GOLF CLUB HEADS COMPRISING PATTERNED MATERIALS AND METHODS FOR MAKING CLUB HEADS COMPRISING PATTERNED MATERIALS

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ABSTRACT

Methods and systems for selecting and fabricating individualized golf clubs or golf club components. Using a website, for example, a golfer can input relevant information about his or her golf game, receive recommendations for golf club components, select from the recommendations, and have the desired golf club components manufactured and delivered. In some embodiments, the golf club components include custom golf club heads fabricated using laser cutting to produce a plurality of flat structures from which a portion of a club head is constructed.
GOLF CLUB HEADS COMPRISING PATTERNED MATERIALS AND METHODS FOR MAKING CLUB HEADS COMPRISING PATTERNED MATERIALS

RELATED APPLICATION

[0001] This application claims priority to U.S. Provisional Application No. 61/760,995, filed Feb. 5, 2013, which is incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

[0002] The present invention relates to methods of making golf club components, especially club heads, by cutting a pattern of materials from a stock (e.g., wood, plastic, metal) and then assembling the pattern to create a three dimensional structure. The invention also provides methods and systems for selecting golf clubs and golf club components that can be constructed with the disclosed methods of making golf clubs.

BACKGROUND

[0003] Golf clubs are formed through a variety of methods. Commonly, a golf club head is forged or cast, and then machined or ground and polished to the requisite dimensions and desired aesthetic quality. The head is coupled with a golf club shaft, typically constructed from graphite (composite) or steel. Most shafts are a tapered cylindrical tube cut to a standard length with a grip on one end and an interface for the club head on the other. In order to reduce manufacturing costs to meet user price points, manufacturers use a limited number of molds to produce most of their club heads. The molds are not readily adjustable with respect to the particular characteristics of the golf club, or the player that will use them.

[0004] This manufacturing process presents a problem due to the fact that not all golfers are built the same, and not all golfers have identical swings. Because of variations in golf swings, body size, and frequency of play, many golfers would benefit from an optimization of lie angle, loft angle, club shape, club size, club weight distribution, or other club design parameters. However, altering the manufacturing process to produce individualized clubs can dramatically increase the price of the clubs, so most golfers simply settle for “off the shelf” clubs. Additionally, obtaining individualized golf clubs can involve meeting with a fitter or other professional who is aware of the club options, and can help the golfer match their needs with particular components. Using a fitter further increases the costs, and professional fitters are not available in all geographic areas.

[0005] Many of the traditional manufacturing processes are also environmentally taxing in addition to producing products that are difficult to custom fit. For example, casting, forging, and etching require great amounts of energy and toxic chemicals. They also produce unwanted by-products in the way of tailings, soot, and greenhouse gasses. Additionally, most golf club manufacturers produce the golf club heads in Asia to take advantage of reduced labor costs. However, because most of the consumers of golf club heads are in Europe and North America, the golf club heads have to be shipped by sea (or otherwise) resulting in an increased transportation footprint. Manufacturing methods that reduce waste and greenhouse gasses while providing improved customizability are likely to be adopted by consumers.

SUMMARY

[0006] As such, there remains a need for methods of selling and manufacturing golf clubs that allow individualized design variations while maintaining efficiency, cost effectiveness and produce less waste.

[0007] The invention makes selecting and obtaining individualized golf club components easier while reducing the fabrication costs and using recyclable or renewable materials. Using the methods and systems of the invention, a golfer can use an interface, e.g., a web browser, to enter information about his or her golf game and body type, whereupon options are presented that are likely to improve his or her game. After the golfer has selected among the options, instructions are sent to cause the golf club components to be fabricated, e.g., with a laser cutting process. The completed personalized golf club head, e.g., clubs, are then delivered to the golfer, or the golfer obtains them from a retailer who will verify the fit of the club head. Thus, the invention allows a larger population of golfers to benefit from individualized golf club components, increasing their enjoyment of the game.

[0008] The invention generally discloses methods for making a golf club head comprising a plurality of flat structures that are interconnected to form a portion of a back of the golf club head. Typically, the flat structures are cut from a stock material such as wood, metal, composite, laminate, rubber, plastic, cardboard or a combination thereof. In an embodiment, the flat structures are assembled to form a cage structure that is a back portion of driver-type club head. Such a driver-type club head may also include a cover comprising wood, fabric, composite, or plastic. In another embodiment, the flat structures are sandwiched together to form a structure of an iron-type club head or a putter-type club head. Such structures may be substantially solid, or such structures may comprise a void or a cut out.

[0009] In one instance, the invention includes a method for producing a golf club component comprising selecting receiving golf club component selections, providing material for the golf club component and forming the golf club component layer by layer from the material. Typically, information is received from a user; the information is compared to a database correlating the information and golf club component options; and golf club component options are output to the user. The user may then select from among the options, resulting in the formation of the desired golf club head.

[0010] The invention includes a method of providing a customized golf club component by receiving a user’s selection of an option and storing the selection in a tangible, non-transitory memory. A digital file with the information about a golf club component including the selected options is created by a computer processor coupled to the memory. The information is transferred to a production facility and a customized golf club component including the selected options is produced. Methods of the invention may additionally include collecting and transferring information to a production facility in addition to billing and shipping data for use in completing delivery of the desired components.

[0011] In some embodiments, the user is an individual golfer, i.e., a golf club user. The golfer may interact with systems of the invention to choose a golf club head or a portion of a golf club head of his or her liking, or golf club heads that have been recommended based upon information provided by the golfer. Such information may include, but
need not be limited to, height, weight, sex, handedness, age, geographic location, golf score handicap, and frequency of play.

[0012] In some embodiments, the user may be a designer rather than an individual golfer. The designer may select from a wide range of parameters to customize a golf club head. For example, the designer may select any of the following parameters: weight, weight distribution, bounce angle, lie angle, offset, loft angle, shape, hardness, sole camber, sole width, cavity undercut, center of gravity, face height, hosel outer diameter, hosel inner diameter, hosel taper, hosel depth, toe height, groove width, groove depth, and groove shape.

[0013] According to certain aspects of the invention, golf club heads can be fabricated using process whereby a stock material is cut into a plurality of flat structures that are assembled to form a portion of a golf club head. Such processes provide nearly limitless variability in shape and size, and allow fabrication of structures that are not achievable with conventional machining, e.g., voids. The flat structures are typically constructed from a stock material such as wood, metal, composite, laminate, rubber, plastic, cardboard or a combination thereof. In some embodiments, the portion of the club head is a cage structure that forms a portion of the back of a driver-type club head. The cage structure may be covered with a covering and may include weights to change the center of mass of the club head. The voids may include internal structure such as cells or honeycombs. The voids may also include high-density materials that allow the center of mass of the club head to be advantageously positioned. In some instances the methods of the invention can be used in combination with other custom manufacturing processes, such as metal sintering using powdered metals. Powdered metals suitable for use in the invention include, but are not limited to steel, stainless steel, iron, copper, bronze, aluminum, tungsten, titanium, titanium alloy, chromium-cobalt alloy, and combinations thereof.

[0014] The invention additionally includes systems for selecting and fabricating golf club heads and portions of golf club heads. Systems of the invention include a processor and a computer-readable storage medium containing instructions which, when executed by the processor, cause the system to receive information from a user, compare the information to a database correlating information and options for a portion of a golf club head, output options for a portion of a golf club head to the user, receive selections regarding a portion of a golf club head, and output fabrication instructions for a portion of a golf club head. The system may further comprise fabrication equipment that receives fabrication instructions for a portion of a golf club head and cuts a stock material to create a plurality of flat structures that are used to assemble the desired portion of a golf club head.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Further features and advantages of the invention can be ascertained from the following detailed description that is provided in connection with the drawings described below:

[0016] FIG. 1 illustrates laser cutting a composite material to create spars for a cage structure of a back of a driver-type golf club head.

[0017] FIG. 2 is an illustration of a sheet of stock material that has been cut to create a plurality of flat structures that will be used to form a portion of the back of a driver-type club head;

[0018] FIG. 3 depicts the construction of a cage structure from the flat structures shown in FIG. 2 and attachment of the cage structure to a portion of a golf club head;

[0019] FIG. 4 depicts a finished driver-type golf club head comprising a cage structure assembled from a plurality of flat structures. The cage structure is shown covered with a fabric covering, however the cover is not limited to fabric;

[0020] FIG. 5 depicts an iron-type club head fabricated with a plurality of flat structures using the disclosed methods of the invention.

[0021] FIG. 6 depicts a putter-type club head fabricated with a plurality of flat structures using the disclosed methods of the invention.

[0022] FIG. 7 is a flow chart describing a system of the invention;

[0023] FIG. 8 is a block diagram of a system for providing a customized club head or golf club;

[0024] FIG. 9 shows a display for receiving option selections;

[0025] FIG. 10 is a block diagram of a method for providing a customized club head or golf club according to certain embodiments.

DETAILED DESCRIPTION

[0026] The invention is directed to golf club heads comprising a plurality of flat structures that are interconnected to form a portion of the club head. In preferred embodiments, the flat structures are cut from a stock material such as wood, metal, composite, laminate, rubber, plastic, cardboard or a combination thereof. Once cut, the flat structures are assembled to form portions of a club head with desired shape and weight characteristics. For example, the structure can be a cage structure forming a portion of a back of driver-type (e.g., wood, driver, fairway wood, hybrid) club head, or the structure can comprise sandwiched flat structures that form a portion of the back of an iron-type (e.g., iron or wedge) club head, or a putter-type club head.

[0027] The present invention is directed to methods and systems for selecting and fabricating individualized golf club heads. Using an interface, such as a website or smart phone application, a user can input information about his or her preferences, golf game, and/or body, whereupon options are presented that are likely to improve his or her game. After the golfer has selected among the options, instructions are sent to cause the golf club components to be fabricated. The clubs may be fabricated from commercially-available components, or the clubs may be specially-fabricated using techniques such as machine tools and metal sintering. Using the methods and systems of the invention, the costs of selecting and fabricating personalized clubs is reduced, allowing a larger population of golfers to benefit from individualized golf club components.

[0028] The golf club heads, methods, and systems of the invention result in golf club heads that are easier to customize and result in a smaller environmental footprint. For example, using precision cutting and assembly processes allow fabrication processes that are typically completed overseas to be distributed closer to a customer base, therefore reducing the distance that the product must be shipped. Also the golf club head, methods, and systems of the invention can make use of recycled and renewable materials, while using less overall material, thereby lessening the amount of greenhouse gas that is produced in the preparation of, e.g., steel ingot for forged club heads. For example, the golf club heads, methods, and
systems of the invention may use recycled aluminum, steel, plastic or even cardboard to create the desired structures. The golf club heads, methods, and systems of the invention may also use renewable resources, such as bamboo and fast growth wood such as fir.

[0029] While most golfers play with “stock” clubs purchased from a sporting goods store or pro shop, there can be substantial benefits from playing a set of custom-fit clubs. Among other benefits, custom-fit clubs provide a golfer with a proper lie angle. The lie angle of a golf club is the angle formed between the shaft axis and the ground line of the club when the club is soled in its proper playing position (address position). Typically, a taller golfer benefits from an increase in lie angle that allows the golfer to comfortably address the ball properly. In a similar fashion, a short golfer benefits from a reduction in lie angle. Accordingly, each golfer can use a natural swinging motion while maintaining a proper address when the club strikes the ball.

[0030] Methods of the invention additionally allow a user to vary the loft angle of a club head to his or her preference. The loft angle is a measurement, in degrees, of the angle at which the face of the club lies relative to a vertical plane. Using a club with a high loft angle will typically result in a golf shot with a high initial trajectory, and typically shorter distance. In contrast, utilizing a club with a low loft angle will typically result in a golf shot with a low initial trajectory and longer distance. Typically, loft angles vary from small to large across a set of irons. For example, one set of irons may have loft angles of 22°, 25°, 28°, 31°, 34°, 37°, and 41° for 3, 4, 5, 6, 7, 8, and 9 irons respectively. However, a golfer’s game may benefit from other loft angles, or a different spacing of loft angles.

[0031] In order to provide properly fit clubs, portions of the club, especially the shaft and club head are specifically selected for the individual golfer. A custom-constructed set of clubs may be crafted from raw materials or modified from stock pieces. As expected, club sets that are hand-crafted from raw materials are very expensive and take a long time to produce. Thus, manufacturers typically rely on post-manufacturing methods for custom fitting golf clubs, the majority of which involve placing the club head in a vice and bending the metal until the desired specifications are met. Often, this type of adjustment will affect parameters that are not meant to be adjusted, such as bounce. Of course, multiple modifications or improper bends may result in fatigue of the metal or weakening of the club head.

[0032] The invention makes use of known techniques for pattern cutting in flat stock material, such as cutting with programmable laser cutting machines. Laser cutting can be achieved with a variety of lasers, including gas and solid state lasers. During the laser cutting of the work piece, i.e., a metal work piece, a laser beam is focused onto the work piece which is to be cut. Often, a cutting gas is simultaneously blown onto the cutting location by means of a nozzle. The cutting gas is intended to protect the nozzle of the cutting installation and the focusing lens contained therein from damaging the surrounding material during the cutting process. The cutting gas also assists with flushing the material, e.g., slag out of the cutting kerf. In many cases, the cutting gas used is oxygen or an oxygen-containing gas mixture. The chemical reaction of the oxygen with the cut material (for example steel) produces additional heat which assists the cutting process. The invention is not limited to laser cutting, however, as other techniques, such as saw, knife, or stamp cutting can be used to produce a plurality of flat structures that will be used form the desired structures.

[0033] The techniques of the invention will also make use of cutting algorithms, e.g., contained in computer software, to calculate an optimum pattern to cut in the stock material in order to minimize the waste produced. Such systems can, for example, calculate how to interleaf the flat structures, e.g., as shown in FIG. 2.

[0034] Additional processes may be used in combination with cutting stock material to produce a plurality of flat structures. Metal sintering and related processes offer an alternative to off-the-shelf club heads. Powdered metal sintering systems involve a bed of metal powder that is sintered or melted layer by layer by a laser or electron beam to create metal parts. After the part has been created, the surrounding powder can be brushed away or shaken out of the part. In addition, a variety of metal powders can be melted in these systems. Metal sintering processes typically require the input of 3-D CAD files and filling a dispenser with the desired powdered starting materials. A control program converts the CAD files into instructions for controlling the layer by layer formation of the metal parts. The layer by layer formation is accomplished by laser sintering a first layer of approximately 20 to 40 micron powder onto a steel platform. The platform then lowers by approximately 20 to 80 microns, a fresh layer of powder is swept over the previously sintered layer, and the next layer is sintered or added on top of the previously built one. The additive process is repeated until the desired part is complete.

[0035] Direct Metal Laser Sintering (DMLS), for example, is a method for manufacturing custom metal parts. DMLS uses a computer-guided laser to sinter layers of powdered metal to create the desired objects. DMLS is an "additive" technology that sinters very fine powders layer by layer from the bottom up until the product is completed. A number of commercially available systems are suitable for use in the present invention. For example, the “MCP Realizer”, a selective laser melting system, available from Mining and Chemical Products Limited of Germany, can create parts from any number of metals including the following powders: zinc, bronze, stainless steel, titanium, chromium-cobalt, silicon carbide, and aluminum oxide. Additionally EOS of Germany provides systems that rely on direct metal laser sintering (DMLS). ARCAM of Sweden produces machines that rely on electron beam melting (EBM) technology.

[0036] While slightly different in execution, metal deposition systems can also be used to make custom golf club components, especially golf club heads. Metal deposition systems use a 3D printing process to create metal parts in a similar manner to how ink is deposited from print heads on an inkjet printer. Multiple heads can be incorporated into these systems to increase the production speed. Metal deposition systems are currently available from FCDHBC AB of Sweden and ProMetal, LLC of Troy, Mich. This process may be used to create a solid part with uniform or non-uniform material properties or to add layers of powdered metal to an existing substrate. For example, a metal deposition device may be employed to coat a portion of a surface of a golf club head with a material that has a high density in order to alter the center of gravity or design specification of the golf club head.

[0037] There are several advantages to the disclosed fabrication methods. For example, it is easy to adjust batch size
and batch configuration, or mix different quantities of parts depending on the demand for particular parts without significantly affecting production cost. Additionally, different portions of a club head can be formed from different stock materials to achieve the desired strength, weight, stiffness, and sound. This is in contrast to traditional methods of manufacturing in which parts are created from specialty tools that are expensive to make. Furthermore, the volume flexibility realized with on-demand manufacturing diminishes the need to accurately forecast the quantity of each part that will be manufactured. Additionally, there is little production downtime since tool changes are not needed.

The disclosed methods, e.g., fabrication of flat structures that are sandwiched into new structures, allow voids, undercuts, or internal channels or structures in pieces that would be impossible or difficult to do with machine tools. In some instances, the voids are filled with a high density material, such as tungsten, nickel, copper, iron, gold, platinum, lead, silver, molybdenum, silver, or uranium.

Design and testing of golf club components is also reduced using the disclosed methods. A functional prototype of a new golf club head, for example, can be directly created from CAD models, thus eliminating the need for prototype tooling. Thus, modifications to a prototype can be immediately tested for performance, durability and appearance. The development and production times of the final product are also shortened by eliminating or reducing the need for other intermediate manufacturing processes. For example, laser cutting followed by assembly eliminates the time for creating tools, wax preparation, creating ceramic shells, pouring metal into shells, breaking shells, cutting parts off of casting trees, and grinding off parting lines and weld heads. Further, the process is capable of implementing changes in design without the need to alter or manufacture a new tool or mold. For example, a change in the design of a club head manufactured by a casting process requires the precise modification of the mold or the production of an entirely new mold. This is a time-consuming and expensive process. By contrast, the laser cutting process merely requires changes to be made to the CAD file, and the process will manufacture the club head based on the modified CAD file. Therefore, changes can be easily implemented by the designer without the need for a halt in production or the construction of new tools or molds.

Materials

Various materials can be used for the fabrication of a plurality of flat structures interconnected to form a portion of a golf club head. In particular, wood, metal, composite, laminate, rubber, plastic, cardboard or combinations thereof are suitable. Wood may include balsa, bamboo, pine, fir, oak, teak, birch, ash, and maple, among others. Metal may include aluminum, iron, tungsten, titanium, chromium, and alloys thereof, among others. Composites may include carbon fiber, glass fiber, and woven fiber composites including various types of pre-impregnated materials, including composites pre-impregnated with high density materials such as tungsten. Rubber may be natural or synthetic rubber. Plastics may include polyvinyl chloride, polyethylene, styrenes (including ABS), urethanes, polyamides, and polyimides, among others. All the materials may be recycled or virgin. Some of the same materials, in addition to other materials, can be used for coverings of disclosed structures. In particular, woods, fabrics, composites, and plastics are suitable for use in the fabrication of a cover. The fabric may be a natural fabric, such as cotton, wool, hemp, or silk, or a synthetic fabric such as polyester, nylon, acrylic, rayon, acetate, spandex, Mylar, or Kevlar. Other materials may also be introduced into the structure to control weight, sound, and performance, such as cork.

Stock materials, including any of the above, can be custom cut to prepare desired club head portions. An exemplary process is shown in FIG. 1, where a laser cutting machine is shown cutting a sheet of composite material to form a series of spars that will be used to form a cage structure for a driver-type club head. The cutting process typically utilizes a pattern such as shown in FIG. 2, which defines what is to be cut from various locations in the stock materials. As shown in FIG. 2, the amount of waste that is produced by the process can be minimized by interleaving various parts to maximize the number of parts cut per sheet of stock material. In some instances, the waste can be recycled to make new stock material.

Club Design

The methods of the invention can be used to create a wide variety of club head shapes and properties. For example, using the patterned material shown in FIG. 2, a cage structure can be assembled that is attached to a metal portion of a club head to create a driver-type club head. As shown in FIG. 3, the cage portion is partially assembled from the plurality of flat structures that are curved in at least one dimension. The flat structures can be held together with a variety of fasteners, such as screws, staples, rivets, clips or wire wraps, or the structures can be welded or brazed together, or the structures can be bonded with epoxy or glue. In some embodiments, the entire assembled structure can be coated with, or impregnated with, an epoxy to give the structure rigidity. The structure may also be assembled using a variety of the above-recited fastening methods.

Once the secondary structure is completed, e.g., the cage structure shown in FIG. 3, the structure can be joined with other portions of the club head. As shown in FIG. 3, the cage structure is joined to a portion of the club head including a hosel and providing an interface for additional components such as the face and sole. The cage structure can be joined to other portions of the head (or other portions of a club, such as a shaft) using fasteners, welding, glue, or epoxy, as discussed above.

Once the cages structure has been assembled and joined with other portions of a club head, the structure may be covered with a covering, e.g., a fabric or other covering discussed above. This concept is depicted in FIG. 4, where a completed club head is shown attached to a shaft and addressing a ball. The covering may be translucent, as shown, or transparent, or opaque. The covering may be affixed to the exterior of the cage structure permanently, or the cover may be removable. A removable cover will allow easy access to the interior of the club head, allowing a user to, for example, place or move weights to change the center of mass of the club head.

The club design process includes selecting a set of design parameters to match specifications of a specific golfer, providing a material, and cutting the material to produce a plurality of flat structures that will be assembled into a portion of a golf club head. Typically, the designer inputs a design from a CAD file or a CAD file is output in response to information received from a user (see below). However, in some embodiments, the system may include a library of existing CAD files or a parametric CAD file that can be modified by inputting a set of new design parameters. A parametric CAD file includes a basic shape of the club head, and a
designer/user selects from a list of parameters to customize the club accordingly. The parameters may include, but are not limited to: density, weight distribution, bounce angle, lie angle, offset, loft angle, hardness, sole camber, sole width, cavity undercut, center of gravity, face height, hosel outer diameter, hosel inner diameter/taper, hosel depth, toe height, groove width, groove depth, and groove shape, or combinations thereof.

[0048] Referring to FIG. 5, a club head 10 of the present invention has a typical iron type club head shape that includes hosel 12, sole 15, heel 14, and toe 16. A ball striking face 18 optionally has a plurality of parallel, horizontally disposed grooves formed in the surface of the face 18. A lie angle 20 is defined by the center line (CL) of hosel 12 and the horizontal plane (OP) on which the club rests when addressing the ball. The lie angle, in conventional club manufacturing processes, is set when the clubs are forged or cast, and in general, the factory set lie angle is suitable for some golfers, but not all. In forged and cast clubs, the hosel must be bent relative to the remainder of the club head to change the lie angle to suit a particular golfer. In the present invention, the lie angle is one of the parameters that can be customized for each club head of each set to suit the specifications of an individual golfer. Similarly, the bounce angle is defined by the leading edge of the club head, the sole of the club, and the ground. That is, the bounce angle is an indication of how much the sole of the head lifts the leading edge when the club strikes the ground. This angle can also be adjusted by custom fitting steps, in the prior art, after forging or casting. In the present invention, the bounce angle is another parameter that can be customized for an individual golfer without subsequent processing steps, such as bending, grinding or otherwise working the metal which comprises the club head.

[0049] A particularly useful aspect of the disclosed method is the ability to control the density of various portions of the club head. Varying the density of certain portions of the club head allows the designer to distribute mass throughout the club head in order to control characteristics of the club head such as the center of gravity and moment of inertia. Density control may be accomplished in a variety of ways.

[0050] In one embodiment, the process uses at least two different stock materials to form the club head. Regions of higher and lower density material, or regions of different materials, can be used to change the center of gravity of the club head, or otherwise redistribute weight in a manner intended to improve playability of the clubs. The high and low density portions may be distributed in a variety of ways to achieve a desired specification. For example, a material with a high density may be used in one or more “heavy” portions, and a material with a low density may be used in one or more “light” portions. The heavy portions may be formed from a material with a density greater than about 1 g/cm³. According to one aspect of the invention, the heavy portions may be formed from a material with a density greater than about 3 g/cm³. In one embodiment, the heavy portions may be formed from a material with a density greater than about 7 g/cm³. In one embodiment, the heavy portions are formed from a material with a density greater than about 20 g/cm³. In another embodiment, the heavy portion is composed of a material with a density that is greater than about 10 g/cm³, e.g., about 18 g/cm³. In addition, the heavy portion may have a density that is greater than the light portion(s) by at least about 1 g/cm³. In another embodiment, the heavy portion has a density that is greater than the light portion by about 3 g/cm³. The heavy portion has a density that is greater than the light portion by about 5 g/cm³. Alternatively, the material of the heavy portion may have a density that is greater than the material of the light portion by about 10 g/cm³.

[0051] In another embodiment, the density of various portions of the club head is controlled by varying the porosity of flat structures. Porosity is a measure of the void spaces in a material, and is measured as a fraction, between 0-1, or as a percentage between 0%-100%. For example, by cutting additional holes, grooves, notches, etc., it is possible to control the density, in terms of porosity, of the flat structures used in the process.

[0052] Another method of increasing porosity is to program the process to leave pockets or voids where no material is placed on the substrate. In some embodiments, a hollow club head may be created using the disclosed methods. Portions of the club head may be made according to the process described above, and subsequently the portions are joined by a welding process. For example, a front portion may include the face and the sole, and a back portion may be welded to the front portion in a manner that creates a hollow area between the front and back portion. Club heads having hollow portions may also have weights added to the hollow portion to change the mass distribution of the club.

[0053] In one embodiment, voids or spaces are formed by programming a process as outlined above. The voids may be interconnected throughout the club head. In other embodiments, one or more of the voids of spaces are filled with a lightweight polymer or other low density material. Alternatively, the interior of the club head may comprise a skeleton or frame made with a high porosity. A low density material may then be injected to fill the areas in and around the frame. The low density material may have a density that is less than about 1.3 g/cm³. In one embodiment, the low density material is an expanding foam that fills the voids and provides vibration dampening.

[0054] In one embodiment, a first amount of material is used for the formation of layers for a first portion of the golf club head, and a second amount of material may be used for the formation of layers for a second portion of the golf club head. The first amount of material is less densely packed than the second amount of material, resulting in a club head with a first portion that is more porous than the second portion. Therefore, the density of the first portion is less than the density of the second portion. This allows for a lighter overall structure, freeing up weight to optimize performance characteristics of the golf club. In some embodiments the center of mass of the club head can be moved away from the hosel using these design techniques, therefore increasing the moment of inertia. In one embodiment, the first portion may comprise about 1% to about 99% of the entire volume of the club head. The first portion may comprise about 5% to about 95% of the entire volume of the club head. In another embodiment the first portion may comprise at least about 95% of the total club head volume. In another embodiment, the first portion of the club head may comprise greater than about 85% of the total volume of the club head. For example, the first portion may comprise the interior of the club head and the second portion may comprise only the surface of a portion of the club head. In one embodiment the surface of the club head is less than about 0.050 in. thick. Alternatively, the thickness of the club head is less than 0.040 in. thick. In another embodiment, the surface of the club head is about 0.030 in. thick. In addition, the porosity of the first portion may range from about 99% poros-
ity to about 1% porosity. In one embodiment, the porosity of the first portion ranges from about 95% to about 5%. Alternatively, the porosity of the first portion may be greater than 90%. The porosity of the first portion may range from about 20% to about 80%. In another embodiment, a third portion may be formed that has a porosity that is greater than the first porosity, which results in a greater density for the first portion in comparison to the third portion.

[0055] The methods for designing, and fabricating an iron-type golf club head, shown in FIG. 5, may also be used to construct a putter-type golf club head, as shown in FIG. 6. Because of the different physics involved in putting, the structural and weight needs of a putter are quite different from the needs of a driver-type or iron-type club. As depicted in FIG. 6, a putter head can be constructed by sandwiching a plurality of flat structures to create the club head. As shown in FIG. 6, the club head may be completely constructed of sandwiched materials, or only portions of the club head constructed from sandwiched materials. The face may be constructed of metal and portions constructed of wood, plastic, and/or composite. The club head may have only a hole to receive a shaft (as shown in FIG. 6) or the head may include a metal portion connected to a hosel configured to be joined with a shaft. The sandwiched layers may also include materials to change the bounce of feel when striking the club, such as sandwiched flat structure cut from rubber.

[0056] Systems for Selecting and Fabricating Clubs

[0057] The invention additionally includes systems for selecting and fabricating golf club components. Using such systems a user, e.g., a golfer, can design and have fabricated a wide variety of golf equipment ranging from a specially-constructed club head to a full set of clubs with combinations of desired components. In many instances, the system will allow “average” golfers to experience the benefits of professional fitting and custom clubs. That is, such systems can be used to select, fabricate, and deliver individualized golf club components that help the user to improve his or her golf game. In some embodiments, systems of the invention include the fabrication equipment, e.g., laser cutting machine, used to create customized components using a plurality of flat structures. In other embodiments, systems of the invention result in the output of design parameters that are used by a fabricator to produce the desired golf club components.

[0058] A system for selecting golf club components 100 according to an embodiment of the invention is shown in FIG. 7. Beginning at step 120 information is received from a user. A user may be the end user of the golf components, e.g., a golfer, or the user may be a professional fitter or other golf professional. The user may enter any of the below-listed information, as it would be helpful in determining the best golf club component for the user or assuring that the selected golf club components are to the user’s liking and delivered to the user (or a third party) in a timely manner. The information may be selected from: name, address, height, weight, sex, handedness, age, geographic location, golf score handicap, physical limitations, annual income, frequency of play, frequency of airline travel, favorite color, alma mater, current clubs or any combination thereof. A user may input additional information relevant to a selection of golf club components, such as a preference for any of the following: golf club head type, golf club shaft type, golf club shaft length, golf club grip type, golf club loft angle, golf club lie angle, golf club head weight, golf club head volume, golf club head shape, golf club shaft shape, golf club head center of gravity, golf club head face size, golf club head color, golf club shaft color, golf club grip color, golf club insignia, golf club head medallion, number of clubs.

[0059] In advanced embodiments, a user may upload still or moving images of a golf swing, e.g., a video of the user swinging a golf club. The user may provide information about ball trajectories or flight distances. In some embodiments, the ball trajectory information may be provided by an optical, IR, or ultrasonic camera, or from a pressure pad, e.g., information from a golf simulator. In advanced embodiments that receive images or flight data, additional components of the system (not shown) may analyze the images or flight data to produce metrics used in subsequent steps to output club type recommendations.

[0060] At step 125, the information provided by the user is compared to a database 123 relating player information and golf club components. Based upon the comparison step 125, one or more golf clubs, or golf club components, are output to the user at step 127. Steps 125 and 127 are optional, however, as a system 100 of the invention may simply require the user to input information which is received at 120 and then the system proceeds to step 130 where a user club choice is received (described below).

[0061] The database 123 provides club component options based upon information provided by the user. A variety of databases 123 may be used with systems 100 of the invention. For example, the database 123 may be as simple as a look-up table relating shaft length to golfer height. In other instances, the database 123 may correlate different styles of club heads with user information about age and golf score handicap. In advanced embodiments, database 123 may comprise algorithms that suggest particular types of club components based upon combinations of user information. For example, values of height, weight, age, sex, handedness, and handicap may be combined to produce a value for comparison to the database.

[0062] At step 130, user choices of golf clubs or golf club components are received. The choices may be selected from the recommendations output in step 127, or club component choices may be received independently of the recommendations. The user choices may include any of the following: golf club head type, golf club shaft type, golf club shaft length, golf club grip type, golf club loft angle, golf club lie angle, golf club head weight, golf club head size, golf club head volume, golf club head shape, golf club head center of gravity, golf club head face size, golf club head color, golf club shaft color, golf club grip color, golf club insignia, golf club head medallion, number of clubs.

[0063] Additionally, a software interface can allow the user to morph shapes to his/her liking. An algorithm then computes the expected mass properties and advises the user of end results. Also, the algorithm may highlight areas to add material (or volume), and areas to remove material to achieve desired characteristics. Starting templates can be utilized to help quickly shape the club. Virtual construction lines can be used to graphically illustrate dimensional limits, or boundaries for preventing the user from creating non-conforming clubs according to the USGA and/or R&A rules, as well as exceeding traditional design guidelines with respect to head weight. Personalization features can be graphically incorporated and erased. Photorealistic rendering can be utilized to give realistic feedback of the final product.

[0064] A byproduct of such an approach to manufacturing and selling clubs this way is the creation of a historic data-
base. Should the user ever lose her golf club, or damage it beyond repair, an exact replica can be produced for replacement. Additionally, it is easily possible for a friend to order an exact replica if she likes the club.

At step 135, the golf club component selections are compared to a database 133 correlating club components to a parameter database. The parameters may include specific information about golf club components or entire clubs. For example, database 133 may include combinations of stock components (shafts, grips, club heads) that can be assembled to produce a golf club of the user’s choosing. Thus, a user selection of a golf club can be correlated with specific components and instructions needed to construct the club. In some embodiments, the parameters include schematics, for example, computer-aided drafting (CAD) files, that can be used to fabricate, form, or construct clubs or club components. The parameters may include specific materials, tolerances, etc. to accompany the schematics. The parameters may include instructions or computer code for controlling machines used to fabricate clubs or club components, for example laser cutting machines, or computer numerical control (CNC) machines, or metal sintering machines. In preferred embodiments, the design files include specifications for forming a golf club head, e.g., an iron-type golf club head, using a machine that forms the golf club head layer by layer from a material, e.g., a powdered metal.

In some embodiments of the system 100, parameters regarding the golf club or golf club components, e.g., design files are output at step 135. Typically, the parameters will not be output to the user, but rather they will be retained for order fulfillment or sent to a third party, such as a fabricator, manufacturer, or assembler.

In preferred embodiments, the output parameters are sent to a fabricator 150 (dashed box) where the golf club or golf club components will be fabricated. In some embodiments, the fabricator 150 is owned by the owner of the system, i.e., the entity that controls the servers (discussed below) used to perform the recited steps. In other embodiments, the fabricator is independent of the owner of the system, but the actions of the fabricator are controlled by the owner of the system, either by contract or because the fabricator is acting as an agent of the owner of the system. Thus, the system 100 can be seen to include steps 140, 145, and 147 in box 150 even when the fabricator 150 is geographically or legally separate from the owner of the system 100.

At step 140, the fabricator receives parameters of the golf clubs or golf club components that were selected by the user. Using the parameters, the fabricator then fabricates the golf clubs or golf club components at step 145. The fabrication process may include casting, forging, bending, stamping, cutting, milling, polishing, plating, grinding, welding, drilling, gluing, extruding, injecting, or sintering. In preferred embodiments, the fabrication step 145 includes cutting stock material to form a plurality of flat structures, such as described above. Using such a process, a wide variety of club shapes and configurations can be constructed, even shapes that are not attainable using conventional machine tools. For example, using laser cutting, it is possible to form a club head having a void. Laser cutting may be used in combination with other processes, such as metal sintering, cutting, welding, or polishing, etc. Components of clubs that are specialized for the user may be combined with other components that are “off the shelf,” for example, a commercially-available golf club grip.

Once the fabrication process is complete, the club component is provided in step 147. The component may be provided to the user directly, e.g., via direct shipping, or the component may be provided to an assembler who will combine the fabricated component with other fabricated components or other commercially-available components to achieve the user club choice. In some instances, the provided component may be packed, e.g., in a box, and labeled for delivery.

A system of the invention will include at least a processor and a computer readable medium having instructions for the processor to carry out tasks according to methods of the invention. However, in practice, a system of the invention will typically include other components such as graphical interfaces, input/output devices, transitory computer readable media, and a network. Systems of the invention may additionally include fabrication equipment, such as a laser cutting machine. FIG. 8 shows components in an exemplary system for selecting customized golf clubs or golf club components. As shown in FIG. 8, system 200 generally includes one or more computers, communicably coupled via a network 215. Systems and methods of the invention may generally be implemented through the use of one or more computers such as any combination of a provider computer 281, a production computer 261, and a user computer 201 along with, for example, a sales server 241 and a production server 221. A computer generally includes a processor (e.g., 209, 289a, 289b, 249, 229) operably coupled to a memory (e.g., 207, 287a, 267a, 247, 227) and configured to send or receive information via an input-output device (e.g., 205, 285a, 265a, 245, 225).

One of skill in the art will recognize that a processor may be provided by one or more processors including, for example, one or more of a single core or multi-core processors (e.g., AMD Phenom II X2, Intel Core Duo, AMD Phenom II X4, Intel Core i5, Intel Core i7, Extreme Edition 980X, or Intel Xeon E7-2820). In certain embodiments, any of user computer 201, provider computer 281, production computer 261 may be a notebook or desktop computer sold by Apple (Cupertino, Calif.) or a desktop, laptop, or similar PC-compatible computer such as a Dell Latitude E5520 PC laptop available from Dell Inc. (Round Rock, Tex.). Such a computer will typically include a suitable operating system such as, for example, Windows 7, Windows 8, Windows XP, all from Microsoft (Redmond, Wash.), OS X from Apple (Cupertino, Calif.), or Ubuntu Linux from Canonical Group Limited (London, UK). In some embodiments, any of user computer 201, provider computer 281, production computer 261 may be a tablet or smart-phone form factor device and processor 281 can be provided by, for example, an ARM-based system-on-a-chip (SoC) processor such as the 1.2 GHz dual-core Exynos SoC processor from Samsung Electronics, (Samsung Town, Seoul, South Korea).

In some embodiments, either of sales server 241 or production server 221 can be a Hitachi Compute Blade 500 computer device sold by Hitachi Data Systems (Santa Clara, Calif.). Either of processor 249 or processor 229 can be, for example, a ES-2600 processor sold under the trademark Xeon by Intel Corporation (Santa Clara, Calif.).

Input-output devices generally includes one or a combination of monitor, keyboard, mouse, data jack (e.g., Ethernet port, modem jack, HDMI port, mini-HDMI port, USB port), Wi-Fi card, touchscreen (e.g., CRT, LCD, LED,
AMOLED, Super AMOLED), pointing device, track pad, microphone, speaker, light (e.g., LED), or light/image projection device.

[0074] In certain embodiments, a user’s selection of options is received via the user’s use of user computer 201 and the selection is received at sales server 241 and stored in memory 247. Sales server 241 uses a network card for input/output 245 to received data. Sales server 241 maintains order database 243 which may include accounts 244 where user information is stored (e.g., for payment and delivery information).

[0075] After orders are received and ready for production, digital files can be transferred via input/output 245 from sales server 241 to production server 221 via input/output 225, which may also be a network card or other data transfer mechanism. Order information (e.g., orders 239) is stored in production database 235 in memory 227. Processor 229 executes computer program instructions stored in memory 229 to perform order batching and to initiate production.

[0076] A production facility may be equipped with a production computer 261 which either automatically coordinates the operation of machines or provides information to production employees, e.g., via input/output 265a, which could include, for example, a monitor or laser printer. The production computer 261 may also be directly connected to fabrication equipment, such as metal sintering equipment or CNC machine tools.

[0077] Many of the steps and functions described herein can be planned or coordinated by a provider personnel using provider computer 281. For example, engineers or sales personnel can prepare and upload information (e.g., digital files such as in a comma-separated values (CSV) format) that, for example, lists options for features for user selection. That is, in certain embodiments, provider personnel use provider computer 281 to “set up” what options are available, for example, within a display such as the one shown in FIG. 9. Such uploaded information may be saved in memory 247 on sales server 241 and can be used, for example, by processor 249 to cause a display to be rendered such as that shown in FIG. 9 on input/output 205 on user computer 201. Input/output 205 can include a monitor displaying a view of a web browser. A user’s selection of options can be stored in one of accounts 244 in order database 243 by writing a file in memory 247.

[0078] Memory generally refers to one or more storage devices for storing data or carrying information, e.g., semiconductor, magnetic, magneto-optical disks, or optical disks. Information carriers for memory suitable for embodying computer program instructions and data include any suitable form of memory that is tangible, non-transitory, non-volatile, or a combination thereof. In certain embodiments, a device of the invention includes a tangible, non-transitory computer readable medium for memory. Exemplary devices for use as memory include semiconductor memory devices, (e.g., EEPROM, EPROM, solid state drive (SSD), and flash memory devices (e.g., SD, micro SD, SDXC, SDIO, SDHC cards); magnetic disks, (e.g., internal hard disks or removable disks); magneto-optical disks; and optical disks (e.g., CD and DVD disks). Memory may also be external to the device and reside on a server or disk in an alternative location, i.e., “the cloud.” The processor and the memory can be supplemented by, or incorporated in, special purpose logic circuitry.

[0079] The subject matter described herein can be implemented in a computing system that includes a back-end component (e.g., sales server 241 or production server 221), a middleware component (e.g., an application server or sales server 241), or a front-end component (e.g., user computer 201 having a graphical user interface or a web browser through which a user can interact with an implementation of the subject matter described herein), or any combination of such back-end, middleware, and front-end components. The components of the system can be interconnected through network 215 by any form or medium of digital data communication, e.g., a communication network. Examples of communication networks include cell network (e.g., 3G or 4G), a local area network (LAN), and a wide area network (WAN), e.g., the Internet.

[0080] The subject matter described herein can be implemented as one or more computer program products, such as one or more computer programs tangibly embodied in an information carrier (e.g., in a non-transitory computer-readable medium) for execution by, or to control the operation of, data processing apparatus (e.g., a programmable processor, a computer, or multiple computers). A computer program (also known as a program, software, software application, app, macro, or code) can be written in any form of programming language, including compiled or interpreted languages (e.g., C, C++, Perl), and it can be deployed in any form, including as a stand-alone program or as a module, component, subroutine, or other unit suitable for use in a computing environment. Systems and methods of the invention can include instructions written in any suitable programming language known in the art, including, without limitation, C, C++, Perl, Java, ActiveX, HTML5, Python, Ruby on Rails, Visual Basic, or JavaScript. In certain embodiments, systems and methods of the invention are implemented through the use of a mobile app. As used herein, mobile app generally refers to a stand-alone program capable of being installed or run on a smartphone platform such as Android, iOS, Blackberry OS, Windows 8, Windows Mobile, etc. Functionality of the invention can be implemented by a mobile app or a software application or computer program in other formats included scripts, shell scripts, and functional modules created in development environments.

[0081] A computer program does not necessarily correspond to a file. A program can be stored in a portion of a file that holds other programs or data, in a single file dedicated to the program in question, or in multiple coordinated files (e.g., files that store one or more modules, sub-programs, or portions of code). A computer program can be deployed to be executed on one computer or on multiple computers at one site or distributed across multiple sites and interconnected by a communication network.

[0082] A file can be a digital file, for example, stored on a hard drive, SSD, CD, or other tangible, non-transitory medium. A file can be sent from one device to another over network 215 (e.g., as packets being sent between a server and a client, for example, through a Network Interface Card, modem, wireless card, or similar).

[0083] Writing a file according to the invention involves transforming a tangible, non-transitory computer-readable medium, for example, by adding, removing, or rearranging particles (e.g., with a net charge or dipole moment into patterns of magnetization by read/write heads), the patterns then representing new collocations of information about objective physical phenomena desired by, and useful to, the user (e.g., a physical arrangement of particles that indicates that a specific, new club head is to be constructed from a certain set of
multiple components and sent to a user). In some embodiments, writing involves a physical transformation of material in tangible, non-transitory computer readable media (e.g., with certain optical properties so that optical read/write devices can then read the new and useful collocation of information, e.g., burning a CD-ROM). In some embodiments, writing a file includes transforming a physical flash memory apparatus such as NAND flash memory device and storing information by transforming physical elements in an array of memory cells made from floating-gate transistors. Methods of writing a file can be invoked manually or automatically by a program or by a save command from software or a write command from a programming language.

[0084] An embodiment for a user interface for a system of the invention is shown in FIG. 9. The interface may be a website, a smart phone or tablet application. Using the interface, a user can select properties of a customized head that will be fabricated and provided to the user or assembled into a golf club. The interface can include options for multiple features that are available with a club head. The interface can receive selections from a user of various options and then retrieve suitable design parameters for fabricating the customized head. FIG. 9 generally shows an exemplary display as could be shown on a screen, for example, of a computer or smartphone, discussed in more detail below. In certain embodiments, FIG. 9 represents a display rendered in a web browser (e.g., a web page being displayed by Internet Explorer, Safari, or Chrome).

[0085] As shown in FIG. 9, the interface can include elements such as pull-down menus for choosing options. Any method of offering options and receiving selections is included, such as, for example, point-and-click selection, keyboard entry, radio buttons, and confirmation of suggested options. A selection of an option can include selecting a given option from a set of possibilities and it can also include selecting whether or not to include a certain feature at all. For example, a user can be offered whether or not they would like a removable crown panel on their club head and, if they choose so, they can then be offered a list. Options can be offered and selections received for any aspect of a club head including all of those discussed herein. For example, the choices of crown panel materials in FIG. 9 could include clear plastic, translucent plastic, composite, carbon fiber, titanium, aluminum, or other alloys.

[0086] The same or other interfaces will provide the user with a variety of design choices with respect to a number of components (e.g., shaft, grip, head). A plurality of interfaces may be used to design a set of clubs or a single interface can be used to select, e.g., shaft and grip, and then a plurality of nested interfaces or pop-ups can be used to select individual club heads for the set. A user could be offered choices of bodies and body materials. Choices of certain bodies may govern the availability of certain other choices. For example, some bodies may have a forward member for supporting a strike face and a body skirt member upon which a crown panel and sole plate are to be installed. Where a user chooses such a body, they may then be offered a choice of sole plate (e.g., with choice of style, material, color, etc.). Other features a user could choose include overall finish of surface (e.g., anodized, painted, decal set), strike face, removable/interchangeable weight members, reconfigurable shaft, setting indicator window, user-uploaded photo printed on surface (e.g., as uploaded digitally), number of club heads (e.g., user orders entire set or matching clubs/sets for whole families), etc. [0087] As shown in FIG. 9, receiving user options can be done via a series of related screens. For example, a user can choose materials for parts in a first screen, choose optional accessories in another screen, and save their choices and pick colors in another screen. However, in other embodiments, all choices are made on a single screen or a different combination of screens. In certain embodiments, choices are offered based upon input information such as height, weight, and age (discussed above). In certain embodiments, choices are suggested based on inferences made according to computer program rules about a user's likely preference. For example, if a user orders a shaft in a given color (e.g., orange), a club head can be shown and suggested with a given matching or complementary color (e.g., orange main material with blue contrast finish details, or all green panels).

[0088] Given the variety of options a user may choose and the variety of numbers a user may order, the invention provides methods of receiving and preparing customized orders. FIG. 10 gives a high-level block diagram of steps of a method of providing a customized club head according to certain embodiments of the invention. A method of providing a customized club head according to certain embodiments of the invention can include receiving a user's choice of a product (e.g., product line driver club head) and showing the user a product example (e.g., FIG. 9). A user's selections of an option are received and saved in a memory. If the selection reflects a change from what was previously shown, the displayed product view can be updated to show what the user has chosen. This can be repeated for as many features as are customizable or as many features as the user chooses to select options for.

[0089] If the user ends up not placing an order, they can be returned to browsing (e.g., shown a web page home screen or another product screen). Their choices can be saved and displayed to them at a later web page visit.

[0090] If the user places an order, methods of the invention include capturing information from the user about how they will pay for the product and how they will receive it. For example, a user can provide a credit card number over a computer network (e.g., by typing into a payment web page), and then choose direct shipping and provide their home address. Or, alternatively, a user can indicate that they will use a corporate account (e.g., they are purchasing a dozen club heads that are printed with a corporate logo for which they have uploaded an image file such as a TIFF) and they can specify delivery to some site. A user can also choose in-store pickup. In certain embodiments, a method of providing a customized club head is operable in conjunction with a special event, and methods include capturing delivery information about providing the club heads at the special event.

[0091] After delivery information is captured, it is determined whether the ordered item is already in stock, as ordered. If it is, the ordered item is shipped or prepared for delivery according to the user's delivery information. If the ordered item is not in stock, the order is batched. After order batching, order information (e.g., info regarding batches, production schedules, and individual orders of club heads) is transmitted to a production system or facility, and the ordered club heads are produced. After production, the club heads are sent. If a user has ordered a club to be shipped to their home, the club is sent to the user. If a user has requested in-store pickup, the club is sent to the store. If a user has requested another delivery option, it is so initiated. The produced club
heads may be shipped to another facility where they are assembled into clubs, or the club heads may be assembled into clubs on site.

[0092] The invention described and claimed herein is not to be limited in scope by the specific embodiments herein disclosed, since these embodiments are intended as illustrations of several aspects of the invention. Any equivalent embodiments are intended to be within the scope of this invention. Indeed, various modifications of the invention in addition to those shown and described herein will become apparent to those skilled in the art from the foregoing description. Such modifications are also intended to fall within the scope of the appended claims. All patents and patent applications cited in the foregoing text are expressly incorporated herein by reference in their entirety.

[0093] Although these inventions have been disclosed in the context of certain preferred embodiments and examples, it will be understood by those skilled in the art that the present inventions extend beyond the specifically disclosed embodiments to other alternative embodiments and/or uses of the inventions and obvious modifications and equivalents thereof. In addition, while several variations of the inventions have been shown and described in detail, other modifications, which are within the scope of these inventions, will be readily apparent to those of skill in the art based upon this disclosure.

It is also contemplated that various combinations or sub-combinations of the specific features and aspects of the embodiments can be made and still fall within the scope of the inventions. It should be understood that various features and aspects of the disclosed embodiments can be combined with or substituted for one another in order to form varying modes of the disclosed inventions. Thus, it is intended that the scope of at least some of the present inventions herein disclosed should not be limited by the particular disclosed embodiments described above.

[0094] Any patent or publication mentioned herein is hereby incorporated by reference in entirety for all purposes.

1. A golf club head comprising a hosel attached to a body: the hosel being configured to receive a shaft; and the body comprising a sole, a face, and a back, the back comprising a plurality of flat structures interconnected to form a portion of the back.

2. The golf club head of claim 1, wherein the flat structures comprise wood, metal, composite, laminate, rubber, plastic, cardboard or a combination thereof.

3. The golf club head of claim 1, wherein the face comprises a metal.

4. The golf club head of claim 1, wherein the sole comprises a metal.

5. The golf club head of claim 1, wherein the body comprises a metal portion connecting to the hosel.

6. The golf club head of claim 5, wherein the metal portion is constructed from sintered metal.

7. The golf club head of claim 5, wherein the golf club head is a driver-type golf club head.

8. The golf club head of claim 7, wherein the portion of the back is connected to the metal portion and comprises a plurality of flat structures that are curved in at least one dimension and assembled to create a cage structure.

9. The golf club head of claim 8, further comprising a cover attached to an exterior surface of the cage structure.

10. The golf club head of claim 9, wherein the cover comprises wood, fabric, composite, or plastic.

11. The golf club head of claim 9, wherein the cover is removable.

12. The golf club head of claim 8, wherein the cage structure additionally comprises a weight comprising a high density material selected from tungsten, nickel, copper, iron, gold, platinum, lead, silver, molybdenum, silver, and uranium.

13. The golf club head of claim 8, wherein the plurality of flat structures are held together with fasteners, welding, epoxy, or glue.

14. The golf club head of claim 3, wherein the golf club head is an iron-type golf club head or a putter-type golf club head.

15. The golf club head of claim 14, wherein the back portion comprises a plurality of flat structures that are sandwiched together to form a structure.

16. The golf club head of claim 15, wherein the structure is substantially solid.

17. The golf club head of claim 15, wherein the structure comprises a void or a cut-out.

18. The golf club head of claim 17, wherein the structure comprises a void, and the void is filled with a high-density material selected from tungsten, nickel, copper, iron, gold, platinum, lead, silver, molybdenum, silver, and uranium.

19. The golf club head of claim 1, wherein the flat structures are cut from a sheet of material.

20. The golf club head of claim 1, wherein the plurality of flat structures are held together with fasteners, welding, epoxy, or glue.