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## COATED DRIVER AND METHOD OF FORMING

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### Abstract

A driver for coupling a driving device and a driven device includes a core defining a plurality of corner chamfers and a casing formed on and encasing the core. The casing has a contoured perimeter surface and a variable casing thickness, and is compressible during an interference fit installation to a coupling socket to provide a non-lubricated coupling which has zero backlash and substantially no running noise. The core is made of a metal-based material and includes a shaft bore for receiving an input shaft. In an illustrative example, the driver core is made of a stainless steel core and the casing is made of a high wear thermoset urethane material. The metal core can be recycled from the coated driver by removal of the polymeric casing, then recoated with a new casing to form a new coated driver including the recycled metal core.

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## Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION [0001] This application claims a priority to U.S. patent application Ser. No. 17/508,088 filed Oct. 22, 2021, and U.S. Provisional Patent Application No. 63/261,703 filed on Sep. 27, 2021, all of which are hereby incorporated by reference in their entirety.

### TECHNICAL FIELD

[0002] The present disclosure pertains to a driver for coupling a driving device to a driven device, and specifically, to a coated driver and method for forming a coated driver.

### BACKGROUND

[0003] Drive coupling systems are used to couple a driving device such as a motor, to a driven device such as a timing screw, gear box, or other rotating device. A known configuration of drive coupling system includes a metal driver which includes a shaft bore to receive an input shaft of the driving device, and a socket coupling including a socket cavity to receive the metal driver. The socket coupling is operatively connected to the driven device, such that when the driver is inserted into the socket cavity and rotated by the driving device, rotational force is transmitted through a drive interface defined by a perimeter surface of the driver (drive surface) and a socket surface forming the socket cavity (coupling surface) to drive rotation of the driven device.

[0004] In a known configuration, a metal driver having a rounded square perimeter surface is coupled with a metal socket cavity having a square or rounded square coupling surface. The perimeter surface of the metal driver is sized to the coupling surface of the socket cavity to provide clearance for insertion of the metal driver into the socket, which at a minimum has a greater than zero clearance to provide a slip fit clearance between the driver perimeter surface and the socket coupling surface. A lubricant or grease can be applied to the perimeter surface of the metal driver and/or in the metal socket cavity, to decrease wear between the components and/or reduce running noise. At the start of rotation of the driver, the driver rotates until corners of the driver perimeter surface make contact with and engage the coupling surface of the socket, at which time the driver in contact with the socket initiates rotation of the socket coupling and the driven device attached to the socket coupling. Clearance between the metal driver and the socket coupling surface at the start and stop of rotation causes backlash in the system, including, for example, backlash in a timing screw connected to the socket coupling. Further, contact of the driver with the socket during take-up of the clearance generates running noise, such as clicking, during start, stop, indexing, and intermittent motion of the coupling system. During rotation of the coupling system, rotational force is transferred from the driving device to the driven device via the coupling socket primarily by contact of the corners of the metal driver with the socket coupling surface, such that, due to the concentrated loading of the corners and repetitive intermittent contact with the socket coupling surface over time, the corners of the metal driver are subject to wear. Wear at the corners of the metal driver increases the clearance between the driver and socket coupling surface, increases backlash, and increases running noise, necessitating removal and replacement of the worn driver

when the clearance increases to a maximum acceptable level. Over time in use, the lubricant may need to be replaced or replenished, for example, due to breakdown of the lubricant and/or contaminants introduced to and retained by the lubricant in use. Downtime of a coupling system including the metal driver can be incurred for one or more of periodic lubrication (greasing) of the metal driver during use, inspection of the metal driver for wear, measurement of the change in clearance level resulting from driver wear, and/or removal and replacement of the metal driver when worn beyond useful life. Typically, a worn metal driver cannot be reworked, such that the worn metal driver must be disposed of or scrapped. In a system including a timing screw, driver wear and increasing backlash may also affect timing screw performance, for example, due to timing screw acceleration during take-up of the backlash, particularly in applications requiring indexing, stop-start cycling and/or other intermittent operation of the timing screw.

## SUMMARY

[0005] A drive coupling system which includes a coated driver for coupling a driving device such as a motor, to a driven device such as a timing screw, gear box, etc. is described herein, where in an illustrative example the coated driver transmits a rotational force from the driving device through a socket coupling connected to the driven device. The coated driver includes a core member, referred to herein as a core, and a casing which encases and is adhered to the exterior surfaces of the core member. The casing is made of a polymeric material and is formed as a single integral casing which defines a continuous perimeter drive surface of the core member. The perimeter drive surface is contoured as further described herein, and such that the casing has a variable thickness relative to the exterior surfaces of the core. The core, which in an illustrative example is made of a metal-based material, includes a shaft bore to receive an input shaft of the driving device, and a pin bore to receive a coupling pin. In a non-limiting example, the casing of the coated driver has a rounded square perimeter surface including rounded square and convex corner portions, for coupling with a metal socket cavity having a square or rounded square coupling surface. The uninstalled width of the coated driver is slightly larger than the width of the socket cavity, such that, when installed to the coupling socket, the casing is compressed to provide an interference fit between the coated driver and the coupling surface of the socket cavity, the interference fit defining a contact interface between the casing and the socket. The compression of the casing and the resulting interference fit advantageously results in a zero clearance connection between the coated driver and the socket, such that when a rotational force is applied to the coated driver, the coated driver transfers a corner force component of the rotational force to the coupling socket via the casing corner portions, and transfers an interface force component FI of the rotational force to the coupling socket across the contact interface, with zero backlash. Further, because the casing is maintained in contact with the coupling surface of the socket at all times, due to the interference fit, there is no clearance to take-up during starting and stopping of rotation of the driver, such that the coupling does not generate any running noise, providing for quiet or near silent operation during indexing, stop-start cycling and/or other intermittent operation of the driven device, which may be, for example, a timing screw. By distributing transmission of the rotational force between a corner force component FC of the rotational force transmitted through the casing corner portion and an interface force component FI transmitted through the side and pin portions of the casing, point loading of the corner portions is decreased relative to the corner loading imposed on the metal corners of an uncoated metal driver, thus substantially reducing wear at the contact interface between the coated driver and the coupling surface, and extending the useful life of the coated driver.

[0006] The coated driver described herein is advantaged by a relatively longer life as compared with an uncoated metal driver, due to the differences in rotational force transfer between the coated driver and the coupling socket. Because the casing of the coated driver is maintained in contact with the coupling surface over a contact interface of substantially larger area than the corner contact of the uncoated metal driver, the rotational force is distributed across the contoured

perimeter surface of the casing, decreasing wear. Further, as detailed herein, the corner portions of the casing are compressed during the start of rotation, damping the contact force such that the contact force is not directly applied to the metal core member. In the examples described herein, the corners of the metal core are chamfered such that corner contact force transmitted through the corner portion of the casing is distributed across the corner chamfer of the metal core to increase the durability of the coated driver, as compared with the durability of an uncoated metal driver. Over time, wear may occur at the casing corners and in the contact interface extending along the side portions of the casing, such that over time, a slight clearance can develop between the driver casing and the socket coupling surface, such that the coated driver can be slipped from the socket cavity, providing an apparent visual indicator that the coated driver has worn to a point where replacement of the coated driver should be considered. Advantageously, the wear and clearance condition of the coated driver can be determined from the condition of the interference fit, or loss thereof, without having to measure clearance between the driver and the socket coupling surface, as was previously required with a noncoated metal driver, to determine whether the level of wear or clearance had reached a threshold where replacement was required.

[0007] Additionally, the coupling joint formed by the coated driver installed with an interference fit in the socket does not require any lubrication, e.g., the coupling joint is a non-lubricated coupling. Advantageously, this reduces system downtime by eliminating periodic lubrication of the coupling, as would be required for an uncoated metal driver. Further, the absence of lubrication in the coupling eliminates the potential for the lubricant to function as a carrier for collection of dust, debris or other contamination, etc. As further described herein, the coated driver is recyclable, such that the metal core of the coated driver can be reclaimed by removal of the polymeric casing, and the reclaimed metal core recoated with a new casing thus forming a recycled coated driver including the reclaimed core. As such, the coated driver including the reusable metal core provides advantages with respect to sustainable manufacturing and lower lifetime cost, as compared with single use noncoated metal drivers which must be scrapped when worn beyond useful life.

[0008] In an illustrative example, a coated driver is provided, the driver configured for engaging a socket including a cavity defined by a coupling surface, the driver including a core made of a metal-based material and including a plurality of exterior surfaces, and a casing made of a polymer material, the casing encasing the plurality of exterior surfaces of the core. The casing is shaped such that the driver is configured to engage the socket via the casing in contact with the coupling surface. The driver further includes a contoured perimeter drive surface defined by the casing, wherein the driver is configured to engage the socket via the contoured perimeter drive surface in contact with the coupling surface. In one example, the coated driver is characterized by a first driver width when the driver is not engaged with the socket, and a second driver width when the driver is engaged with the socket, where the second driver width is less than the first driver width and the second driver width is defined by compression of the casing in contact with the coupling surface. The core can be made of a stainless steel material, and the casing can be made of a polymer material which is a urethane-based material. In an illustrative example, the urethane-based material is a thermoset urethane of about 65 durometer Shore A hardness to about 65 durometer Shore D hardness. By way of example, the urethane-based material can have a DIN resilience in a range of about 40% to 45% and a cured specific gravity in a range of about 1.1 to 1.2 (g/cm<sup>3</sup>).

[0009] In an illustrative example, the plurality of exterior surfaces defined by the core includes a plurality of corner chamfers, where each of the corner chamfers has an octagonal shape. In an illustrative example, the plurality of exterior surfaces defined by the core includes a plurality of corner chamfers, and the casing includes a plurality of corner portions configured such that each corner portion encases a respective corner chamfer, and where each corner portion of the casing is characterized by a rounded contour in a first plane normal to the corner chamfer and a convex contour in a second plane normal to the corner chamfer, where the second plane is normal to the first plane. In another example, the plurality of exterior surfaces includes a plurality of faces and a

plurality of corner chamfers, where each corner chamfer is intermediate one of the faces and another of the faces, and the casing is adhered to the plurality of faces and the plurality of corner chamfers and is defined by a convex contoured surface relative to the plurality of faces. The driver can include a bore extending through the core and defined by a bore surface, where the casing is configured such that the bore surface is not encased by the casing. The driver can include a bore extending through a face of the core and through the casing, where the casing adjacent the bore is characterized by a concave contour relative to the face of the core.

[0010] A method for engaging a driver to socket is described herein. In an illustrative example, the socket includes a cavity defined by a coupling surface, the method including providing a coated driver as described herein, and inserting the driver into the cavity such that the casing is in contact with the coupling surface, which can include engaging the socket via the contoured perimeter drive surface in contact with the coupling surface. In this example, the casing in contact with the coupling surface defines a contact interface, such that the contact interface is characterized by zero clearance between the casing and the coupling surface. The method can further include applying a rotational force input to the driver and transmitting the rotation force to the socket via the casing, where transmitting the rotation force is characterized by zero backlash. The coated driver engaged to the socket with zero backlash, in the example, is characterized by no running noise generated at the contact interface during transmission of the rotation force, providing a silent or substantially silent operation of the coupling system **100**.

[0011] A method for forming a coated driver is described herein, the method including inserting a core configured as described herein, into a mold defining a casing including a contoured perimeter drive surface, the method further including flowing a polymer-based material into the mold such that the polymer-based material is in contact with the exterior surfaces of the core, curing the polymer-based material, where curing includes forming the casing, the casing encases the plurality of exterior surfaces, and the coated driver includes the core encased by the casing. The method can further include reclaiming a core from a coated driver, and recoating the core with a new casing, such that, as described further herein, the core can be recycled. In this example, the driver is a first driver including a first core encased by a first casing, and the method includes recycling the first core by removing the first casing from the first core, and forming a second driver including the first core and a second casing.

[0012] The above noted and other features and advantages of the present disclosure are readily apparent from the following detailed description when taken in connection with the accompanying drawings.

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## Description

### BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIG. 1 shows a schematic perspective view of a drive system including an exemplary coated driver for coupling a driving device to a driven device;

[0014] FIG. 2 shows a schematic perspective view of the coated driver of FIG. 1;

[0015] FIG. 3 shows a schematic perspective view of the coated driver of FIG. 2, including a core and casing, further showing the core member in phantom;

[0016] FIG. 4 shows a schematic perspective view of the core of the coated driver of FIG. 3;

[0017] FIG. 5 shows a schematic perspective view of the coated driver of FIG. 2;

[0018] FIG. 6 shows a schematic front elevational view of the coated driver of FIG. 2;

[0019] FIG. 7 shows a schematic front elevational view showing the coated driver inserted in an installed position to a coupling of the drive system of FIG. 1;

[0020] FIG. 8 shows a schematic perspective view of exemplary coated drivers;

[0021] FIG. 9 shows a schematic flow chart showing a method for forming the coated drivers;

[0022] FIG. 10 shows a schematic perspective view of the coated driver of FIG. 2 including a contoured perimeter surface;

[0023] FIG. 11 shows a schematic top end view of the coated driver of FIG. 10 showing casing side portions having a convex contour;

[0024] FIG. 12 shows a schematic front elevational view of the coated driver of FIG. 10 showing casing corner portions having a rounded and convex contour;

[0025] FIG. 13 shows a schematic side elevational view of the coated driver of FIG. 10 showing casing pin portions having a concave contour;

[0026] FIG. 14 shows a schematic perspective view of an exemplary core of the coated driver of FIG. 3, the core including a plurality of chamfers;

[0027] FIG. 15 shows a schematic perspective view of another exemplary core of the coated driver of FIG. 3, the core including a plurality of chamfers;

[0028] FIG. 16 shows a schematic top end view of the core of FIG. 15;

[0029] FIG. 17 shows a schematic corner view of the core of FIG. 15;

[0030] FIG. 18 shows a schematic front elevational view of the core of FIG. 15;

[0031] FIG. 19 shows a schematic side elevational view of the core of FIG. 15;

[0032] FIG. 20 shows a schematic front elevational view of the coated driver of FIG. 2;

[0033] FIG. 21 shows a schematic bottom end view E-E of the coated driver of FIG. 20;

[0034] FIG. 22 shows a schematic cross-sectional view of section A-A of FIG. 20;

[0035] FIG. 23 shows a schematic cross-sectional view of section B-B of FIG. 20;

[0036] FIG. 24 shows a schematic cross-sectional view of section C-C of FIG. 20; and

[0037] FIG. 25 shows a schematic cross-sectional view of section D-D of FIG. 21.

#### DETAILED DESCRIPTION

[0038] The present disclosure provides a drive coupling system which includes a coated driver for coupling a driving device such as a motor, to a driven device such as a timing screw, gear box, etc., where in an illustrative example the coated driver transmits a rotational force from the driving device through a socket coupling connected to the driven device. The coated driver includes a core member, referred to herein as a core, and a casing which is formed on and attached to the core member. The casing is made of a polymeric material and is formed as a single integral casing which defines a continuous perimeter drive surface of the core member. The perimeter drive surface is contoured such that the casing has a variable thickness, as further described herein. The core, which in an illustrative example is made of a metal-based material, includes a shaft bore to receive an input shaft of the driving device, and pin bore to receive a coupling pin. In a non-limiting example, the casing of the coated driver has a rounded square perimeter surface including rounded square and convex corner portions, for coupling with a metal socket cavity having a square or rounded square coupling surface. The uninstalled width of the coated driver is slightly larger than the width of the socket cavity, such that, when installed to the coupling socket, the casing is compressed to provide an interference fit between the coated driver and the coupling surface of the socket cavity, the interference fit defining a contact interface between the casing and the socket. The compression of the casing and the resulting interference fit advantageously results in a zero clearance connection between the coated driver and the socket, such that when a rotational force is applied to the coated driver, the coated driver transfers a corner force component of the rotational force to the coupling socket via the casing corner portions, and transfers an interface force component FI of the rotational force to the coupling socket across the contact interface, with zero backlash. Further, because the casing is maintained in contact with the coupling surface of the socket at all times, due to the interference fit, there is no clearance to take-up during starting and stopping of rotation of the driver, such that the coupling does not generate any running noise, providing for quiet or near silent operation during indexing, stop-start cycling and/or other intermittent operation of the driven device, which may be, for example, a timing screw. By distributing transmission of the rotational force between a corner force component FC of the

rotational force transmitted through the casing corner portion and an interface force component FI transmitted through the side and pin portions of the casing, point loading of the corner portions is decreased relative to the corner loading imposed on the metal corners of an uncoated metal driver, thus substantially reducing wear at the contact interface between the coated driver and the coupling surface, and extending the useful life of the coated driver.

[0039] The coated driver described herein is advantaged by a relatively longer life as compared with an uncoated metal driver, due to the differences in rotational force transfer between the coated driver and the coupling socket. Because the casing of the coated driver is maintained in contact with the coupling surface over a contact interface of substantially larger area than the corner contact of the uncoated metal driver, the rotational force is distributed across the contoured perimeter surface of the casing, decreasing wear. Further, as detailed herein, the corner portions of the casing are compressed during the start of rotation, damping the contact force such that the contact force is not directly applied to the metal core member. In the examples described herein, the corners of the metal core are chamfered such that corner contact force transmitted through the corner portion of the casing is distributed across the corner chamfer of the metal core to increase the durability of the coated driver, as compared with the durability of an uncoated metal driver. Over time, wear may occur at the casing corners and in the contact interface extending along the side portions of the casing, such that over time, a slight clearance can develop between the driver casing and the socket coupling surface, such that the coated driver can be slipped from the socket cavity, providing a visual indication that replacement of the coated driver should be considered, without having to measure clearance between the driver and the socket coupling surface, as was previously required with a noncoated metal driver, to determine if replacement was required.

[0040] As further described herein, the coated driver is recyclable, such that the metal core of the coated driver can be reclaimed and recoated, by removing the current casing, and recoating the reclaimed metal core with a new casing thus form a recycled coated driver. As such, the coated driver including the reusable metal core provides an advantage with respect to sustainable manufacturing, as compared with a single use noncoated metal driver which must be scrapped when worn beyond its useful life.

[0041] Referring to the drawings wherein like reference numbers represent like components throughout the several figures, the elements shown in FIGS. 1-25 are not necessarily to scale or proportion. Accordingly, the particular dimensions and applications provided in the drawings presented herein are not to be considered limiting. Referring to FIG. 1, a drive system **100** is shown. The drive system **100** can also be referred to herein as a drive assembly or coupling system. In the illustrative example shown, the drive system **100** includes a driving device **102** and a driven device **104** which are coupled via a coated driver **10**. The coated driver **10** can also be referred to herein as the driver **10**. The driving device **102** includes an output shaft **110** and is actuatable to output a rotation force **22** via the output shaft **110**, by rotating the output shaft **110**. In a non-limiting example, the driving device **102** includes a motor. The drive system **100** includes a driven device **104** including a coupling **112**. In a non-limiting example, the driven device **104** includes a timing screw which is rotated by the rotation force **22** output from the driving device **102** and transferred to the coupling **112** via a coated driver **10** connecting the output shaft **110** to the coupling **112**. In a further example, the timing screw and/or the drive system **100** can be configured for use in container handling applications, including food and drug container processing, where the components of the drive system **100** are configured for compliance with food-grade and/or pharmaceutical processing requirements, including forming the coated driver **10** from materials meeting these requirements. In an illustrative example, the coated driver **10** can include a core **40** made of stainless steel encased in a casing **30** made of a food-grade urethane coating material, such that the coated driver **10** is suitable for use in timing screw and container handling applications requiring compliance with food and drug material handling requirements. In another example, the driven device **104** can be any device actuatable by a rotation force **22**, such as a gearbox, etc.

[0042] In the illustrative example shown in FIG. 1, the coupling **112** is configured as a socket coupling, including a socket **114** defined by an interior surface **116** of the coupling **112**. The interior surface **116** can also be referred to herein as the socket surface or coupling surface **116**. In use, the coupling surface **116** is in contact with a contoured perimeter drive surface **14** (see FIGS. **13** and **21**) of the coated driver **10** via an interference fit of the coated driver **10** to the socket cavity **114**, such that a rotation force **22** transmitted from the output shaft **110** is transmitted through the driver **10** and the socket coupling **112** to the driven device **104**. In the example, the coupling system **100** further includes a coupling pin **106**, also referred to herein as a cross-pin **106**, and a locking pin **108**. In the example shown, the output shaft **110** includes a coupling bore **120** for receiving the cross-pin **106**, and the socket coupling **112** includes a coupling slot **118** for receiving the cross-pin **106**. The coated driver **10** includes a casing **30** and a core **40** (shown in phantom in FIG. **3**). The coated driver **10** further includes a shaft bore **16** defined by a shaft bore surface **48** and configured for receiving the output shaft **110** via a driver face **18**, and a pin bore **12** defined by a pin bore surface **50** and configured for receiving the cross-pin **106**. The casing **30** is made of a polymer-based material and is formed onto the core **40** such that the casing **30** substantially encases the exterior (non-bore) surfaces **42, 44, 46, 52, 54, 56** of the core **40**. The casing **30** defines the contoured perimeter drive surface **14** (see FIGS. **13** and **21**) which is at least partially compressed during installation of the driver **10** to the socket cavity **114**, to provide an interference fit between the driver **10** and the coupling surface **116** of the socket coupling **112**. In the example shown, the cross-pin **106** is inserted through the coupling slot **118**, pin bore **12** and coupling bore **120** to operatively connect and couple the driving device **102** to the driven device **104**. The locking pin is configured to engage an annular groove in the cross-pin **106** to lock the cross-pin **106** in position.

[0043] Throughout the description and figures and for illustrative purposes, a coordinate system comprising a P-axis, S-axis and T-axis is used. As shown in FIG. **1**, the P-axis, which can also be referred to herein as the pin axis, is defined as the axis of the pin bore **12** which is coincident with the longitudinal axis of the cross-pin **106** when the cross-pin **106** is installed to the coated driver **10**. The S-axis, which can also be referred to herein as the shaft axis, is defined as the axis of the shaft bore **16**, and is coincident with the longitudinal axis of the output shaft **110** when the output shaft **110** is positioned in the shaft bore **16**. The T-axis, which can also be referred to herein as the transverse axis, is orthogonal to the P-axis and the S-axis, and intersects the intersection of the P-axis and the S-axis. Throughout the description and figures and for illustrative purposes, the coated driver **10** is configured, in a non-limiting example, as a rounded square driver **10** having a width and height which are substantially equal and indicated in the figures as a driver width DW, and further defining a driver length DL, a driver diagonal dimension DD, and a driver face width DF, as shown in the figures. The driver width DW, as that term is used herein, is the width and height of the casing **30** and the coated driver **10** in the uninstalled condition, e.g., without compression of the casing **30**. The driver length DL, as that term is used herein, is the length of the casing **30** and the coated driver **10**, measured across opposing driver faces **18** (front and rear faces including the shaft bore **16**, as viewed along the S-axis in FIG. **1**). The core **40** is configured, as shown in FIGS. **4** and **14-19**, as a rectangular cuboid including chamfered edges, the core **40** having a width and height which are substantially equal and indicated in the figures as a core width CW, and further defining a core length CL, a core diagonal dimension CD, a core face width CF and chamfer dimensions CC, SS, PS as shown in the figures. The casing **30** encapsulates the exterior (non-bore) surfaces **42, 44, 46, 52, 54, 56** of the core **40** such that  $DW > CW$ ,  $DL > CL$ ,  $DD > CD$  and  $DF > CF$ . The casing **30** is contoured such that a thickness **20** of the casing **30** is variable. As used herein, the thickness **20** of the casing **30** is measured along a line projected normal to the surface of the core **40** at the point where the casing thickness **20**, from the surface of the core **40** to which the casing **30** is adhered to the exterior surface of the casing **30**.

[0044] The coupling socket **112** includes a socket cavity **114** having a rounded square shape, as shown in FIGS. **1** and **7**, the cavity **114** having a width and height which are substantially equal and



indicated in the figures as a socket with SW. Referring to FIG. 7, shown is a coated driver **10** installed in the socket cavity **114**, where, as described previously, the casing **30** is compressed during installation of the driver **10** to the socket cavity **114** to provide an interference fit between the driver **10** and the coupling surface **116** of the socket coupling **112**, such that, in the installed condition, the perimeter drive surface **14** of the driver **10** in contact with the coupling surface **116** of the socket cavity **114** to define one or more areas of contact interface **122** therebetween. The width of the coated driver **10** is compressed in the areas of the contact interface **122** from the uninstalled driver width DW to an installed driver width IW, which is defined by and substantially equal to the socket width SW, such that in the areas of the contact interface **122** there is zero clearance between the coupling surface **116** and compressed perimeter drive surface **14**.

[0045] Referring to FIGS. 2-6, a non-limiting example of a coated driver **10** is shown. The coated driver **10** includes a core **40** which is coated with a polymeric material forming a casing **30** encapsulating the outer surfaces of the core **40**. The casing **30** can be formed from any polymeric material which can be fabricated (molded, cast, potted, etc.) to form a casing **30** including the shape and surface finish characteristics, adhesion properties (for adhesion of the casing **30** to the core **40**), abrasion resistance, wear resistance, hardness, resilience and load bearing properties required by the coated driver **10** in use, as described in further detail herein. In an illustrative example, the casing **30** is formed of a thermoset urethane material configured to provide the adhesion properties, abrasion resistance, wear resistance, resilience and load bearing properties required by the coated driver **10** in use, as described in further detail herein. The thermoset urethane material can be a food-grade urethane. In a non-limiting first example, a casing **30** is formed from a thermoset urethane material including a cross-linker and having a tensile strength of greater than 5000 pounds per square inch (psi), a 100% modulus of greater than 1800 psi, a 300% modulus of greater than 2900 psi, and an elongation of 490%. In one example, the urethane material is characterized by one or more of a DIN resilience in the range of about 40% to 45%, and is a urethane of about 65 durometer Shore A hardness to about 65 durometer Shore D hardness. The hardness and resilience of the casing material can be varied, for example, to obtain certain operating characteristics of the coupling system **100**, and/or based on the configuration of the components of the coupling system **100**. For example, a coated driver **10** can be configured with a casing **30** having relatively higher resilience and/or a relatively lower hardness of in a range of about 65 durometer Shore A to about 90 durometer Shore A to provide a coated driver **10** which exhibits a relatively higher compressibility during installation to the socket **114**, and/or when a relatively more elastic response to rotational loading is desirable. For example, a coated driver **10** can be configured with a casing **30** having relatively lower resilience and/or a relatively higher hardness of in a range of about 85 durometer Shore A to about 65 durometer Shore D to provide a coated driver **10** which exhibits a relatively lower compressibility during installation to the socket **114**, and/or when a relatively less elastic response to rotational loading is desirable. For example, a coated driver **10** can be configured with a casing **30** having a mid-range hardness in a range of about 85 durometer Shore A to about 95 durometer Shore A. In another example, the coated driver **10** has a casing **30** which a hardness of at least 90 durometer Shore A. In one example, the casing **30** has a cured specific gravity in the range of about 1.1 to 1.2 (g/cm<sup>3</sup>).

[0046] As an illustrative example, sample coated drivers **10** including a casing **30** made of a thermoplastic ultra-high-molecular-weight polyethylene (UHMWPE, UHMW) and subject to durability testing produced unsatisfactory results, including loss of adhesion at the casing-core interface. Natural polymers, such as natural rubbers, may not have sufficient strength and/or abrasion resistance for use in the casing **30** described herein.

[0047] The core **40** is made of a material which has sufficient strength, rigidity and wear resistance to transfer the rotation force **22** from the output shaft **110** to the socket coupling **112** via the bore surfaces **48**, **50** through the coated driver **10** as described in further detail herein. In an illustrative example, the core **40** is formed of a metal-based material such as a steel, aluminum or other metal

material. In one example, the core **40** is formed of a stainless steel material, for strength, wear resistance, corrosion resistance and/or for compliance with food and drug industry material handling equipment requirements. In the example shown, the surfaces of the pin bore **12** and the shaft bore **16** are uncoated, such that the metal bore surfaces **48**, **50** are respectively in contact with the metal output shaft **110** and the metal cross-pin **106** as bearing surfaces. The example of a metal based core is non-limiting, and other materials and/or combinations of materials to which the casing **30** can be adhered and which can provide the functional properties of the core **40** are anticipated within the scope of this disclosure, including, for example, a core **40** formed of a high strength wear resistant polymer such as a filled polymer, or a core **40** formed of a combination of materials, for example, a polymer core **40** including metal bearing sleeve(s) forming one or both of the shaft and pin bores **16**, **12**.

[0048] Referring to FIGS. **4** and **14-19**, shown are illustrative examples of an uncoated core **40**, indicated as core **40a** in FIGS. **4** and **14** and as core **40b** in FIGS. **15-19** and referred to collectively herein as a core **40**. The examples shown in the figures are illustrative and non-limiting, and other configurations of the core **40**, for example, including chamfers **52**, **54**, **56** having shapes and/or relative dimensions other than those shown, are anticipated within the scope of this disclosure. Referring to FIGS. **15** and **15**, the core **40** includes a shaft bore **16** defined by a shaft bore surface **48** and configured for receiving the output shaft **110** via a driver face **18**, and a pin bore **12** defined by a pin bore surface **50** and configured for receiving the cross-pin **106**. The shaft bore surface **48** and the pin bore surface **50** can be referred to collectively herein as the bore surfaces **48**, **50** and/or as the interior surfaces **48**, **50** of the core **40** and/or the coated driver **10**. In a non-limiting example, the casing **30** does not extend into the bores **16**, **12**, such that the bore surfaces **48**, **50** are not encased by the polymer casing **30**, and such that, in use, the metal bore surfaces **48**, **50** are in respective contact with the wear resistant metal surfaces of the output shaft **110** and the cross-pin **106**, to function as bearing surfaces **48**, **50**.

[0049] Still referring to FIGS. **14** and **15**, the core **40** includes a plurality of faces **42**, **44**, **46**, **52**, **54**, **56** collectively referred to herein as the exterior surfaces or non-bore surfaces of the core **40**. The core **40** includes opposing (front and rear, as viewed in FIGS. **14** and **15**) shaft faces **42** having a core face width CF (see FIGS. **19**, **22**, **23**). The core **40** includes opposing pin faces **44** (top and bottom, as viewed in FIGS. **15** and **15**), and opposing first and second side faces (left and right, as viewed in FIGS. **15** and **15**). The core **40** further includes a plurality of chamfer faces, which are also referred to as chamfers, including pin-shaft (PS) chamfers **52**, side-shaft (SS) chamfers **54**, and corner (CC) chamfers **56**. The plurality of chamfers **52**, **54**, **56** truncate the edges of the rectangular cuboid shape of the core **40**. Notably, the thickness **20** of the casing **30** in these chamfered areas is relatively thicker as compared to a non-chamfered core having sharp edges adjoining the faces **42**, **44**, **46**, and such that the relatively thicker areas of the casing **30** can function to absorb, dampen and/or distribute the rotational forces **22** imposed on the coated driver **10** during use, to lessen the rotation force **22** transferred via the casing **30** to the core **40**, including the corner forces FC (see FIG. **7**) imposed on the coated driver **10** during start/stop, indexing and intermittent operation of the drive system **100**. The chamfers **52**, **54**, **56** also promote the flow of the coating material across and over the exterior surfaces **42**, **44**, **46**, **52**, **54**, **56** of the core **40** during the coating process forming the casing **30**, for example, in a mold cavity and/or potting device for molding the casing **30** onto the core **40**, in contrast to a core member formed without chamfers **52**, **54**, **56** having sharp (perpendicular or near perpendicular) edges and corners intermediate faces **42**, **44**, **46**, and reduce the potential for loss of adhesion of the casing **30** to the core **40** at the transition between the faces **42**, **44**, **46**, **52**, **54**, **56**, as compare with the potential for loss of adhesion of the casing **30** at a sharp edge or corner under repetitive rotational loading and over time.

[0050] As shown in the figures, each of the pin-shaft (PS) chamfers **52** is intermediate a pin face **44** and a shaft face **42** of the core **42** and is characterized by a chamfer dimension PS (see FIG. **19**). Each of the side-shaft (SS) chamfers **54**, is intermediate a side face **46** and a shaft face **42** of the

core **42** and is characterized by a chamfer dimension SS (see FIG. **16**). Each of the corner (CC) chamfers **56** is intermediate a pin face **44** and a side face **46** of the core **42** and is characterized by a corner chamfer dimension CC (see FIG. **18**). In the example shown in FIG. **14**, each of the chamfers **52**, **54**, **56** has a hexagonal shape, sharing common edges with two adjacent faces and four adjacent chamfers. For example, the corner chamfer **56** has a hexagonal shape and has a common edge with each of a pin face **44**, opposing PS chamfers **52**, opposing SS chamfers **54** and a side face **46**. In the example shown, at least one of the chamfers **52**, **54**, **56** has a different chamfer size PS, SS, CC, as compared to the chamfer size PS, SS, CC of at least one other of the chamfers **52**, **54**, **56**. In the example shown in FIG. **15**, each of the PS and SS chamfers **52**, **54** has a quadrilateral shape, sharing common edges with two adjacent faces and two adjacent corner chamfers **56**. For example, the PS chamfer **52** has a quadrilateral shape and has a common edge with each of a pin face **44**, opposing corner chamfers **56**, and a shaft face **42**. In the example shown in FIG. **15**, each of the corner chamfers **56** has an octagonal shape and has a common edge with each of a pin face **44**, a side face **46**, opposing shaft faces **42**, opposing PS chamfers **52**, and opposing SS chamfers **54**. In the example shown, at least one of the chamfers **52**, **54**, **56** has a different chamfer size PS, SS, CC, as compare with at least one other of the chamfers **52**, **54**, **56**, and in the illustrative example, each of the chamfers **52**, **54**, **56** has a unique size, e.g., the values of PS, SS, CC are different.

[0051] FIGS. **2**, **3**, **5**, **6**, and **10-13** show the casing **30** adhered to and encasing the exterior surfaces the core **40** to form the coated driver **10**. The casing **30** is formed as an integral, e.g., unitary and continuous casing which in a non-limiting example is molded onto the core **40**. The polymeric material, which can be a urethane-type material, such as a high strength and/or thermoset urethane, is introduced in liquid or semi-liquid form or as a resin into a mold containing the core **40**, to encase the exterior surfaces **42**, **44**, **46**, **52**, **54**, **56**, and is cured to form the casing **30** including a contoured perimeter drive surface **14** of the casing **30**. As shown in FIGS. **13** and **21**, the perimeter drive surface **14** extends from a plane including the P-axis and T-axis, along the perimeter of the coated driver **10**, to define area of the casing **30** subject to compression and interference fit during installation of the coated driver **10** into the socket **114**. The indication of the perimeter drive surface **14** in FIGS. **13** and **21** is intended to be illustrative, recognizing that the actual contact interface **122** defined by the compressed coated driver **10** in contact with the coupling surface **116** of the socket **114** may vary from the illustrative boundaries of the perimeter drive surface **14** provided for illustration in FIGS. **13** and **21**, such that the contact interface **122** may be irregular in shape, vary in width, and have areas of non-contact such as in the area of the concave contour **58** defined by the pin face **32**, due to variability in the magnitude of interference fit between the coated driver **10** and the coupling surface **116**, hardness and/or resilience of the casing **30**, and/or axial alignment of the coated driver **10** relative to the socket cavity **114**. In the illustrative example, the casing **30** is molded to finished form, e.g., in use is retained in its as molded condition, and is not reshaped or modified by machining, cutting, or any other secondary operations. As such, the surface finish and/or surface texture of the casing **30** is substantially defined by the surface finish and/or surface texture of the mold in which the coated driver **10** is formed. In a non-limiting example, the surface is molded with a substantially smooth surface finish which is absent any texturing or surface discontinuities, to maximize the contact area of contact interface **122** formed by contact of the casing perimeter surface **14** with the coupling surface **116** of the socket coupling **112** in an installed condition to distribute an interface force component FI of the rotation force transferred via the coated driver **10**, (see FIG. **7**) and to minimize and/or avoid abrasive wear between the casing perimeter surface **14** and the coupling surface **116**, thereby extending the useful life of the coated driver **10**, for example, relative to the useful life of an all metal uncoated driver.

[0052] For purposes of describing the structure and function of the casing **30**, the casing **30** is described herein as including a plurality of portions **32**, **34**, **36** and **38**, recognizing that the casing **30** is integrally formed such that portions **32**, **34**, **36** and **38** are continuous and homogeneous

portions of the integral casing **30**. Referring to FIGS. **5** and **6**, the casing **30** includes opposing pin portions **32** each encasing and adhered to a pin face **44** and adjacent PS chamfers **52** of the core **40**, opposing shaft portions **34** each encasing and adhered to shaft face **42** of the core **40**, opposing side portions **36** each encasing and adhered to a side face **46** and adjacent SS chamfers **54**, and four corner portions **38** each adhered to and encasing a corner chamfer **56**. As seen in the figures, each portion **32**, **34**, **36**, **38** is continuous with another portion **32**, **34**, **36**, **38** such that the surfaces of the core **40** identified as being encased by a particular portion of the casing **30** can be encased primarily by one of the portions **32**, **34**, **36**, **38** and partially by a combination of other of the casing portions **32**, **34**, **36**, **38**, and such that the descriptions of the casing portions **32**, **34**, **36**, **38** are intended for illustrative purposes and are non-limiting.

[0053] Referring to FIGS. **5**, **10-13** and **20-25**, the exterior surface of casing portions **32**, **36** and **38** is contoured, having a convex cross-sectional shape **60** defined by a convex radius of curvature **26** (see FIGS. **11**, **13**) As such, the casing thickness **20** of these portions of the casing **30** is variable, and at a maximum casing thickness **20** within the perimeter drive surface **14**, such that, during installation of the coated driver **10** to the socket cavity **114**, the casing **30** contacts the coupling surface **116** at its maximum casing thickness **20** and is compressed by the socket surface from an uninstalled driver width DW to an installed driver width IW, where the installed driver width IW is substantially equivalent to the socket width SW. As shown in the figures, the convex contour **60** of the pin portion **32** of the casing **30** is modified by a concave contour **58** adjacent the circumference of the pin bore **12**, the concave contour **58** defined by a concave radius of curvature **28** (see FIG. **12**) such that the casing thickness **20** is relatively thinner adjacent the pin bore **12**. As such, the concave contour **58** aids the insertion of the cross-pin **106** into the pin bore **12** during assembly of the drive system **100**, by reducing the casing thickness **20** adjacent the pin bore **12** and thereby reducing resistance to insertion of the cross-pin **106** from contact of the cross-pin surface with the casing **30**.

[0054] As shown in the figures, the convex contour **60** of the corner portion **38** of the casing **30** is modified by a rounded contour **62** to form rounded corner radius **24** of the coated driver **10**, as shown in FIGS. **6** and **12**. The rounded corner radius **24**, the convex radius **28**, the core diagonal dimension DD and the corner chamfer dimension CC define the shape and volume of the corner portion of the casing **30**, as illustrated by the diagonal cross-sectional views of the coated driver **10** shown in FIGS. **24** and **25**, and such that the casing thickness **20** as at a maximum thickness in the corner portions **38**. As described previously, and as illustrated in FIG. **7**, a corner force component FC of the rotational force **22** is primarily transmitted via the corner portions **38** of the coated driver and across the corner chamfer **56** to minimize forces imposed on the metal core **40** and/or to avoid abrasive wear between the casing **30** at the contact interface **122** between the corner portion **38** of the casing **30** and the coupling surface **116**, thereby extending the useful life of the coated driver **10**, for example, relative to the useful life of an uncoated metal driver.

[0055] Referring to FIGS. **12** and **20-24**, the casing **30** includes a shaft portion **34** adhered to and encasing the shaft face **42** of the core **40**. The shaft portion **34** of the casing **30**, in an illustrative example, can be of a uniform thickness **20** across the shaft face **42**. The shaft portion **34** extends from and is continuous with the other casing portions **32**, **36**, **38**, such that the shaft portion **34** functions to support and promote adhesion of the casing **30** to the core **40**, including adhesion to the PS and SS chamfers **52**, **54**, and to prevent delamination of the casing **30** over time in use. FIGS. **10-25** show additional details of a non-limiting example configuration of the coated driver **10** including elements and features of the coated driver **10**, casing **30** and core **40** as described herein.

[0056] FIG. **9** shows a schematic flow chart showing a method **200** for forming a coated driver **10**, including, at step **202**, providing a core **40**. As shown in FIG. **9**, the a new core **40** can be formed at step **202a**, for example, by machining or other metal fabrication methods, or alternatively, at step **202b**, a reclaimed core **40** can be provided, where the reclaimed core **40** is recycled from a coated

driver **10** by removal of the casing **30** to provide the core **40**. The coated driver **10** from which the reclaimed core **40** is removed can be, for example, a used coated driver **10**, a defective coated driver **10** rejected from the driver molding process, a damaged or otherwise unusable coated driver **10**, etc. Step **202b** can include inspecting the reclaimed core **40** for compliance with the core specifications, including for example, inspecting the shaft and cross-pin bores **16**, **12** for wear and dimensional compliance. At step **204**, the core **40** provided at step **202** can be surface treat, for example, to increase the receptivity of the exterior surfaces of the core **40** for adhesion of the casing material to the core material. Step **204** can include for example, cleaning and degreasing the core **40** and/or surface treating the core **40** to texturize or otherwise modify the surface finish of the exterior surfaces of the core **40** to increase adhesion of the casing **30** to the core **40** during forming. At step **206**, one or more of the pin bore surface **50** and the shaft bore surface **50** can be masked or plugged to prevent the flow of the casing material onto these surfaces during molding of the casing **30**. In a non-limiting example, a removable plug can be inserted to the pin bore surface **50** to mask this surface, and removed after molding at step **210**. Other forms of masks, including masking materials, can be applied to the interior bore surfaces **48**, **50** at **206** to prevent coating of these surfaces with the casing material and can be removed subsequent to molding of the coated driver **10**. In an optional step **212**, after demolding the coated driver **10** from the casing mold at **208**, one or more of the pin bore **12** and shaft bore **16** can be finished, for example, by surface finishing, polishing, machining, etc., to provide a finished bore **12**, **16** in compliance with dimension and surface finish requirements to function as a bearing surface. At step **208**, the core **40** received from step **206** is inserted to a mold cavity defining the exterior shape of the coated driver **10**. Casing material, which in a non-limiting example can be a urethane based liquid, semi-liquid or resin, is added to the mold cavity and cured to form the coated driver **10**. After curing, the coated driver **10** is removed from the mold and proceeds to finishing steps at **212**, if required. The exterior surface of the casing **30**, including the concave, convex and rounded contours **58**, **60**, **62** is formed to its final shape during molding. The final surface finish and surface texture of the molded casing **30** is formed during molding, defined by casing material and the surface characteristics of the mold cavity surface. Advantageously, no further processing of the casing **30** is required after molding, such that the final shape and surface finish of the casing **30** is achieved during molding.

[0057] In another example, the driver **10**, output shaft **110** and cross-pin **106** can be formed integrally, e.g., having a single piece or monolithic structure, such that in this example, the driver **10** does not include a pin bore **12** or shaft bore **16**. In this case, the casing **30** can be formed as described herein, using, for example, a mold cavity configured to receive the driver **10** portion of the monolithic structure. In one example, the masking may be used and/or the mold cavity can be configured such that the polymeric material is not applied to the output shaft **110** or the surfaces of the integral cross-pin **106** extending from the pin surfaces **50** of the driver **10**. In another example, the casing **30** may extend partially along a length of the output shaft **110** adjacent the shaft surface **48** of the driver **10**, and/or the casing **30** can partially or fully encapsulate the surfaces of the integral cross-pin **106** extending from the pin surfaces **50** of the driver **10**. Optionally, a finishing operation can be used to remove the casing **30** from the surfaces of one or both of the output shaft **110** and the cross-pin **106**.

[0058] In another example, the driver **10** and output shaft **110** can be formed integrally, e.g., having a single piece or monolithic structure, such that in this example, the driver **10** does not include a shaft bore **16**. The driver **10** can include, as previously described, a pin bore **12** for receiving a cross-pin **106**. In one option, the driver **10** is configured as a solid driver **10**, e.g., has no pin bore **12**. In one option, the driver **10** can be configured to include, for example, a pin bore **12** which extends only partially through the driver **10**, to receive a cross-pin **106** that can be, for example, press-fit or otherwise inserted and/or attached to the driver **10** either before or after coating the driver **10** to form the casing **30**. In the present example, the casing **30** can be formed as described herein, using, for example, a mold cavity configured to receive the driver **10** portion of the

monolithic structure. In one example, masking may be used and/or the mold cavity can be configured such that the polymeric material is not applied to the output shaft **110** or the surfaces of the integral cross-pin **106** extending from the pin surfaces **50** of the driver **10**, or if so configured, to a pin bore **12**. In another example, the casing **30** may extend partially along a length of the output shaft **110** adjacent the shaft surface **48** of the driver **10**, and/or the casing **30** can partially or fully encapsulate the surfaces of an integral cross-pin **106** extending from the pin surfaces **50** of the driver **10**, or the pin bore **12**, if so configured. Optionally, a finishing operation can be used to remove the casing **30** from the surfaces of one or both of the output shaft **110** and the cross-pin **106** or pin bore **12**.

[0059] The detailed description and the drawings or figures are supportive and descriptive of the disclosure, but the scope of the disclosure is defined solely by the claims. While some of the best modes and other embodiments for carrying out the claimed disclosure have been described in detail, various alternative designs and embodiments exist for practicing the disclosure defined in the appended claims. Furthermore, the embodiments shown in the drawings or the characteristics of various embodiments mentioned in the present description are not necessarily to be understood as embodiments independent of each other. Rather, it is possible that each of the characteristics described in one of the examples of an embodiment can be combined with one or a plurality of other desired characteristics from other embodiments, resulting in other embodiments not described in words or by reference to the drawings. Accordingly, such other embodiments fall within the framework of the scope of the appended claims.

## Claims

1. A driver comprising: a core including a plurality of exterior core surfaces; the core made of a metal-based material; the plurality of exterior core surfaces including a plurality of corner chamfers; a casing encasing the plurality of exterior core surfaces; the casing made of a polymer-based material; the casing including a plurality of corner portions, each corner portion encasing a respective corner chamfer; wherein the corner portion of the casing is characterized by: a rounded contour in a first plane normal to the corner chamfer; and a convex contour in a second plane normal to the corner chamfer; and wherein the second plane is normal to the first plane.
2. The driver of claim 1, further comprising: a contoured perimeter drive surface defined by the casing.
3. The driver of claim 1, wherein the metal-based material is stainless steel.
4. The driver of claim 1, wherein the polymer-based material is a urethane-based material.
5. The driver of claim 4, wherein the urethane-based material is a thermoset urethane of about 65 durometer Shore A hardness to about 65 durometer Shore D hardness.
6. The driver of claim 1, further comprising: a bore extending through the core and defined by a bore surface; wherein the bore surface is not encased by the casing.
7. The driver of claim 1, further comprising: a bore extending through a face of the core and through the casing; wherein the casing adjacent the bore is characterized by a concave contour relative to the face of the core.
8. The driver of claim 1, wherein each of the corner chamfers has an octagonal shape.
9. A driver comprising: a core including a plurality of exterior core surfaces; the core made of a metal-based material; a casing encasing the plurality of exterior casing surfaces; the casing made of a polymer-based material; wherein: the plurality of exterior core surfaces includes a plurality of faces and a plurality of corner chamfers; each corner chamfer is intermediate one of the faces and another of the faces; and the casing is adhered to the plurality of faces and the plurality of corner chamfers and is defined by a convex contoured surface relative to the plurality of faces.
10. The driver of claim 9, wherein each of the corner chamfers has an octagonal shape.
11. The driver of claim 9, wherein the metal-based material is stainless steel.

- 12.** The driver of claim 9, wherein the polymer-based material is a urethane-based material.
- 13.** The driver of claim 12, wherein the urethane-based material is a thermoset urethane of about 65 durometer Shore A hardness to about 65 durometer Shore D hardness.
- 14.** The driver of claim 9, further comprising: a bore extending through the core and defined by a bore surface; wherein the bore surface is not encased by the casing.
- 15.** The driver of claim 9, further comprising: a bore extending through a face of the core and through the casing; wherein the casing adjacent the bore is characterized by a concave contour relative to the face of the core.
- 16.** A method for forming a driver, the method comprising: providing a core including a plurality of exterior core surfaces; the core made of a metal-based material; the plurality of exterior core surfaces including a plurality of corner chamfers; encasing the core in a casing made of a polymer-based material; wherein the casing encases the plurality of exterior core surfaces; the casing including a plurality of corner portions, each corner portion encasing a respective corner chamfer; wherein the corner portion of the casing is characterized by: a rounded contour in a first plane normal to the corner chamfer; and a convex contour in a second plane normal to the corner chamfer; wherein the second plane is normal to the first plane; and wherein the driver includes the core encased by the casing.
- 17.** The method of claim 16, further comprising: inserting the core into a mold defining the plurality of corner portions of the casing; flowing the polymer-based material into the mold such that the polymer-based material is in contact with the exterior core surfaces; and curing the polymer-based material; wherein curing includes forming the casing.
- 18.** The method of claim 16, wherein the driver is a first driver including a first core encased by a first casing; the method further comprising: forming a recycled core by removing the first casing from the first core.
- 19.** The method of claim 18, further comprising: forming a second driver including the recycled core and a second casing; wherein forming the second driver comprises: providing the recycled core; encasing the recycled core in a second casing made of a polymer-based material; wherein the second casing encases the plurality of exterior core surfaces of the recycled core; the second casing including a plurality of corner portions, each corner portion encasing a respective corner chamfer of the recycled core; wherein the corner portion of the second casing is characterized by: a rounded contour in a first plane normal to the corner chamfer; and a convex contour in a second plane normal to the corner chamfer; wherein the second plane is normal to the first plane; and wherein the second driver includes the recycled core encased by the second casing.
- 20.** The method of claim 19, further comprising: inserting the recycled core into a mold defining the plurality of corner portions of the casing; flowing the polymer-based material into the mold such that the polymer-based material is in contact with the exterior core surfaces; and curing the polymer-based material; wherein curing includes forming the second casing.
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