BIT OPTIMIZATION IN CAD SYSTEM

RAPID PROTOTYPING FEMALE MOLD

FILL THE MOLD WITH MOLTEN METALLIC MATERIAL OR WITH MATRIX POWDER AND BINDER

PUT THE MOLD IN A FURNACE TO MELT THE BINDER AND INFILTRATE THE MATRIX POWDER

COOL MATERIAL AND BREAK THE MOLD TO EXPOSE A BIT HAVING THE DESIRED COMPLEX FORM

ABSTRACT
A method for creating a rapid prototype mold for parts of an earth boring tool for manufacture thereof comprises initially optimizing the drill bit design and integrating this design into CAD code. The CAD code is utilized to generate a prototype file in a computer outputting command signals to a laser, and a laser scanner to prototype a mold utilizing stereolithography, selective laser sintering, or laminated object manufacturing, in addition to other prototype techniques to manufacture earth boring tool parts.
**FIG. 3**

- **Step 1:** Optimize drill bit design.
- **Step 2:** Integrate design into CAD code.
- **Step 3:** Generate prototype file.
- **Step 4:** Prototype mold for a drill bit.
- **Step 5:** Manufacture drill bit.

**FIG. 4**

- **Step 1:** Bit optimization in CAD system.
- **Step 2:** Rapid prototyping female mold.
- **Step 3:** Fill the mold with molten metallic material or with matrix powder and binder.
- **Step 4:** Put the mold in a furnace to melt the binder and infiltrate the matrix powder.
- **Step 5:** Cool material and break the mold to expose a bit having the desired complex form.
FIG. 6

108 BIT OPTIMIZATION IN CAD SYSTEM
110 RAPID PROTOTYPED SUPPLE FEMALE MOLD
112 FILL THE MOLD WITH A RESILIENT MATERIAL
114 DRY THE RESILIENT MATERIAL TO PRODUCE A MALE FORMER AND REMOVE IT FROM THE FEMALE SUPPLE MOLD
116 COAT THE FORMER WITH A HARDENABLE AND REFRACTORY MATERIAL AND REMOVE THE FORMER FROM THE RESULTING MOLD
118 FILL THE MOLD WITH MOLLEN MATERIAL OR WITH MATRIX POWDER AND BINDER
120 PUT THE MOLD IN A FURNACE TO MELT THE BINDER AND INFILTRATE THE MATRIX POWDER
122 COOL MATERIAL AND BREAK THE MOLD TO EXPOSE THE DRILL BIT

FIG. 7

68 BIT OPTIMIZATION IN CAD SYSTEM
70 RAPID PROTOTYPING SUPPLE FEMALE MOLD
72 FILL THE MOLD WITH A RESILIENT MATERIAL
74 DRY THE RESILIENT MATERIAL TO PRODUCE A MALE FORMER
76 COAT THE MALE FORMER WITH A MIXTURE OF SAND AND RESIN
78 DRY THE MIXED MATERIAL TO PRODUCE A SHELL BY REMOVING THE MALE FORMER
80 FILL THE SHELL WITH MOLTEN METALLIC MATERIAL OR WITH MATRIX POWDER AND A BINDER
82 PUT THE SHELL IN A FURNACE TO MELT THE BINDER AND INFILTRATE THE MATRIX POWDER
84 COOL MATERIAL AND BREAK THE SHELL TO EXPOSE A BIT HAVING THE DESIRED COMPLEX FORM
METHOD AND FABRICATING TOOLS FOR EARTH BORING

BACKGROUND OF THE INVENTION

[0001] Heretofore, earth boring tools were fabricated by a process that started with a design of parts for the tool and then painstakingly produce a prototype of each part and assemble the parts into the desired tool. All this involved considerable time, effort and expense and oftentimes the process had to be repeated before an acceptable earth boring tool was ready for production.

[0002] A present basic process for manufacturing tools for earth boring, for example a drill bit, is to machine a solid billet of steel into the desired final form of the bit body after the design of the bit has been approved. An improvement in this basic process is to cast the body of the bit into a form approximating the final body form. This permitted a substantial reduction in machining from the basic process and improved the production of tools for earth boring considering both the time factor and the cost factor. The casting process for the fabrication of tools is complicated by the addition of the metal casting step, but the overall savings in time and costs over the basic process are more than offset.

[0003] To fabricate a bit from a casting, a mold is prepared by machining a cavity in a cylinder of graphite, reproducing a negative of the bit profile in the exact dimensions of the body of the bit. Cutting elements are located and the fluid passageways are traced in the interior of the mold. Cutting elements and nozzle openings, plus fluid circulation channels, are prepared from a material destructible after firing of the mold in a furnace. The various elements utilized in producing a mold are subsequently destroyed after the casting process thereby resulting in a bit body having shaped cutting element receptacles in the head of the bit.

[0004] Recently, techniques have been developed for generating three-dimensional objects within a fluid medium which is selectively cured by beams of radiation brought to focus at prescribed intersection points within the three-dimensional volume of the fluid medium. These techniques utilize a process known as "stereolithography" as a method for making solid objects by successfully generating thin layers of a curable material one on top of the other in response to a programmed movable beam of light directed to a surface or layer of the curable liquid. Each layer formed in the curable liquid is a solid cross section of the object at the surface of the curable liquid. The process of generating layers in cross section of an object is continued until the entire object is formed in the curable liquid.

[0005] Use of stereolithography has become known as a "rapid prototyping process." The first industries to utilize the rapid prototyping process were manufacturers of aircraft modular units that specialized in the design and manufacture of interior components for military and commercial aircraft. Major applications now include rapid prototyping and product tooling in the automotive, aerospace, medical, computer, electronic and consumer product industries. A leader in the field of rapid prototyping is 3D Systems Inc. of San Gabriel, Calif. 3D Systems Inc. has numerous U.S. patents directed to various inventions relating to rapid prototyping utilizing stereolithography.


[0007] However, there continues to be a need in the design and production of tools for earth boring that rapidly and reliably moves from a design stage to a prototype stage and ultimately the fabrication of tools while moving directly from computer designs to production and fabrication of finished tools.

[0008] Engineers and production managers in the earth boring industries have long investigated and searched for rapid, reliable, economical and automatic means to facilitate manufacture of tools for earth boring moving from a design stage to the prototype stage and to the production and fabrication, while avoiding the complicated painstaking procedures utilized in the basic machine process and the casting process described above.

SUMMARY OF THE INVENTION

[0009] The present invention is a method of fabricating a tool for earth boring comprising creating a CAD data base of parts for a desired tool. Utilizing the CAD data base, a prototype of molds of the tool parts is fabricated. The mold is then prepared for casting of the tool part, for example, a drill bit body. The prepared mold is filled with a material selected for the drill bit body and the filled mold is then processed into a tool part.

[0010] More specifically, after optimizing the design of the tool parts by operation of a computer program that designs both mechanical and fluid flow specification, the computed results are integrated into a CAD code. A rapid prototyping file is generated and depending on the type of tool part to be manufactured, the file contains either a female geometry of the tool parts. The corresponding mold is then manufactured utilizing a rapid prototyping process such as stereolithography, fretted metal by laser, or strata of paper cut by laser.

[0011] Further, in accordance with the present invention, there is provided a method for fabricating a component of a drill bit for earth boring comprising creating a CAD data base comprising a design of the component of the drill bit and then prototyping a mold of the design of the drill bit component from the created CAD database. The prototype mold is prepared for casting utilizing either a male mold or a female mold, the latter considered a "master-mold." Following preparation of the mold for casting, the mold is filled with a material selected for the drill bit component and the filled mold is fired in a furnace to solidify the selected material into a component of the drill bit. Following preparation of the mold for casting, the mold is filled with a molten material and the selected material is solidified into a component of the drill bit.

[0012] In accordance with the present invention, various tools for earth boring may be fabricated using the rapid prototyping method. Complex forms are easily created by using a computer to generate the program commands as a CAD file that sends the signals to the fabrication system. Although the invention will be described with reference to
fabrication of a drill bit for earth boring, it also finds utility in the fabrication of other tools for earth boring.

A technical advantage of the present invention is the fabrication of earth boring tools using an efficient fabrication process that saves considerable time, effort and expense. The present invention also has the technical advantage of readily modifying a tool design for specialized application that results in improved cutting features. The parts fabricated in accordance with the present invention are readily machined to a final specification for fabrication into a complete tool for earth boring.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention and the advantages thereof, reference is now made to the following description, taken in connection with the accompanying drawings:

FIG. 1 is a top view of a steel body drag bit fabricated in accordance with the process of the present invention;

FIG. 2 is a side view of the drag bit of FIG. 1;

FIG. 3 is a pictorial illustration of a system for performing the process of the present invention;

FIG. 4 is a top level flowchart of the process for manufacturing a drill bit for earth boring utilizing rapid prototyping of a mold for the drill bit body;

FIG. 5 is a flowchart of one embodiment of the process of the present invention for fabrication of a tool bit utilizing rapid prototyping of a female mold;

FIG. 6 is a flowchart of an alternate embodiment of the process of the present invention for manufacturing a drill bit utilizing rapid prototyping of a female mold;

FIG. 7 is a flowchart of an alternate embodiment of the process of the present invention for manufacturing a drill bit utilizing rapid prototyping of a female mold;

FIG. 8 is a pictorial illustration of selective laser sintering for rapid prototyping of molds for drill bit fabrication in accordance with the process of the present invention; and

FIG. 9 is a pictorial illustration of a paper cut by laser process for rapid prototyping a mold for the fabrication of a drill bit body in accordance with the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring to FIGS. 1 and 2, there is shown a drill bit body 10 fabricated in accordance with the rapid prototyping process of the present invention. As illustrated, the bit body 10 includes cavities for fixed cutters and is conventionally referred to in the industry as a drag bit. It should be understood that the process of the present invention is not limited to drag bits but finds utility for other drill bits for earth boring and in addition for the fabrication of other tools for earth boring.

As best illustrated in FIG. 2, the drill bit 10 comprises a bit body 12, a shank 14 and a threaded connection or pin 16 for connecting the drill bit to a sub or as part of a drill string (not shown) in a manner conventional for drilling in formations of the earth.

The bit body 12 includes a central longitudinal bore (not shown) as is conventional with drill bit construction as a passage for drilling fluid to flow through the drill string into the bit body and exit through nozzles (not shown) arranged in the operating end face 20. Extending radially from essentially the center of the operating end face 20 are circumferentially spaced blades 22 that extend down the side of the bit body 12 to the shank 14. The end of the blades 22 at the shank 14 function as gauge pads. The bit body 12 is formed in accordance with the process of the present invention typically utilizing powdered metal tungsten carbide (a matrix bit body) or a molen metal casting process.

As best illustrated in FIG. 1, formed in each of the blades 22 of the bit body 12 is a pattern of pockets 24 that receive primary cutting elements as is conventional in drag bit assembly. The pockets 24 along with the passage for drilling fluid are fabricated during the process of the present invention for fabricating the bit body 12.

Referring to FIG. 3, there is pictorially illustrated a stereolithographic system for generating complex geometry three dimensional drill bit parts by creating a cross-sectional pattern of the drill bit geometry at a surface of a fluid medium capable of physical state alteration in response to appropriate synergistic stimulation. A programmable movable spot beam of light from a laser 30 passing through a laser scanner 32 impinges on a surface or layer of curable liquid in a photopolymer vat 34. The laser scanner 32, the photopolymer vat 34 and a Z-axis elevator 36 along with controlling computers 38, 40 and 42, comprise together a stereolithography system for creating complex geometry drill bit parts. The stereolithography system of FIG. 3 represents a technique to quickly make complex geometry drill bit parts without conventional tooling.

To create the complex drill bit parts, a computer program is run in the computer 42 to optimize a bit design including both mechanical components and fluid passageways. This design is integrated into a computer aided design (CAD) code in a computer 40. A rapid prototyping file is generated from the CAD code in a computer 40. Depending on the type of bit to be manufactured, the rapid prototyping file contains either the female or the male geometry of the drill bit parts. The computer 38 then provides drive signals to the laser 30, the laser scanner 32, and the Z-axis elevator 36.

The stereolithographic system of FIG. 3 has many advantages over currently used apparatus for producing complex geometry drill bit parts. The system as illustrated in FIG. 3 minimizes the need for producing design layouts and drawings and tooling drawings and tooling. A drill bit engineer works directly with the computer 42 and the stereolithographic equipment of FIG. 3 and when satisfied with the design of a drill bit part as displayed on the monitor of the computer 42, a mold for the part is fabricated in the photopolymer vat 34 for an immediate analysis and examination. If the design requires modification, such modification is easily accomplished through the computer 42 and another mold for a prototyping part is fabricated to verify the change in a desired drill bit design. Inasmuch as earth boring tools require many parts with interacting functions, the method of rapid prototyping as described herein becomes even more useful because all of the part designs may be quickly changed and made again so that the total assembly
may be examined, repeatedly if necessary. After the design is complete, part production begins immediately, weeks and months between design and production are avoided.

[0031] As mentioned, depending on the type of bit to be manufactured, the rapid prototyping file in the computer 38 contains either a female or a male mold geometry of the drill bit parts. If the rapid prototyping file contains a female mold design, this female mold as created in the photopolymer vat 34 is subsequently utilized to manufacture a male former or used directly to manufacture the bit. In the case of the direct use of the female mold, the female former is filled and cured in a furnace for a matrix body bit or the female former is filled with a molten metal material in the case of a steel body bit.

[0032] If the rapid prototyping file contains a male mold design, the rapid prototyping male mold from the photopolymer vat 34 is mounted on a burnable pattern and the mold along with the burnable pattern is covered with a slurry of hardenable, refractory material. The coated pattern is placed in a dryer to harden the refractory material to form a ceramic shell and simultaneously burn out the burnable pattern and the rapid prototype female mold. The resulting female former, preferably of a ceramic material, is either placed in a supporting bed and filled with a molten metallic material, or a matrix powder with a binder. For a matrix body bit, the filled female former is cured in a furnace to create the desired drill bit part. For a steel body bit, the ceramic mold is filled with a molten steel to create the desired drill bit part. After the molten metal has cooled to solidification, the ceramic male former is broken away to expose the drill bit part having the desired complex form.

[0033] Also by way of example, the rapid prototyping female mold from the photo multiplier vat 34 is filled with a molten metallic material or with a matrix powder and a binder. For a matrix body bit, the filled female mold is cured in a furnace to create the desired drill bit part. For a steel body bit, the female mold is filled with a molten steel to create the desired drill bit part. In either application, either the matrix body bit or the steel body bit, after the material has solidified the female mold is broken away to expose the drill bit part having the desired complex form.

[0034] Alternatively, when the rapid prototyping file contains a design for a female mold, the mold created is utilized to manufacture a male former called a “master-mold.” This master-mold is then utilized to manufacture a destructible sand shell. The sand shell is filled with the desired matrix and binder material and placed in a furnace for hardening. For a steel body bit, the shell is filled with a molten metal and allowed to harden.

[0035] Referring to FIG. 4, there is illustrated a flow diagram of the process for manufacturing a drill bit utilizing the rapid prototyping of a mold as illustrated and described with reference to FIG. 3. Initially, by use of the computer 42, a designer optimizes the drill bit design in a design operation 44. The optimized drill bit design from operation 44 is integrated into CAD code in the computer 40 by operation 46. The CAD code is then utilized to generate a prototype file in the computer 38 in operation 48. Output signals from the computer 38 utilizing the prototype file actuate the laser 30, the laser scanner 32 and the Z-axis elevator 36 to rapid prototype a mold for a drill bit part in operation 50. When the rapid prototyping mold from operation 50 meets the design specification for a drill bit, the mold is used in a conventional process to manufacture the drill bit part during operation 52. The various parts of a drill bit are then assembled into a fabricated drill bit of the type illustrated in FIGS. 1 and 2.

[0036] Referring to FIG. 5, there is illustrated a flow chart of the process for creating a female mold from the rapid prototyping system as illustrated in FIG. 3. As discussed with reference to FIG. 4, initially the drill bit design is optimized in a CAD system during operation 54. Utilizing the rapid prototyping file in the computer 38, a rapid prototyping female mold is created in the polymer vat 34 during operation 56. Utilizing the female mold during an operation 62, the rapid prototyping mold is filled with a molten metallic material for a steel bit body or with matrix powder and binder. For a matrix mold and binder bit body, the filled female mold is placed in a furnace during operation 64 to melt the binder and infiltrate the matrix powder. Following operation 64 for a matrix bit or following operation 62 for a steel body bit, the material is cooled in an operation 66 and the rapid prototyping female mold is broken away to expose the drill bit part having the desired complex design.

[0037] Referring to FIG. 6, there is illustrated a flow diagram for fabricating drill bit parts utilizing the rapid prototyping of a female mold. As previously explained, initially the drill bit design is optimized in a CAD system during operation 108. Utilizing the stereolithography system of FIG. 3 a supple female mold is rapid prototyped during operation 110. It should be noted that other rapid prototyping processes can also be used such as selective laser sintering (SLS), fused deposition modeling (FDM), laminated object manufacturing (LOM), ballistic particle manufacturing (BPM), and 3D printing.

[0038] After removing the rapid prototype mold from the photopolymer vat 34, the mold is filled with a resilient material in an operation 112 to produce a male former. The resilient material in the female mold is dried during an operation 114 to produce a male former. During an operation 116, the male former is coated with a hardenable and refractory material in an operation 116 and the male former is removed leaving a resulting shell mold.

[0039] The shell resulting from the operation 116 is filled with a molten metallic material or with a matrix powder and binder in an operation 118. For the matrix powder and binder, the filled shell is placed in a furnace to melt the binder and infiltrate the matrix powder during an operation 120. For a steel body bit and for the matrix body bit, the last operation to fabricate a drill bit part is completed in an operation 122.

[0040] Referring to FIG. 7, there is illustrated a flow diagram for fabricating drill bit part utilizing the rapid prototyping of a female mold. Again, initially the drill bit design is optimized in a CAD system during operation 68. Utilizing the stereolithography system of FIG. 3, the female mold is rapid prototyped during operation 70. After removing the rapid prototype mold from the photopolymer vat 34, the mold is filled with a resilient material to produce a male pattern (master-mold) of the bit design during operation 72. The resilient material in the female mold is dried during an operation 74 to produce the master male former. During an operation 76 the male former is coated with a mix of sand
and resin during operation 76. The mix of sand and resin is dried in an operation 78 to produce a shell by removing the rapid prototyping mold.

[0041] Following the operation 78, the process for manufacturing drill bit parts using a female mold is the same as illustrated and described with reference to FIG. 5 utilizing the described mold. The shell produced by the operation 78 is filled with a metallic material (a steel body bit) or with matrix powder and a binder in an operation 80. For the matrix powder and binder (a matrix body bit), the filled shell is placed in a furnace to melt the binder and infiltrate the matrix powder during an operation 82. For a steel body bit and, for the matrix body bit, the last operation to fabricate a drill bit part is completed in operation 84.

[0042] It will be appreciated that other forms of appropriate synergistic stimulation for a curable medium are available in addition to the stereolithography system of FIG. 3. Referring to FIG. 8, there is pictorially illustrated a process for selective laser sintering (SLS) to create a rapid prototype mold for parts of a drill bit. The drill bit design for use with the process of FIG. 8 is optimized by the computers 38, 40 and 42 as illustrated in FIG. 3 and described with reference to FIG. 4. The output of the computer 38 actuates a CO2 laser 86, a laser scanner 88 and a precision roller mechanism 90. A layer of powder 92, for example, a resin (polystyrene polycarbonates), a metallic or a ceramic, is deposited in a powder bed 94. The powder is supplied from a powder cartridge (not shown) typically contained within the housing 96. The powder can be selected from other ceramic materials, such as, alumina, zircon oxides (Al₂O₃, SiO₂, ZrO₂), carbides (SiC, B₄C and others), nitrous (Si₃N₄, AlN, BN), or gains of these materials coated with a binder.

[0043] The precision roller mechanism 90, comprising a linearly extending feedhead is horizontally moved across and above the powder bed to spread a thin layer of powdered selective laser sintering (SLS) material across the build platform. Using data from the computer 38 the CO2 laser 86 in conjunction with the laser scanner 88 selectively draws a cross section of the drill bit part on the layer of powder in the powder bed 94. As the laser beam is drawn across the section, it selectively “sinters” (heats and fuses) the powder creating a solid mass that represents one cross section of the drill bit mold part. Only the heated grains of the powder participate in the development of the cross section with the grains of powder surrounding the part acting to support the following layers of the part being created by rapid prototyping.

[0044] The process for creating a rapid prototype part utilizing the selective laser sintering (SLS) system of FIG. 8 repeats the process of spreading the powder by means of a precision roller mechanism 90 and sintering layer after layer of the powder 92 until the complete object is created. Once the part is completed, it is removed from the build chamber of the housing 96 and any loose powder is blown away. The rapid prototype mold created by the system of FIG. 8 is then utilized to manufacture drill bit parts the same as the molds created by the system of FIG. 3. Either a female mold or a male mold will be created and drill bit parts fabricated in accordance with the description of FIGS. 4, 5, 6, and 7. The selective laser sintering (SLS) process represents a remarkable evolution in the rapid prototyping of three-dimensional objects.

[0045] Another process for creating a rapid prototyping mold for drill bit parts is a paper cut by laser process. Referring to FIG. 9, there is pictorially illustrated a laminated object manufacturing (LOM) process for the formation of three dimensional objects. A laser 100 and a laser scanner 102 receive command signals from the computer 38 as illustrated in FIG. 3. The process of FIG. 9 utilizes the rapid prototyping file resident in the computer 38 resulting from optimizing a drill bit design by means of the computer 42 and the computer 40 of FIG. 3.

[0046] In accordance with the laminated object manufacturing (LOM) process, the system of FIG. 9 deposits layers of “thermal-adhesive” paper on a platen support 104 and these pieces of paper are cut by the light beam emitting from the laser 100 in a pattern as determined by positioning of the X-Y laser scanner 102. Each layer of paper deposited on the platen 104 forms a cross section of the three-dimensional object created by the laminated object manufacturing (LOM) process. Upon completion of cutting of one layer of paper, an additional layer is placed on the platen 104 from a supply roll 106. This process of cutting the deposited layer of paper by means of the laser 100 as controlled by the X-Y laser scanner 102 continues until a compact block of paper is supported on the platen 104. As illustrated in FIG. 9, a three-dimensional object, e.g., a mold for a drill bit part, is in the center of the compact block of paper on the platen 104. It is therefore necessary to clear the cutting surrounding the object to reveal the mold for manufacture of drill bit parts.

[0047] The resulting mold from operation of the system of FIG. 9 is either a female mold or a male mold as previously described. These molds are utilized in accordance with the processes of FIGS. 4, 5, 6 and 7 to fabricate drill bit parts in accordance with an optimized design. For a more complete description of the laminated object manufacturing (LOM) process, reference is made to U.S. Pat. No. 4,752,352, issued Jun. 21, 1998, and U.S. Pat. No. 5,015,312 issued May 14, 1991, and PCT publication WO 95/18009 published Jul. 6, 1995.

[0048] It will be understood from the foregoing that, although particular embodiments of the invention have been illustrated and described, various modifications can be made without the departing from the invention as set forth in the appended claims.

What is claimed is:

1. A method for fabricating components of an earth boring tool, comprising:
   (a) creating a CAD database comprising a design of a component of the tool;
   (b) prototyping a mold of the design of the tool component from the created CAD database;
   (c) preparing the mold for casting the tool component; and
   (d) filling the prepared mold with a material selected for the tool component.

2. A method of fabricating a component of an earth boring tool as set forth in claim 1 further comprising:
   repeating (a) through (d) for each component of a tool.

3. The method of fabricating a component of an earth boring tool as set forth in claim 1 further comprising firing the filled mold in a furnace to solidify the selected material of the tool component.
4. The method of fabricating a component of an earth boring tool as set forth in claim 1 wherein filling the prepared mold comprises filling the prepared mold with a molten metal.

5. The method of fabricating a component of an earth boring tool as set forth in claim 1 wherein filling the prepared mold comprises filling the mold with a nonmetallic material.

6. The method of fabricating a component of an earth boring tool as set forth in claim 1 wherein filling the prepared mold comprises filling the mold with a matrix powder with a binder.

7. A method of fabricating a component of an earth boring tool, comprising:
   (a) optimizing a design of a tool component by operation of a computer program;
   (b) integrating the optimized design of the tool component into a CAD database;
   (c) prototyping a mold of the design of the tool component from the integrated CAD database;
   (d) preparing the mold for casting the tool component; and
   (e) filling the prepared mold with a material selected for the tool component.

8. The method of fabricating a component of an earth boring tool as set forth in claim 7 further comprising repeating (a) through (e) for each component of an earth boring tool.

9. The method of fabricating a component of an earth boring tool as set forth in claim 7 wherein optimizing the design comprises optimizing both the mechanical and hydraulic design of a tool component.

10. The method of fabricating a component of an earth boring tool as set forth in claim 7 further comprising firing the filled mold in a furnace to solidify the selected material of the drill bit component.

11. The method of fabricating a component of an earth boring tool as set forth in claim 10 further comprising breaking away the prepared mold to recover the molded tool component.

12. The method of fabricating a component of an earth boring tool as set forth in claim 7 wherein prototyping a mold comprises prototyping the mold by stereolithography.

13. The method of fabricating a component of an earth boring tool as set forth in claim 7 wherein prototyping a mold comprises prototyping by selective laser sintering.

14. The method of fabricating a component of an earth boring tool as set forth in claim 7 wherein prototyping a mold comprises prototyping by laminated object manufacturing.

15. The method of fabricating a component of an earth boring tool as set forth in claim 7 wherein prototyping a mold comprises prototyping by fused deposition modeling.

16. A method for creating a mold for components of a drill bit for fabrication thereof, comprising:
   optimizing the design of a component of a drill bit by operation of a computer program;
   integrating the optimized design of the drill bit component into a CAD database; and
   prototyping a mold of the drill bit component to be fabricated in accordance with the optimized design.

17. The method for creating a mold of components of a drill bit as set forth in claim 16 wherein prototyping a mold comprises prototyping a male mold of the drill bit component.

18. The method for creating a mold for components of a drill bit as set forth in claim 16 further comprising covering the prototyped mold supported on a burnable pattern with a slurry of a hardenable refractory material.

19. The method for creating a mold for components of a drill bit as set forth in claim 16 further comprising hardening the refractory material to form a shell.

20. The method for creating a mold for components of a drill bit as set forth in claim 16 further comprising burning out the burnable pattern and the prototype mold leaving the shell.

21. The method for creating a mold for components of a drill bit as set forth in claim 20 further comprising filling the shell with a material selected for the drill bit component.

22. The method for creating a mold for components of a drill bit as set forth in claim 21 further comprising breaking away the shell to release the molded drill bit component.

23. The method for creating a mold for components of a drill bit as set forth in claim 21 wherein prototyping a mold comprises prototyping a female mold of a drill bit component.

24. The method for creating a mold for components of a drill bit as set forth in claim 22 further comprising creating a male master mold from the prototyped female mold.

25. The method for creating a mold for components of a drill bit as set forth in claim 24 further comprising creating a destructible female mold from the male master mold.

26. The method for creating a mold for components of a drill bit as set forth in claim 25 further comprising filling the destructible female mold with a material selected for the drill bit component.

27. A method for fabricating a component of a drill bit for earth boring, comprising:
   optimizing the design of a drill bit component by operation of a computer program;
   integrating the optimized design into a CAD database comprising a design of the component of the drill bit;
   generating a prototype file on the drill bit comprising the CAD database;
   prototyping a mold of the drill bit component from the prototype file;
   preparing the mold for casting the drill bit component; and
   filling the prepared mold with a material selected for the drill bit component.

28. The method of fabricating a component of a drill bit as set forth in claim 27 wherein prototyping a mold comprises prototyping a male mold of the drill bit components.

29. The method of fabricating a component of a drill bit as set forth in claim 27 further comprising covering the mold supported on a burnable pattern with a slurry of hardenable refractory material.

30. The method of fabricating a component of a drill bit as set forth in claim 29 further comprising hardening the refractory material to form a shell.
31. The method of fabricating a component of a drill bit as set forth in claim 30 further comprising burning out the burnable pattern and the prototype mold leaving the shell.

32. The method of fabricating a component of a drill bit as set forth in claim 31 wherein filling the prepared mold comprises filling the shell with a material selected for the drill bit component.

33. The method of fabricating a component of a drill bit as set forth in claim 32 wherein filling the prepared mold further comprises breaking away the shell to uncover the molded bit body component.

34. The method of fabricating a component of a drill bit as set forth in claim 27 wherein prototyping a mold comprises prototyping a female mold of the drill bit component.

35. The method of fabricating a component of a drill bit as set forth in claim 34 further comprising creating a male master mold from the prototype female mold.

36. The method of fabricating a component of a drill bit as set forth in claim 35 further comprising creating a destructible female mold from the male master mold.

37. The method of fabricating a component of a drill bit as set forth in claim 36 wherein filling the prepared mold comprises filling the destructible female mold with a material selected for the drill bit component.

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