Suspension system 228 includes active and passive suspension systems 229 and 230, respectively, that provide shock absorption, serve to ruggedize the externals and internals of the 3D printer and allow for printing during movement. Much of the disturbances faced by 3D printers during deployment can be mitigated with dampening and vibration compensation. Preferably, passive suspension system 230 includes one or more tuned mass dampeners 231, specifically tuned to the most common mode of noise and vibrations the 3D printing system is expected to experience. Also, preferably, one or more tuned mass dampeners 231 are made of a rubberized mechanical device or fluid. Active suspension system 229 preferably includes actuated servos 232, inertial measurement units 233, and other motion sensors 234 tasked with actively responding to extraneous vibrations and disturbances that passive suspension system 230 is not tuned for. Together, active suspension system 229 and passive

suspension system 230 ensure that the printer is capable of surviving falls and handling disturbances during printing operations.

[0033] Figure 5 gives an overview of components that reside within electronics housing 19 of 3D printing system 1. In particular, within electronics housing 19 resides a power supply 237, a fan 238, a processor 239 and a controller 240. Processor 239 and controller 240 work together, along with user interface 17, one or more sensors 244 and a potential network of 3D printers 245 to operate 3D printing system 1. A memory 241 is also provided and is operatively connected to the controller 240. A decryption system 242 is shown being in housing 19. However, the decryption system 242 can also be located outside the housing 19 so long as the system 242 can control the 3D printing system 1. A compliance monitoring system 243 is also associated with the 3D printing system and is configured to track and report usage metrics to an OEM management server or back to a TDP for offline controlled distribution.

[0034] The decryption system 242 is preferably integrated with a 3D printer 1 or endpoint and is configured to validate the printer's unique hardware/software fingerprint. The 3D printer system 1 is further configured to decrypt the TDP upon successful validation; destroy the original encrypted TDP and associated decryption keys post-decryption;

[0035] The compliance monitoring system 242 is also configured to embed the encrypted metadata (shape data and printer profile data) into an image on pdf/other file type for tamper resistance. The system 242 provides end-to-end integration, tamper resistance, IP protection, and offline controlled distribution not merely general metadata or encryption systems.

[0036] Figure 6 gives an overview of the sensor fusion suite. One or more sensors 244 include internal and/or external sensors that monitor various aspects of 3D printing system 1, its environment, and/or the object being printed, in real-time, including: motor diagnostics; input current; rotation speed; axis velocity/acceleration/jerk; climate conditions; temperature; barometric pressure; humidity; print diagnostics; filament parameters; print quality (e.g., 3D visual or infrared imaging); and location (i.e., GPS data). Part of the implementation of sensor 244 includes integration of inertial measurement units (IMUs) and/or accelerometers placed on the inside of the external shell of the case, as well as another set placed on or outside the shell surrounding the 3D printer, and another on the extruder head/gantry of the 3D printer itself will provide important benefits. Sensors 244 are to ensure that 3D printing system 1 can withstand harsh climates and react to disturbances and shocks during printing. Sensors 244 are also to ensure the printed object is of good quality and is printed accurately. The output of sensors 244 is directed to processor 239 which employs one or more sensor fusion machine learning (ML) algorithms and which in turn provides input to controller 240. Controller 240 then directs various elements 246 of 3D printing system 1. For example, controller 240 can drive active suspension system 229, stepper motors 112, 113, 184 and 185, hot end assembly 172 and manifolds 45 and 46. This list is not exclusive in that controller 240 is not limited to controlling only those aspects of 3D printing system. Also, sensors 244, particularly a 3D imaging device, would be used for detecting part position within the chamber to calibrate extruder head position relative to the position of the part and current print layer either during the print process, or after restarting after a pause, abort, loss of power, or any other discontinuity in 3D print process. The

sensor data can also be stored, preferably embedded in an PDF as described below with regard to Figure 11 and made available for post-hoc activities such as analysis for quality control or systems improvements, troubleshooting and for training intelligent software such as machine learning and artificial intelligence. Further details of this type of printer are disclosed in WO2022/104264, entitled, “Portable, Ruggedized and Easy to use Printing System”, which is incorporated herein by reference.

Climate and Atmospheric Control

[0037] 3D printing of higher-grade materials is a very sensitive process. Composite materials and metals require high print temperatures and are extremely sensitive to fluctuations in humidity, pressure, and atmospheric temperature. Climate and atmospheric control are required to ensure parts have good structural integrity. The 3D printing system of the present invention can react to changes in the climate during prints and perform the required print adjustments to ensure strong print quality. In one embodiment, in reaction to sensor data from one or more sensors 244, processor 239 implements smart software such as ML algorithms to optimize the internal atmosphere (temperature, humidity, etc.) of 3D printing system 1. The implemented reaction is computed from available simulations of the climate’s effect on the print and is fed into controller 240 for facilitation.

Active Print Monitoring

[0038] A challenge of adopting 3D printing technologies for the replacement and repair of traditionally manufactured parts is that 3D

printed parts often manifest vastly different material properties from the parts to be replaced and are likely to diverge from the tolerance limits of their traditionally minded designs. The 3D printing system of the present invention, in order to more closely conform with the intended specifications of the design, preferably employs a variant of the bi-directional evolutionary structural optimization (BESO) algorithm to optimize a given part's infill topology for various mechanical characteristics under a fixed infill density constraint. The particular algorithmic variant will account for the anisotropic behavior of FDM parts given their print parameter context and print orientation. In one embodiment, sensors 244 include a 3D imaging device, such as a camera, filament sensors and thermal sensors that actively monitor the progress and quality of the 3D object being printed and check for signs of poor print quality. Controller 240 can adjust print settings automatically to react to dropping quality or failing prints. In another embodiment, sensors 244 include motor diagnostics sensors that allow for real-time reconstruction of the expected and actual prints. This creates an error term that can be minimized using intelligent software such as ML sensor fusion algorithms to ensure accurate and high-quality prints. The 3D imaging device can also be used to verify specifications (e.g., measurement tolerances) and to test for inclusions and defects in the printed object. Integrated x-ray scanning can additionally or alternatively be used to validate the quality of printed object and test for defects.

[0039] Figure 7 outlines flaw detection capabilities of the 3D printing system enhanced with intelligent software including but not limited to artificial intelligence or machine learning leading to the live detection of print quality and scoring of print quality. In step 320, a flaw is detected based on data obtained from, e.g., computer vision, a humidity

sensor, a temperature sensor or an accelerometer. In response to the flaw detection, in step 322 a minimum print quality score or trigger threshold set by the operator or described in the part file technical data sheet is consulted. In step 324, the software (ML, AI, models) determines that the print will not meet the minimum quality threshold. In step 326, the print will be automatically canceled, or the operator will be notified to make the decision whether to cancel or continue. In step 328, feedback loops (decision results sent to operator) allow the system (e.g., ML) to learn and improve decision making. Alerts to the operator could be any one or a combination of electronic alerts such as email or text messages, audible alerts such as an alarm or voice message, or visual alerts such as flashing lights or a text notification screen attached to or associated with the printer.

Sensor Fusion ML Algorithms

[0040] In accordance with the one or more sensor fusion ML algorithms used by process 239, ML is implemented to modify operating internal print parameters via sensor fusion (i.e., the combination of data collected from one or more sensors 244). ML may include one or more of: a Gaussian process regression algorithm, a Kalman or Particle filter, a deep convolutional neural network algorithm, a deep recurrent neural network, a random forest model, gradient boosting algorithms, Joint Probabilistic Data Association Filters, a hidden Markov model, meta reinforcement learning model, key point detection, canonical correlation analysis, factor graph models, Markov random field models, or any combination thereof. Preferably, the one or more sensor fusion ML algorithms are developed and updated through a communications device

or network 245 (e.g., a cloud network), where 3D printers operate as data collection nodes for a central ML algorithm. Data on all the printers in network 245 is transmitted to a central command or company during maintenance and updated with collective intelligence. Major updates to control algorithms are done by connecting to network 245 for updates while maintaining onboard ML capabilities.

Print Report

[0041] In an embodiment, processor 239 tracks the data collected by one or more sensors 244 and all adjustments made during a print cycle and controller 240 creates a report 247 for the user. Report 247 shows any potential issues and time-stamped “events” (e.g., a shock to the system or sudden changes in temperature or humidity). Preferably, report 247 includes a score reflecting how “successful” the print was (e.g., based on the number of adjustments needed, any detectable deviations from a render or theoretical model, etc.) This score is given to the user to help facilitate use decisions and is also saved to be used to optimize ML algorithms.

[0042] In another embodiment, shown in Figure 8, a part is downloaded or generated and includes a specified quality assurance (QA) score in step 370. In step 372, the part is printed and the printer logs all “events” and environmental data. Should a live score determined by ML fall below the required threshold, the print is cancelled in step 374. Otherwise, the print is completed in step 376 and in step 378 a report is generated as a PDF document, a text document or a log report showing history of the part manufacturing. In step 380, the print is given a score optimized through ML based on how optimal the print conditions were.

Lastly, at step 382 the operator determines whether to accept the print score and use the printed part.

[0043] The print report (that is also stored for improving ML models of the printer and supporting software and providing data for analysis by the customer for optimizing their supply chain, part files, and deployment) could contain a scoring system that could be represented by a score between 0-100. The staged threshold of acceptance would vary from part to part and be assigned by an engineer in the technical data package for the part. For example, if the part were considered high risk, it would mandate a print score of above 95; however, if the part is a draft and does not require precision, it may be set a required print score of 50. The print score would be determined by an automated process that would leverage the sensor fusion suite to provide a score.

[0044] Figure 9 shows an exemplary scorecard-based report 390. In addition to providing the part name and info 392 (e.g., file name, image) and material specifications 394 (e.g., tensile strength), report 390 displays a matrix 396 of logged events like shocks, vibrations, or spikes in and of the recorded conditions. A graph 398 shows logged variations in e.g., humidity and temperature. A final score 400 is displayed and color coded to categories of usage (e.g., green for completely passing specifications, yellow for close to threshold and should be determined by operator, red for does not meet specifications laid out in the technical data package). Report 90 is preferably formatted as an infographic or dashboard display.

Pricing and Payment

[0045] Figure 10 gives an overview of how the 3D printing system can facilitate the production of parts using an integrated payment and

quality assurance system. In step 353, a digital rendering of a part is generated or is downloaded from a central repository. In step 355, a quote for the price of the part is generated by considering one or more of: the type of material; the volume/mass of material; the time to print; and the actual or estimated retail or wholesale price of an equivalent commercially available part (and could include a premium or discount based on value-add). Price inputs could be automatically updated based on market changes. The part is printed at step 357 and at step 359 the operator reviews the printed part and confirms the printed part meets expectations (e.g., printed to specification). Before the part is printed, there may be a step of verifying that the part file selected for print is the correct part. Following the operator confirming print success, the 3D printing system at step 361 charges the operator or associated organizing and the payment is processed. It should be noted that payment could be required just to receive the file.

[0046] Many of the above-described embodiments require information about the printer to be stored. In another preferred embodiment, the information is stored in a computer file that is preferably in PDF format. The embodiment includes a system for storing information such as in the form of visual or metadata in existing files that are in portable data format, PDF, or 3D PDFs for use by a 3D printing system. An exemplary PDF file 500 is shown in Figure 11.

Alternatively, other formats such as CAD, STL, GCode, STEP, OBJ, AMF, 3MF, IGES, PLY, FBX, etc. could be employed. Various types of print quality data or metrics generated are by a 3D printing system 1 as discussed above. The data is stored as metadata 510 in the 3D PDF file 500 along with typical descriptive data used to print a 3D part stored in

the main file 520. The metadata includes numerous categories of information as described below.

[0047] Preferably the metadata includes QC/QA data (quality assurance scores/data that is generated by a 3D print quality evaluation system). The metadata can include print quality scoring metrics (warping, blobbing, ripples, etc.). The metadata can also include images of the printer and print chamber before, during and after print or visual images, hyperspectral imaging, x-ray/infrared imaging. The metadata may be related to the environmental conditions within and outside the printer, before, during and after print. The metadata could be temperature, pressure, humidity, volatile organic compounds, shock, vibration, air quality, air chemical composition, particulate matter in air.

[0048] Another area of information stored in the metadata is related to manufacturing instructions, settings and/or requirements such as the system configuration, modified print settings such as speed, filament size, walls infill, etc. The metadata can be related to the printing material configuration. For example, the metadata can be nozzle, bed and/or chamber temperature, speed, flow rate, etc.

[0049] In another area, information is related to 3D printer firmware configuration. The configuration includes fan speed, lighting, microstepping, motor currents, acceleration, mechanical control system parameters, power system parameters.

[0050] The information stored in the metadata can be related to a manufacturing/printing process validation or QA/QC evaluation system. The metadata could contain information related to the configuration of a QA/QC system to alter scoring/data collection methodologies such as updating model parameters (mathematical function, ML weights and biases, model structure, model type). The metadata related to the 3D

printer could also be hours of uptime, hours of printing time, age of various components such as electrical systems, hot end nozzle, fans, heaters, etc.

[0051] Turning back to Figure 11, the secure technical data package (TDP) system employs the PDF file 500 as a secure technical data package 511 which is a file containing encrypted 3D shape data 512 and printer profile data 513. In addition, in accordance with the invention, the technical data packages 511 are digital files for manufacturing that can be sold. The technical data packages 511 have embedded 3D data and manufacturing instructions (printer profile data 513, but generic to include other manufacturing machines like CNCs) that are developed and certified in form by the original equipment manufacturer or intellectual property holder, or a 3rd party that provides the technical data package. The tamper-proof metadata 510 is a layer embedded in the file 510 and stores the printer validation parameters and usage history.

[0052] The 3D shape data 512 and profile data 513 (the metadata) are encrypted and embedded in the metadata 510 or in image data on the PDF 500. The profile data 513 preferably includes information such as material selection, layer height, infill percentage, flow rates etc. These 3D shape data 512 and profile data 513 are only decryptable at the endpoint- the 3D printer or manufacturing machine itself or a decryption system 242 at the manufacturing endpoint. The endpoint is the 3D printing system 1. The decryption system 242 does not have to be physically inside the 3D printer enclosure 19 but can also simply be in control of the 3D printer system 1. Preferably the decryption system 242 is a plugin on slicer software that is on the computer that runs the printer. The TCP in the PDF file 500 can be decrypted by the "printer" (manufacturing endpoint) 1 and then used for printing. The process of

decryption strips the data 512, 513 from the TDP 500 and makes it unusable either immediately, or after verification of successful print by an automated QA/QC, the operator, or both. Optionally, a counter/trace is embedded with the profile data 513 that can allow for multiple prints, and instead of immediately destroying the metadata the counter on the TDP is altered (subtract a usage) and resaved. The TDP 500 can be exchanged based on payment or licenses.

[0053] All of the data above can be stored in various ways. The data can be stored as text, image, video etc. Data could also be stored in various formats such as a xml, json, html, css, csv, excel or as a word document embedded within the PDF that may or may not be user visible. Alternatively, the information can be stored in a relational/key-value/object database embedded within the PDF.

[0054] Another source of information stored as metadata is user inputted feedback. The information is preferably from various areas, for example, feedback regarding the usage/usability of the 3D printer or Ease of use, UI/UX, hardware, firmware or software functionality, etc. The feedback could also be feedback regarding the quality of the 3D printer or part quality history, information on whether a specific part had issues that are known, etc. Another area of feedback is preferably regarding the quality of the 3D printed part; the environmental conditions such as temperature, humidity, volatile organic compounds, pressure, shock, vibrations, etc. The feedback could also be internal conditions of the printer such as temperature, humidity, volatile organic compounds, pressure, shock, vibrations, etc. or electrical conditions before, during and after the print for example, (power, voltage, current, power source, generator, UPS, etc.)

[0055] Finally, there is a form of process documentation which includes listing outlining execution of all manufacturing steps and verification of completion and quality assurance of manufacturing steps. The information stored in the metadata relates to the environmental and internal conditions of the 3d printer temperature, humidity, volatile organic compounds, pressure, shock, vibrations, etc. The information also relates to the electrical conditions before, during and after the print such as power, voltage, current, power source, generator, UPS/battery, etc.

[0056] Based on the above, it should be readily apparent that the invention provides for a specialized computer file containing data for a system for manufacturing components. In any case, although described with reference to exemplary embodiments of the invention, it should still be understood that modifications can be made to the invention as disclosed without departing from the spirit of the invention.

WHAT IS CLAIMED IS:

1. A system for manufacturing a component comprising:
an electronics unit having:
a processor configured to adjust operating parameters of the system needed to manufacture the component,
a memory, configured to store the operating parameters, connected to the processor, and
a communications device, connected to the processor, configured to receive the operating parameters; and
a computer file including the operating parameters stored as embedded information.
2. The system of claim 1, wherein the computer file is in PDF format and the embedded information includes a 3D part file.
3. The system of claim 1, wherein the computer file includes metadata, and the metadata includes some of the embedded information.
4. The system of claim 3, wherein the system includes a 3D printer having a 3D print quality evaluation system and the computer file includes metadata representing quality data generated by the 3D print quality evaluation system.
5. The system of claim 4, wherein the 3D printer has sensors for measuring scoring metrics and the scoring metrics are warping, bobbling, and ripples, flowrate, inclusions, or any structural defects.

6. The system of claim 4, wherein the 3D printer includes a camera, and the quality data is images of the 3D printer and a print chamber before, during, and after printing.
7. The system of claim 4, wherein the 3D printer includes environmental sensors, and the quality data includes temperature, pressure, humidity, volatile organic compounds, shock, vibration, air quality, air chemical composition, or particulate matter in air.
8. The system of claim 3, wherein the computer file includes metadata representing manufacturing instructions, settings, or requirements.
9. The system of claim 4, further comprising a slicer system wherein the metadata includes slicer system configuration print settings and wherein the print settings include printing speed or filament size.
10. The system of claim 8, wherein the printer includes a nozzle, a bed, and a print chamber and the manufacturing instructions include a temperature of the nozzle, a temperature of the bed, a temperature of the print chamber, a speed of printing and a flow rate of a printing material.
11. The system of claim 8, wherein the printer includes a firmware module in the memory, a fan, a light and a motor, and the manufacturing instructions include a 3D printer firmware configuration, setting fan speed, lighting, micro stepping instruction, amounts and timing of motor currents, acceleration of nozzle, mechanical control system parameters, and power system parameters.

12. The system of claim 8, wherein the manufacturing instructions include a configuration of a quality assurance or quality control system to alter scoring or data collection methodologies, updating model parameters including mathematical function parameters, machine learning parameters or weight parameters.

13. The system of claim 4, wherein the metadata include hours of uptime, hours of printing time, age of various components such as electrical systems, hot end, nozzles, fans, or heaters.

14. The system of claim 8, wherein the metadata is stored as text, image or video data that is visible to end users or stored as an xml, json, html, css, csv, excel or word type document embedded within the computer file and the data is stored in a relational/key-value/object database embedded within the computer file.

15. The system of claim 4, wherein the metadata includes user inputted feedback and the feedback includes an amount of usage or a usability of the 3D printer, ease of use, UI/UX factors, hardware, firmware and or software functionality, quality of the 3d printer, part quality history, a quality of a 3d printed part, environmental conditions, internal conditions of the printer, electrical conditions before, during, and after the print, or power related metrics including power, voltage, current, power source, or generator.

16. The system of claim 4, wherein the metadata includes process documentation and the process documentation includes a list outlining

execution of all manufacturing steps and verification of completion and quality assurance of manufacturing steps, data regarding environmental and internal conditions of the 3D printer or data regarding electrical conditions before, during and after printing wherein the electrical conditions include power, voltage, current, power source, generator, or battery.

17. The system of claim 4, wherein the metadata includes encrypted 3D shape data and printer profile data.

18. The system of claim 3, wherein the metadata is embedded into an image in the computer file, making the metadata tamper-proof, and includes validation parameters and usage history.

19. The system of claim 3, further comprising a decryption processor configured to validate hardware and software, decrypt the metadata, destroy the metadata and decryption keys after decrypting the metadata.

20. A method of printing a 3D component with a system, said method comprising:

adjusting operating parameters of the system needed to manufacture the component, with a processor,

storing the operating parameters, in a memory connected to the processor, and

receiving the operating parameters, in a computer file having the operating parameters stored as embedded information, with a communications device connected to the processor.

21. The method of claim 20 further comprising embedding metadata, having the operating parameters into the computer file.
22. The method of claim 21 further comprising encrypting 3D shape data and profile data into the metadata of the computer file, wherein the computer file is in PDF format.
23. The method of claim 21 further comprising:
embedding the metadata into an image in the computer file,
making the metadata tamper-proof, and
including validation parameters and usage history in the metadata.
24. The method of claim 21 further comprising;

validating hardware and software,
decrypting the metadata, and
destroying the metadata after decrypting the metadata.
25. The method of claim 21, wherein the system includes a 3D printer, the method further comprising;

validating hardware and software in the 3D printer,
decrypting the metadata with decryption keys, and
destroying the decryption keys after decrypting the metadata.