A method comprising the use of additive manufacturing techniques for creating molds and pattern parts for subsequent use in the casting of die components and die shoes for use in die stamping processes.
TRANSFER OF CAD DATA

APPLICATION OF PLASTIC POWDER

SELECTIVE ADDITION OF BINDER

LOWERING OF BUILDING Platform

APPLICATION OF POWDER AND SELECTIVE BINDER REPEATED

REMOVAL OF UNBOUND PLASTIC POWDER

FINISHED ELEMENT

FIG. 10
ADDITIONAL FABRICATION TECHNOLOGIES
FOR CREATING MOLDS FOR DIE COMPONENTS

CROSS-REFERENCE TO RELATED APPLICATIONS


FIELD OF THE INVENTION

[0002] The present invention generally relates to the use of additive manufacturing techniques for creating molds and pattern parts for use in the casting of die components for use on die assemblies, as well as for making molds for die shoes.

BACKGROUND OF THE INVENTION

[0003] Die components, such as trim steels, scrap cutters, flange steels, form steels, pierce inserts, trim inserts, button block inserts, and the like, are components of a stamping die assembly that form and cut away excess sheet steel from a vehicle part, such as a hood, door panel, or other like part being formed. There are any number of die components used per stamping die assembly, each one having a unique configuration and function. Thus, it is impractical to cast multiple die components using traditional sand casting methods, which involve tooling up a mold pattern to form a sand core from which the die component is cast. The present invention provides techniques to create a pattern part or a mold core package that can later be used in the casting process to cast one or more die components having a near net-shape of the finished part. In this way, the present invention provides a cast part which greatly reduces the amount of finishing work that needs to be performed on the part after being cast. Further, the present invention provides a method which involves less stock material to cast the near net-shape die component part.

[0004] The common method for producing die components is through an investment casting process, which involves a pattern maker gluing Styrofoam® pieces together in an approximate shape of the die component and then machining that Styrofoam® into the desired shape and size of the die component to be cast. Recently, this technology has been referred to as subtractive manufacturing and is also used with metallic blocks or other such billets that are machined down to the approximate shape of a die component. This machining process lacks the precision needed to cast a near net-shape of the die component. Thus, extra machining stock, as much as 10 mm, is left on the subtractively manufactured pattern part and the resulting casting. This extra casting stock must be machined using a lengthy process, which involves scanning the object and creating a CNC program that is based on the actual shape of the desired part. Having the extra machining stock on the final cast part often exceeds the penetration depth of the CNC machine, such that the extra stock must first be removed through any number of rough cut operations. The part must be hardened between rough machining processes, and, finally, finish machined. The present invention eliminates several of the post-casting steps involved in making a finished die component.

SUMMARY OF THE INVENTION

[0005] According to one aspect of the present invention, a method of making a pattern part for use in casting a die component includes the steps of (a) depositing a thin layer of polymeric powder on a build platform and (b) selectively applying a solvent to particular regions of the thin layer of polymeric powder to bind the polymeric powder in said regions to define a cross-section of the pattern part. Steps (a) and (b) are repeated to produce a completed pattern part having a configuration of the die component to be cast. The pattern part is then coated with a slurry to form a shell surrounding the pattern part. The shell is then heated to harden the shell and vaporize the pattern part to create a shell comprising a negative image of the pattern part. A molten material is cast into the shell to form the die component.

[0006] According to another aspect of the present invention, a method of making a die component includes the steps of forming a mold core package using an additive manufacturing process, wherein the mold core package comprises a negative image of the die component to be cast. A molten material is cast into the mold core package, and the molten material is cooled to form the die component having a near net configuration of the mold core package within an accuracy range of plus or minus 1 mm to 5 mm.

[0007] According to yet another aspect of the present invention, a method of making a plurality of sand mold packages for use in casting die components includes the steps of printing a plurality of sand mold packages using an additive 3D printer wherein the plurality of sand mold packages comprises one or more die component configurations. Select sand mold packages from the plurality of sand mold packages are nested into a casting structure having runners in communication with each select sand mold package. A molten material is cast into the casting structure to fill each select sand mold package using the runners. The molten material is then cooled to form the die component having a near net configuration of each select sand mold package.

[0008] These and other aspects, objects, and features of the present invention will be understood and appreciated by those skilled in the art upon studying the following specification, claims, and appended drawings.

BRIEF DESCRIPTION OF DRAWINGS

[0009] In the drawings:

[0010] FIG. 1 is a top perspective view of a job box or rigid containment box prior to formation of sand mold packages by a sandprinting device;
[0011] FIG. 2 is a top perspective view of the job box of FIG. 1 as a layer of fine particulates is being spread in the job box;
[0012] FIG. 3 is a top perspective view of the job box of FIG. 1 as a binder is being added in the printing area by a sandprinting device to form cross-sectional layers of the sand mold packages;
[0013] FIG. 4 is a top perspective view of the job box of FIG. 1 after several layers of sand have been printed by a sandprinting device;
[0014] FIG. 5 is a top perspective view of the job box of FIG. 1 with a fresh layer of fine particulates being spread over the print surface of the job box;
[0015] FIG. 6 is a top perspective view of the job box of FIG. 1 after a plurality of mold core packages have been printed and the job box removed from the printing device;
[0016] FIG. 6A is a perspective view of the plurality of mold core packages as removed from the job box, wherein the mold core packages are made from bound sand and excess unbound sand is proposed to be removed;
[0017] FIG. 7 is a top perspective view of a cope and drag mold assembly having printed sand mold packages nested therein;
[0018] FIG. 8 is a perspective view of a cast die component;
[0019] FIG. 9 is a perspective view of a die assembly having die components affixed thereto; and
[0020] FIG. 10 is a flow chart representing an additive manufacturing process for creating a pattern part.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0021] For the purposes of description herein, the terms “upper,” “lower,” “right,” “left,” “rear,” “front,” “vertical,” “horizontal,” and derivatives thereof shall relate to the invention as oriented in FIG. 1. However, it is to be understood that the invention may assume various alternative orientations, except where expressly specified to the contrary. It is also to be understood that the specific devices and processes illustrated in the attached drawings, and described in following specification, are simply exemplary embodiments. Hence, specific dimensions and other physical characteristics relating to the embodiments disclosed herein are not to be construed as limiting, unless expressly stated otherwise.

[0022] The present invention eliminates many steps in the process of making a die component due to its accuracy and automation, which saves a great deal of time, materials, and costs in the manufacturing of a die component. Using additive manufacturing or additive fabrication techniques, the accuracy and automation of the present invention allows for the elimination of several post-casting processing steps to create the desired die components. According to embodiments of the present invention, sacrificial dies and sacrificial pattern parts are provided through various additive manufacturing processes that manufacture the molds or pattern parts three-dimensionally one layer at a time. Sacrificial materials used in the additive manufacturing processes of the present invention include epoxies, sand, sand-ceramic mixes, powdered metals, plastic resins, and the like. In the additive manufacturing processes of the present invention, a three-dimensional (3D) mold or pattern part is assembled by producing and sequentially stacking thin cross-sectional layers of the desired mold or part as generated in an additive manufacturing machine. To create a three-dimensional part used in the methods of the present invention, a CAD program or other like computer-aided drawing software is used to create design data of the mold or pattern part to be formed.

[0023] Types of additive manufacturing processes known in the art include stereolithography apparatus (SLA), 3D sandprinting, and other three-dimensional printers, ink jet printers that bond layers of powder material, plastic compositions using a bonding solvent, metallic based powders using a laser sintering device, and many other such processes known in the art that will be appreciated by one skilled in the art. Thus, any such process may be suitable in conjunction with the present invention in creating a sacrificial pattern part of a die component or a sacrificial mold for a die component without departing from the spirit of the present invention.

[0024] One such rapid manufacturing process includes a sandprinting process which will now be described. This method is commenced by first acquiring a 3D data design using a CAD model program to create a sand mold package for a die component which, as exemplified below, will be in the form of a semi steel die component. It is contemplated, however, that any such die component can be created using this process. First a 3D image of the pattern part is created using a CAD program. The pattern part or mold is then subtracted from a 3D CAD model to create a sand mold package design. The resulting 3D model of the sand mold package is then produced using the techniques as described with reference to FIGS. 1-6.

[0025] Referring now to FIGS. 1-6, a job box 40 from any number of materials, including wood, metal, etc., is positioned below a printing device 42. The job box 40 defines a print area 44 within which a mold core package will be formed from a plurality of stacked particulate layers, as further described below. The printing device 42 is capable of printing 3D molds, cores, and mold core packages for use in the present invention.

[0026] As used throughout this disclosure, the term “mold core packages” will refer to sand printed or otherwise formed molds that are ready for casting of molten material. The term “molds” will refer to a component of the mold core package and the term “cores” refers to an insert that is inserted into a mold for placing molten material as cast into the mold core package. Thus, the combination of molds and cores creates a mold core package for casting. For purposes of the description of the formation of mold core packages or sand mold packages using the three-dimensional printing process discussed below, a sand mold package 110 as shown in FIG. 7 will be referenced for exemplary purposes only. It is to be understood that several different sand mold packages can be printed for casting other die components and such sand mold packages can be printed simultaneously in a single printing process.

[0027] The printing device 42 includes a hopper 46 at a deposition trough 48, which lays a thin layer of activated fine particulate 50, such as silica sand, ceramic-sand mixes, etc., inside the print area 44. The particulate 50 may be of any size, including 0.002 mm to 2 mm in diameter. The printing device 42 also includes a binder deposition device or binder dispenser 52. As disclosed in detail below, the binder dispenser 52 sprays a thin layer of binder or binding agent 16 in a configuration or pattern 50 of a single layer of a desired sand mold package or sand core package. Repetition of the layering of sand and spraying of binding agent 16 by the binder dispenser 52 on the fine particulate 50 results in the production of a three-dimensional sand mold package or sand core package from a plurality of the stacked particulate layers. The
3D sand mold package is manufactured additively over a length of time sufficient to print each thin layer of the fine particulate 50 in succession, such that each layer of bound particulate is further bound to adjacent layers, to form a completed sand mold package. Each thin layer of the completed sand mold package measures approximately 0.28 mm. The sand mold package will ultimately be used as a sacrificial mold to fabricate a die component, such as the trim steel 120 as shown in FIG. 8.

[0028] With specific reference to FIG. 1, a computer-aided design (CAD) program is developed wherein the specific configurations of a plurality of sand mold packages 100 (FIG. 6A) are entered and loaded up on a computer 60, which is another to create of the printing device 42. The computer 60 feeds the information from the CAD program with the specific configurations of the plurality of sand mold packages 100 to the printing device 42 for formation of the sand mold packages 100.

[0029] It is contemplated that CAD, or any other form of 3D modeling software, can be used to provide sufficient information for the 3D printing device 42 to form the desired sand mold packages 100. Prior to activation of the 3D printing device 42, a predetermined quantity of the fine particulates 50 is dumped into the hopper 46 by a particulate 62, along with an activation coating or activator 70 supplied by an activator 70. Although the illustrated embodiment uses a fine sand, such as the fine particulate 50, as noted above, the fine particulate 50 may include any of a variety of materials or combinations thereof suitable for the additive manufacturing techniques disclosed herein. The fine particulates 50 are mixed in the hopper 46 with the activator 70. The mixture of fine particulates 50 and activator 70 may be mixed by an agitator 74 or other known mixing device such that the fine particulates 50 become thoroughly mixed and activated. After the fine particulates 50 and activator 70 have been thoroughly mixed, the fine particulates 50 are moved to the deposition trough 48.

[0030] Referring now to FIG. 2-6, after the fine particulates 50 have been moved to the deposition trough 48, the fine particulates 50 are spread across the print area 44 in a thin even layer of unbond sand 90 by the deposition trough 48. After being spread in a thin layer on the print area 44 in the job box 40, the activated fine particulates 50 are sprayed with the binder or binding agent 16 (FIG. 3). The binding agent 16 is dispensed from the binder dispenser 52, which sprays a thin layer of the binding agent 16 in a pattern 50 that represents a first thin cross-sectional layer of the desired sand mold packages 100. After the binding agent 16 has been sprayed, another layer of fine particulates 50 and activator 70 is prepared and dumped into the deposition trough 48. The deposition trough 48 then dispenses another layer 90 of unbond activated fine particulates 50 over the previously spread fine particulates 50 layer in the job box 40, as shown in FIG. 5. The binder dispenser 52 passes over the print area 44 again, spraying a thin layer of the binding agent 16 in the pattern 50 that represents a second thin cross-sectional layer of the desired sand mold packages 100 adjacent to the first thin cross-sectional layer. These steps are repeated many times until every thin cross-sectional layer of the completed sand mold package 110 (FIG. 7) has been printed. Using this additive manufacturing technique, virtually any shape of a sand mold package can be formed. Further, a sand mold package produced using 3D sandprinting can have internal structural features that cannot otherwise be created by other known subtractive methods.

[0031] As shown in FIG. 3, the exemplified sandprinting process as described above is creating a plurality of sand mold packages 100 which will be used as molds for forming die components. Thus, the printing process described above is capable of printing several different sand mold packages in a single print session for use in casting a variety of unique die components. With the precision and accuracy of the 3D sandprinting technology, anywhere from 80 to 150 sand mold packages can be printed in a single printing process. Thus, as shown in FIG. 6A, a plurality of sand mold packages 100 are shown having been printed with the additive manufacturing process as described above, and unbond sand is removed to reveal the individual sand mold packages, such as sand mold package 110 shown in FIG. 7, used to create a die component in the form of a trim steel 120, as shown in FIG. 8.

[0032] Once the sand mold packages 100 have been printed, they are removed from the job box 40 and then sent to a foundry to be cast. The sand mold packages 100 can be unique molds for casting a variety of die components wherein each sand mold package comprises a negative image of the die component to be cast. As used throughout this disclosure, the term “negative image” or “negative configuration” refers to an image or configuration formed in a mold that imports a reciprocal positive image or configuration in the part cast or otherwise formed from the mold. At the foundry, the sand mold packages, such as sand mold packages 110-114 selected from the plurality of printed sand mold packages 100, are nested into a cope 116 and drag 118 frame apparatus or casting structure, as shown in FIG. 7, where they are backed up with common foundry sand and the die components cast. As shown in the example of FIG. 7, a cope mold 116 is shown having sand mold packages 110-114 nested therein. As further shown in FIG. 7, a drag mold 118 is shown with correlating sand core packages 110-114 also nested therein. During a casting process, an access point (not shown) disposed on the top of the cope mold 116 is used to pour a molten material into the cope and drag molds 116, 118 to fill the sand mold packages 110-114 with the molten casting material. Generally, for producing die components, tool steel is used as the molten material. The tool steel is poured into the access point disposed on the top of the cope mold 116, which will then travel through a series of runners which can extend through the cope mold 116 to the drag mold 118 and then to the sand mold packages 110-114 to fill the sand mold packages 110-114 to capacity. It is further contemplated that the runners can be printed between adjacent sand mold packages to allow communication of molten material from one sand mold package to an adjacent sand mold package. One or more risers (not shown) may be disposed on the top of the cope mold 116 to indicate when the molten material has filled the sand core packages disposed in the cope and drag apparatus. When the molten material solidifies and hardens in the sand mold packages, the cope and drag molds 116, 118 are removed, and the sand core packages 110-114 are broken away or otherwise destroyed to reveal the cast die components. The runner system used to fill the sand mold packages 110-114 during the sand mold casting process are removed from the cast die components, and the cast die components are then scrubbed and cleaned to reveal a precision made and accurately configured die component, which needs little or no finish machining to function in a die assembly. As noted above, the 3D
sandprinting technique as described can also be used to create a die show sand mold package for casting a die shoe 140 (FIG. 9) to which die components can be attached for making a completed die assembly for use in a stamping process.

[0033] The accuracy and precision of the casting of the die components is within a range of accuracy of approximately 1-5 mm, or more preferably plus or minus 0.8 mm. Thus, the cast die components require very little extra machining stock, approximately 1 mm to 1.5 mm to be added. With the reduced amount of stock as compared to standard sand casting methods, which produce approximately 10 mm of extra machining stock, the cast die components of the present invention can be hardened and ground at a mounting base 122, shown in FIG. 8, and then finish machined. This eliminates white light scanning, programming, rough machining, hardening, transportation for hardening, and lapping of the mounting base. Additionally, due to the accuracy of the casting, the machining of cutting surfaces of a die component having a cutting edge may be eliminated altogether.

[0034] The present invention imparts several benefits as compared to the traditional casting process in that there is a significant reduction of time-to-market because the timeline to produce a completed die set can be reduced as much as 10 to 17 days. Another significant benefit is the elimination of design constraints on the die components. Since the sand mold packages are printed using the additive manufacturing technique described above, traditional limitations found in subtractive manufacturing are eliminated, such that complex sand mold packages can be created for casting die components having complex geometries and functionality. Further, due to the accuracy of the casting, some features of the die components, which currently require time consuming post-casting machining, may be left as cast or require little to no finish machining. For example, bore holes 124 and counter bore holes 126, as shown on the trim steel 120 of FIG. 8, can be cast as part of the die component, and require little post-casting machining to develop useable attachment apertures for attaching the trim steel 120 to a die shoe, such as a die shoe 140, shown in FIG. 9. To create attachment features such as the bores 124 and counter bore holes 126, as shown on the trim steel 120 of FIG. 8, the sand mold packages can be printed with negative images of such attachment features. Further, the sand mold packages can be printed with negative images of other features of the die components such as cutting edge 128, shown on the trim steel 120 of FIG. 8. The flexibility of the present invention allows for die components to be created with heat treat depth optimization features. Heat treat depth optimization is currently dependent on the geometry and thickness of the die component. The die components cast using the methods of the present invention can have the complex geometry and thickness required to optimize the heat treat depth. Casting flash, which can be created during a casting process, is also eliminated due to the accuracy of the sand core packages that are printed. Generally, casting flash is produced during traditional sand casting processes, and this casting flash must later be machined off. The methods of the present invention greatly reduce or eliminate altogether the amount of casting flash on a resulting cast die component.

[0035] As described above, Styrofoam® or CNC machining of billets can be used to create pattern parts which are later used to form molds for casting die components. The present invention also relates to using additive manufacturing techniques to create a pattern part which is later used for the creation of a mold for casting a die component. Of the additive manufacturing techniques mentioned above, one preferred process is an additive manufacturing technique using a polymeric powder containing poly(methyl methacrylate) (PMMA) as a base building material to form a polymeric pattern part. As used throughout this disclosure, the additive manufacturing process using the PMMA powder will be referred to as the PMMA process. One of ordinary skill in the art will appreciate that other additive manufacturing techniques can be used to create a pattern part for later use in a casting process.

[0036] As shown in FIG. 10, the PMMA process involves the use of an STL or CAD file to produce 3D design data of a pattern part from a computer 200. The pattern part, such as pattern part 220, shown in FIG. 10, will have a configuration of the die component part to be cast. Using the computer-generated design data, a recoater 202 spreads a thin layer of PMMA powder 204 over a build platform 206. The spreading of the PMMA powder is conceptually similar to the spreading of the fine particulate 50, as noted with reference to FIGS. 1-6. After a layer of PMMA powder 204 has been spread over the build platform 206, a computer-controlled print head jets tiny droplets of solvent or binder to bond the PMMA powder particles to form a cross-sectional layer 208 of the pattern part. Once a cross-sectional layer is complete, the build platform 206 is lowered approximately 0.28 mm and another layer of PMMA powder 204 is spread over the build platform 206. The process is repeated layer by layer 0.28 mm layer until the pattern part is completed. As shown in FIG. 10, the pattern part 220 is essentially buried in unbound PMMA powder 204 when the PMMA process is complete. This unbound PMMA powder 204 is vacuumed or otherwise removed from the pattern part 220 and can be reused in another PMMA process. Once the pattern part 220 is complete, it can be post-cured in a low temperature oven. It is contemplated that a job box, such as job box 40, shown in FIGS. 1-6, can also be implemented in the PMMA forming process to contain unbound PMMA powder. The pattern part 220 can then be impregnated with a wax resin to seal the pattern part 220.

[0037] Once the pattern part is created, it is taken to a foundry for the creation of a shell to be used in an investment casting process. In order to use the pattern part in an investment casting process, the part 220 is submerged or otherwise coated in a ceramic slurries or an investment coating to coat the entire pattern part. The part 220 is then dipped or otherwise introduced into a fluidized bed of sand, ceramic-sand, or other like powder material, which sticks to the liquid ceramic slurry. Once the sand from the fluidized bed of sand has been applied, the liquid ceramic slurry and sand mixture dries and hardens, and the process is then repeated multiple times to form a hard ceramic shell about and around the pattern part. Once a shell of sufficient thickness is formed, the shell containing the pattern part is then heated, such that the polymeric pattern part is removed within the ceramic shell burns away or vaporizes. Thus, after the heating process, the operator is left with a ceramic shell comprising a negative image of the pattern part. Using an investment casting or shell casting process, molten material, such as tool steel, is poured into the ceramic shell having the negative image of the pattern part. After the molten material solidifies, the ceramic shell is broken away or otherwise destroyed to reveal the cast metal part which, in accordance with the present invention, would be a die component, such as die component 120 shown in FIG. 8.

[0038] Using this PMMA process, an accurate and precise pattern part representing a die component can be made layer
by layer, such that complex geometries can be formed within the pattern part to produce a die component cast having a near net-shape of the pattern part. As noted above with the three-dimensional sandprinting process, the PMMA process also reduces the post-casting rough machining and finishing steps that are often required to make a finished die component. Die components cast using the PMMA pattern part as described above can have an near net-shape of the pattern part within an accuracy range of approximately 1-5 mm. Further, it is contemplated that the range of accuracy can be within plus or minus 0.8 mm of the pattern part from which the shell is formed.

[0039] The mold core packages and methods of making tools from the mold core packages, such as, but not limited to, die components, as disclosed herein provide an improved ability create configurations with an optimized wall thickness and heat treat depth as needed, thereby reducing the potential for warpage, cracks, etc. In addition, the accuracy associated with making the mold core packages from the printing process provides for better part quality, precision, and design flexibility. Further, the mold core packages and the die components made from the mold core packages can be designed to improve cycle time, thereby increasing part manufacturing capacity.

[0040] It will be understood by one having ordinary skill in the art that construction of the described invention and other components is not limited to any specific material. Other exemplary embodiments of the invention disclosed herein may be formed from a wide variety of materials and additive manufacturing techniques, unless described otherwise herein.

[0041] It is also important to note that the construction and arrangement of the elements of the invention as shown in the exemplary embodiments is illustrative only. Although only a few embodiments of the present invention have been described in detail in this disclosure, those skilled in the art who review this disclosure will readily appreciate that many modifications are possible (e.g., variations in sizes, dimensions, structures, shapes and proportions of the various elements, values of parameters, mounting arrangements, use of materials, colors, orientations, etc.) without materially departing from the novel teachings and advantages of the subject matter recited. For example, elements shown as integrally formed may be constructed of multiple parts or elements shown as multiple parts may be integrally formed, the operation of the interfaces may be reversed or otherwise varied, the length or width of the structures and/or members or connector or other elements of the system may be varied, the nature or number of adjustment positions provided between the elements may be varied. It should be noted that the elements and/or assemblies of the system may be constructed from any of a wide variety of materials that provide sufficient strength or durability, in any of a wide variety of colors, textures, and combinations. Accordingly, all such modifications are intended to be included within the scope of the present innovations. Other substitutions, modifications, changes, and omissions may be made in the design, operating conditions, and arrangement of the desired embodiment and other exemplary embodiments without departing from the spirit of the present innovations.

[0042] It will be understood that any described processes or steps within described processes may be combined with other disclosed processes or steps to form structures within the scope of the present invention. The exemplary structures and processes disclosed herein are for illustrative purposes and are not to be construed as limiting.

[0043] It is also to be understood that variations and modifications can be made on the aforementioned structure without departing from the concepts of the present invention, and further it is to be understood that such concepts are intended to be covered by the following claims unless these claims by their language expressly state otherwise.

What is claimed is:

1. A method of making a pattern part for use in casting a die component, comprising:
   (a) depositing a thin layer of polymeric powder on a build platform;
   (b) selectively applying a solvent to particular regions of the thin layer of polymeric powder to bind the polymeric powder in said regions to define a cross-section of the pattern part;
   repeating steps (a) and (b) to produce a completed pattern part having a configuration of the die component;
   coating the pattern part with a slurry to form a shell about the pattern part;
   heating the shell to harden the shell and vaporize the pattern part to create a shell comprising a negative image of the pattern part; and
   casting a molten material into the shell to form the die component.

2. The method of claim 1, wherein the step of depositing a thin layer of polymeric powder on a build platform further comprises:
   depositing a layer of polymeric powder comprising poly (methyl methacrylate).

3. The method of claim 2, wherein the step of selectively applying a solvent to particular regions of the thin layer of polymeric powder further comprises:
   jetting droplets of the solvent on the thin layer of polymeric powder using a print head.

4. The method of claim 3, further comprising:
   curing the pattern part.

5. The method of claim 4, further comprising:
   impregnating the pattern part with a wax resin to seal the pattern part.

6. The method of claim 5, wherein the step of coating the pattern part with a slurry to form a shell about the pattern part further comprises:
   coating the pattern part with a ceramic slurry.

7. The method of claim 4, further comprising:
   dipping the pattern part in a fluidized bed of sand after coating the pattern part with the ceramic slurry.

8. The method of claim 1, wherein the step of casting a molten material into the shell to form the die component further comprises:
   forming a die component having a near net-shape of the pattern part within an accuracy range of 1 mm to 5 mm.

9. A method of making a die component, comprising:
   forming a mold core package using an additive manufacturing process, wherein the mold core package comprises a negative image of the die component;
   casting a molten material into the mold core package; and
   cooling the molten material to form the die component having a near net configuration of the mold core package within an accuracy range of 1 mm to 5 mm.

10. The method of claim 9, wherein the set of forming a mold core package using an additive manufacturing process further comprises:
(a) depositing a thin layer of particulate;
(b) selectively applying a binder to the thin layer to define
a cross-section of a mold core package; and
repeating steps (a) and (b) to produce a completed mold
core package.

11. The method of claim 10, wherein the step of selectively
applying a binder to the thin layer to define a cross-section of
a mold core package further comprises:
printing the binder on the thin layer using a three-dimen-
sional sandprinting device.

12. The method of claim 11, the step of cooling the molten
material to form the die component having a near net con-
figuration of the mold core package within an accuracy range
of 1 mm to 5 mm further comprises:
forming a die component having a near net configuration
of the mold core package within 0.8 mm.

13. The method of claim 9, wherein the step of forming a
mold core package using an additive manufacturing process,
wherein the mold core package comprises a negative image of
the die component further comprises:
forming a mold core package having a negative image of
attachment features for attaching the die component to a
die stamping assembly.

14. The method of claim 13, wherein the step of forming a
mold core package having a negative image of attachment
features for attaching the die component to a die stamping
assembly further comprises:
forming a mold core package having a negative image of
bores and counter bores.

15. The method of claim 9, wherein the step of forming a
mold core package using an additive manufacturing process,
wherein the mold core package comprises a negative image of
the die component further comprises:
forming a mold core package having a negative image of a
cutting edge.

16. A method of making a plurality of sand mold packages
for use in casting die components, comprising:

printing a plurality of sand mold packages using an addi-
tive 3D printer wherein the plurality of sand mold pack-
ees comprises one or more die component configurations;
nesting select sand mold packages from the plurality of
sand mold packages into a casting structure having run-
ers in communication with each select sand mold pack-
age;
casting a molten material into the casting structure to fill
each select sand mold package using the runners; and
allowing the molten material to cool to form said die com-
ponents having a near net configuration of each select
sand mold package.

17. The method of claim 16, wherein the step of printing a
plurality of sand mold packages using an additive 3D printer
further comprises:
printing a plurality of sand mold packages in a range of
about 80-150 sand mold packages in a single printing
process.

18. The method of claim 16, wherein the step of printing a
plurality of sand mold packages using an additive 3D printer
further comprises:
printing runners in communication with each sand mold
package of the plurality of sand mold packages.

19. The method of claim 16, wherein the step of casting a
molten material into the casting structure to fill each select
sand mold package further comprises:
casting tool steel into the casting structure.

20. The method of claim 16, wherein the step of nesting
select sand mold packages from the plurality of sand mold
packages into a casting structure having runners in commu-
nication with each select sand mold package further com-
prises:
using a cope and drag assembly to investment cast the
molten material into the sand mold packages.

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