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## Socket with laser induced friction surfaces


### Abstract

A fastening tool having a socket and a socket wrench with laser induced friction surfaces or lines on the outer surface of the socket is described herein. The laser induced friction surfaces may have a plurality of kerfs with recast material to increase the coefficient of friction on the outer surface of the socket. As a result, the user of the fastening tool may pull the socket off a head of a fastener with his or her hands instead of having to dislodge the socket first with a blunt object, such as a hammer. It is contemplated that the socket wrench may have laser induced friction surfaces or lines also.



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## Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS (1) This application claims the benefits of Ser. No. 63/383,908, filed on 2022 Nov. 15, the entire content of which is expressly incorporated herein by reference.

STATEMENT RE: FEDERALLY SPONSORED RESEARCH/DEVELOPMENT
(1) Not Applicable
BACKGROUND
(2) The various embodiments and aspects described herein relate to components for a supercharger of an automobile.
(3) The supercharger has a pulley which is connected to a rotating shaft of the engine and drives the supercharger. The pulley has a small diameter which leads to slippage between the pulley and the belt driving the pulley.
(4) Accordingly, there is a need in the art for an improved method and device for mitigating slippage between the pulley and the belt and addressing other deficiencies.
BRIEF SUMMARY
(5) The various embodiments and aspects disclosed herein address the needs discussed above, discussed below and those that are known in the art.
(6) A pulley assembly having a body, a shaft mount and a plurality of bolts that attach the body to the shaft mount is disclosed. The shaft mount is mountable to a shaft of a supercharger. The body is attachable to the shaft mount with the bolts. In particular, the shaft mount has a plurality of threaded holes that engage threads of the bolts. The body has a series of counter sunk holes that are aligned to the threaded holes of the shaft mount. The counter sunk holes have a him neck area that is minimally larger than a shoulder area of the bolt. As such, when the bolt is inserted into the counter sunk holes and threaded into the threaded holes of the shaft mount, the tight tolerancing (i.e., within 0.001 inches) between diameters of the necks of the counter sunk holes and the shoulder of the bolts align the body of the pulley assembly to the shaft mount and ultimately to the shaft of the supercharger. In another aspect, the outer surface of the body of the pulley assembly has a pattern of friction lines for increasing the frictional forces between the outer surface of the body of the pulley assembly and the belt driving the pulley. The friction lines may be formed by applying particulate matter to the outer surface of the body of the pulley assembly and fusing the applied particulate matter to the outer surface by heating the outer surface and the particulate matter. The heat may be generated by a laser beam that traces a desired pattern of friction lines. The increased friction mitigates noise by reducing slippage between a belt and the pulley. Alternatively, the laser may be used to remove material and to create a rough surface on the outer surface of the body of the pulley assembly. The heat generated from the laser beam may trace a desired pattern of friction lines.
(7) A fastening tool having a socket and a socket wrench with laser induced friction surfaces or lines on the outer surface of the socket is described herein. It is contemplated that the friction surfaces described herein may be applied to an exterior surface of the socket of the fastening tool so that when the socket needs to be pulled off a head of a fastener, the user may do so with his or her hands instead of having to dislodge the socket first with a blunt object, such as a hammer. The laser induced friction surfaces on the socket may have a plurality of kerfs with recast material that increase the coefficient of friction on the surface of the socket for easy gripping and separation of the socket from the fastener. Furthermore, a method for separating a socket, which has the friction surfaces, that is stuck to a fastener is described herein.
(8) More particularly, a pulley for transmitting rotational motion between first and second rotating shafts with a belt on an automobile engine is disclosed. The pulley may be fixed to the first rotating shaft. The pulley comprising a body and a laser infused friction material. The body may have a cylindrical central hole for receiving the first rotating shaft and mounting the body onto the first rotating shaft on the automobile engine. The cylindrical central hole may define a central axis about

which the body rotates. The body may have at least one groove formed circumferentially about the central axis for receiving the belt. The laser infused friction material may be bonded to an outer surface of the at least one groove.
(9) The laser infused friction material may be configured into a pattern on the outer surface of the at least one groove. The pulley may have at least three grooves. The pulley may have a diameter of about 1-10 inches, and more preferably between about 2-4 inches, and even more preferably about 2.5 inches.
(10) In another aspect, a method of fabricating a pulley for transmitting rotational motion between first and second rotating shafts with a belt on an automobile engine is disclosed. The pulley may be fixed to the first rotating shaft. The method may comprise the steps of forming a body having a cylindrical central hole for receiving the first rotating shaft and mounting the body onto the first rotating shaft on the automobile engine, the cylindrical central hole defining a central axis about which the body rotates, the body having at least one groove formed circumferentially about the central axis for receiving the belt; covering an outer surface of the at least one groove with a powder material; and selectively applying heat from a laser beam to the powder material and the outer surface of the at least one groove to fuse the powder material to the outer surface of the at least one groove. The fused powder material provides a surface texture to increase its coefficient of friction and reduce slip with another material such as a belt.
(11) The powder material used in the method may be a formulation sold under the trademark THERMARK or CERMARK. The powder material used in the method may also be any powdered metallic material or powdered oxide material. By way of example and not limitation, the metallic material may be tungsten, various types of carbides, cobalt, titanium, aluminum, steel or combinations thereof. The average size of the of the powdered material may be up to about 100 microns, and is preferably up to about 35 microns. More preferably, the powdered material is between about 2-25 microns. The texture of the fused material may be increased or decreased by respectively using larger or smaller sized powdered oxide material. Additionally, ceramic and/or diamond particles may be heterogeneously mixed in with the powdered metallic material or powdered oxide material.
(12) The powder material and the outer surface of the at least one groove may reach a temperature of at least 200 degrees Fahrenheit depending on the specific powder material and the outer surface to fuse the powder material to the outer surface of the groove. By way of example and not limitation, the powder material may be configured so that the fusing temperature of the powder material and the outer surface may be as high as about 1,221 degrees Fahrenheit to about 4,566 degrees Fahrenheit for aluminum which are the respective melting and boiling points for aluminum. More broadly speaking, the heat applied to the powder material and the outer surface is regulated so that the temperature of the outer surface may reach between the melting point and the boiling point of the base material.
(13) In the method, the covering step may include the step of covering the entire outer surface of the at least one groove.
(14) In the method, the applying step may comprise the steps of mounting the body to a chuck; mounting the body and the chuck to a laser machine; rotating the body with the chuck while performing the applying heat from the laser beam step, rotational motion of the body defining a rotational axis; and traversing a head of the laser machine along the rotational axis while performing the applying heat from the laser beam step.
(15) In another aspect, a method of removing a pulley from a rotating shaft of an automobile engine is disclosed. The method may comprise the steps of unscrewing a plurality of first bolts from the pulley to disassemble a first outer body of the pulley from an inner mounting fixture of the pulley; removing the first outer body from the inner mounting fixture; positioning a second outer body over the inner mounting fixture wherein an internal configuration of the second outer body is sized to interface with the inner mounting fixture and an external configuration of the second outer body

is sized to mate with a puller; screwing the plurality of first bolts or a plurality of second bolts to the pulley to fix the second outer body to the inner mounting fixture wherein the second outer body has a larger flange compared to a flange of the first outer body; engaging the puller to the larger flange of the second outer body; and pulling on the larger flange of the second outer body with the puller to remove the inner mounting fixture from the rotating shaft.
(16) In the method, the larger flange of the second outer body may be located on an inner side of the pulley.
(17) In a different aspect, a method for increasing a coefficient of friction of a surface of a pulley is disclosed. The method may comprise the steps of disposing a laser machine adjacent to the pulley so that a laser beam of the laser machine is applied to an area of the surface of the pulley; adjusting the laser machine to a roughing setting to emit a laser beam that vaporizes the surface of the area to increase a roughness of the pulley surface; applying the laser beam of the laser machine onto the pulley surface with the laser machine set to the roughing setting; adjusting the laser machine to a smoothing setting to emit the laser beam to reduce sharps peaks on the pulley surface caused by the applying the laser beam of the laser machine set to the roughing setting; and applying the laser beam of the laser machine onto the pulley surface with the laser machine set to the smoothing setting.
(18) The step of adjusting the laser machine to the smoothing setting from the roughing setting may comprise the steps of decreasing a kerf width, decreasing a fill distance and decreasing a power of the laser beam.
(19) The step of adjusting the laser machine to the roughing setting may comprise the steps of setting a kerf width and setting a fill distance to be greater than the kerf width. The kerf width may be about between 0.0019 and about 0.004 inches. The step of adjusting the laser machine to the smoothing setting may comprise the steps of setting the fill distance to about double the kerf width but can be more or less depending on the material being worked on. By way of example and not limitation, the fill distance may be less than double the kerf width for aluminum and more than double the kerf width for 17-4 stainless steel.
(20) The method may further comprise the step of adjusting the laser machine to an annealing setting to harden the pulley surface.
(21) The method may further comprise the step of rotating the pulley or the laser machine after performing both applying steps to apply the laser beam of the laser machine about a circumference of the pulley.

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## Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) These and other features and advantages of the various embodiments disclosed herein will be better understood with respect to the following description and drawings, in which like numbers refer to like parts throughout, and in which:
(2) FIG. **1** is a perspective view of a pulley assembly mounted on a shaft of the supercharger;
(3) FIG. **2** is a cross-sectional exploded view of the pulley assembly shown in FIG. **1**;
(4) FIG. **3** is a cross-sectional view of the pulley assembly illustrating a bolt that aligns a body of the pulley assembly to a shaft mount of the pulley assembly;
(5) FIG. **4** is a flowchart for forming friction lines on an outer surface of the body of the pulley assembly; and
(6) FIG. **5** illustrates a laser beam used to fuse particulate matter on the outer surface of the body of the pulley assembly for forming the friction lines;
(7) FIG. **6** is a front view of a variable diameter pulley of a continuously variable transmission;
(8) FIG. **7** is a front view of one of first and second parts of the variable diameter pulley

individually mounted to a chuck;
(9) FIG. **8** is a front view of one of first and second parts of the variable diameter pulley individually mounted to a chuck in a different orientation to a laser beam of a laser;
(10) FIG. **9** is a perspective view of the pulley assembly having an outer surface debossed with a laser to increase a coefficient of friction of the outer surface;
(11) FIG. **10** is a cross-sectional view of the pulley assembly shown in FIG. **9**;
(12) FIG. **11** is a top view of the pulley assembly shown in FIG. **9**;
(13) FIG. **11**A is a top view of a crosshatching pattern formed on an area of the outer surface the pulley assembly;
(14) FIG. **11**B is a schematic diagram illustrating a pulse width of a laser beam of the laser;
(15) FIG. **12** is a cross-sectional view of the outer surface illustrating a plurality of kerfs formed by the laser beam of the laser;
(16) FIG. **13** is a graph of temperature as a function of distance as the laser beam passes over the outer surface of the pulley assembly to anneal the outer surface;
(17) FIG. **14** is a table of settings of a laser;
(18) FIG. **15** illustrates a drag race car;
(19) FIG. **16** is a side view of the drag race car illustrated in FIG. **15**;
(20) FIG. **17** is a cross-sectional view of a wheel of the drag race car shown in FIGS. **15** and **16**;
(21) FIG. **18** is a cross-sectional view of a rim of the wheel shown in FIG. **17**;
(22) FIG. **19** is a top view of the rim shown in FIG. **18** illustrating spaced apart friction lines in a first direction;
(23) FIG. **20** is a top view of the rim shown in FIG. **18** illustrating spaced apart friction lines in an opposite skew second direction compared to the direction shown in FIG. **19**;
(24) FIG. **21** is a top view of the rim shown in FIG. **18** illustrating friction lines close together in the first direction;
(25) FIG. **22** is a top view of the rim shown in FIG. **18** illustrating friction lines close together forming a V shaped pattern of friction lines;
(26) FIG. **23** is a top view of the rim shown in FIG. **18** illustrating a cross hatch of friction lines close together;
(27) FIG. **24** is a perspective view of a drum pulley with a friction patch formed on an interface surface of the drum pulley that engages; and
(28) FIG. **25** is a perspective view of V groove idler and drive pulleys with a friction patch formed on an interface surface of the idler and drive pulleys.
(29) FIG. **26** is a perspective view of a fastening tool (i.e., socket and a socket wrench) with laser induced friction surfaces;
(30) FIG. **27** is a front perspective view of the socket;
(31) FIG. **28** is a rear perspective view of the socket;
(32) FIG. **29** is a front perspective view of a socket having a stepped collar portion and an identifier portion;
(33) FIG. **30**A is a front perspective view of the socket with longitudinal friction surfaces or lines;
(34) FIG. **30**B is a front view of the socket shown in FIG. **30**A illustrating the longitudinal friction surfaces or lines;
(35) FIG. **31**A is a front perspective view of the socket with circumferential friction surfaces or lines;
(36) FIG. **31**B is a front view of the socket with circumferential friction surfaces or lines;
(37) FIG. **32** is a block diagram of a method for removing the socket that is stuck to a fastener;
(38) FIG. **33** illustrates a universal adapter with friction lines and surfaces;
(39) FIG. **34** illustrates an extension bar with friction lines and surfaces;
(40) FIG. **35** illustrates a bit adapter with friction lines or surfaces;
(41) FIG. **36** illustrates a soft flexible extension with friction lines or surfaces; and

(42) FIG. **37** illustrates a sliding bar with friction lines or surfaces.

DETAILED DESCRIPTION

(43) Referring now to the drawings, a pulley assembly **10** for a supercharger **12** is shown. The pulley assembly **10** is mounted to a shaft **14** of the supercharger **12**. The pulley assembly **10** may have three different components, namely, a shaft mount **16**, a body **18** and a plurality of bolts **20**. The body **18** is mounted to the shaft mount **16** with the plurality of bolts **20**. In particular, each of the bolts **20** may have a shoulder **22** having an outer diameter **24** which is smaller than and within 0.001 inches of an inner diameter **26** of a neck **54** of a countersunk hole **28** formed in the body **18**. The shaft mount **16** has a plurality of threaded holes **30** which receive the bolts **20**. In this manner, the neck **54** of the body **18** aligns the body **18** to the shaft mount **16**. Additionally, an outer surface **32** of the body **18** may have a plurality of friction lines **34** which mitigate slip between the outer surface **32** of the body **18** and a belt being driven by the pulley assembly **10** or driving the pulley assembly **10**. The increased friction mitigates noise by reducing slippage between the belt and the pulley assembly **10**.

(44) Referring to FIG. **26**, a fastening tool **300** comprising a socket **301** and a socket wrench **303** with friction surfaces or lines **305** on the outer surface **307** of the socket **301** is described herein. The friction surfaces or lines **305** may be formed by the methods described herein. By way of example and not limitation, the friction surfaces or lines **305** may be formed by lasering a plurality of kerfs having recast material that increase the coefficient of friction on the outer surface **307** for easy gripping and separation of the socket **301** from a fastener (e.g., bolt head). By way of example and not limitation, the friction surfaces or lines **305** may be formed longitudinally on the outer surface **307** of the socket **301**. In another example, the friction surfaces or lines **335***a*, *b* may be formed circumferentially on the outer surface **307**, as shown in FIG. **31**A. At a minimum, there may exist two opposing friction surfaces or lines **305** on the outer surface **307** of the socket **301** for the user to grip with his or her fingers. The two opposing friction surfaces or lines **305** may both be part of a continuous surface or line running along the outer surface **307** or be two different surfaces or lines. It is contemplated that the outer surface **311** of the socket wrench may also have friction surfaces or lines **309**.

(45) Furthermore, a method for separating a socket having the friction surfaces from the stuck fastener is described herein. The method may comprise a gripping step and a pulling step. In these series of steps, the user grips the friction surfaces on the socket and pulls to separate the socket from the fastener. Additionally, a dislocating step where the user separates the socket from the socket wrench may be incorporated.

(46) More particularly, referring now to FIG. **2**, the pulley assembly **10** is made up of at least the shaft mount **16**, the body **18** and the plurality of fasteners or bolts **20**. To mount the pulley assembly **10** to the shaft **14** of the supercharger **12**, the shaft mount **16** is heated to a temperature above the temperature of the shaft **14**. The inner diameter **36** of the hole **38** of the shaft mount **16** is enlarged due to the heat so that the shaft mount **16** may be slid over the shaft **14**. When the shaft mount **16** cools down, the shaft mount **16** is fixedly secured to the shaft **14** of the supercharger **12**. The inner diameter **36** of the hole **38** of the shaft mount **16** is slightly smaller than an outer diameter **40** of the shaft **14** when the shaft **14** and the shaft mount **16** are at the same temperature. The shaft mount **16** compresses on the shaft **14** when the temperature of the shaft mount **16** reaches the temperature of the shaft **14**.

(47) The shaft mount **16** may have a flange **42** that extends outwardly around a periphery of the shaft mount **16**. The flange **42** may have a plurality of threaded holes **44** symmetrically disposed about a central axis **46**. The flange **42** may have a proximal surface **48** which mates with a distal surface **50** of the body **18**. The body **18** is mounted to the shaft mount **16** with the plurality of fasteners **20**. The body **18** has a set of corresponding countersunk holes **28** that receive the bolts **20**. These countersunk holes **28** are aligned in the same pattern as the threaded holes **44** formed in the flange **42** of the shaft mount **16**. The body **18** has an inner cavity **55** which is large enough to

receive the shaft mount **16** and a portion **53** of the supercharger **12** that holds the shaft **14**. The body **18** is disposed over the shaft mount **16** and the countersunk holes **28** are aligned to the threaded holes **44**. Each of the fasteners **20** are then inserted through the countersunk holes **28** and engage to the threaded holes **44** of the shaft mount **16**. The fasteners **20** fixedly secure the body **18** the shaft mount **16**. Also, the interference fit between the hole **38** of the shaft mount **16** and the shaft **14** of the supercharger **12** fixedly secure the shaft mount **16** to the shaft **14**.

(48) To align the body **18** to the shaft mount **16**, the bolts **20** have a shoulder **22** that mates to a neck **54** of the countersunk hole **28** formed in the body **18**. In particular, referring now to FIG. **3**, a cross-sectional view of the pulley assembly **10** is shown. The countersunk hole **28** has two different diameters. A first diameter at a neck **54** identified as inner diameter **26**. A second diameter at a countersunk portion **56** identified as inner diameter **58**. The inner diameter **58** receives a head **60** of the bolt **20**. More particularly, the inner diameter **58** is significantly larger than an outer diameter **62** of the head **60** of the bolt **20**. In contrast, the inner diameter **26** of the neck **54** of the threaded hole **28** is only minimally larger than an outer diameter **24** of the neck portion **22** of the bolt **20**. More particularly, the inner diameter **26** is within 0.001 inches of the outer diameter **24** of the neck **22** of the bolt **20**. As the threads **64** of the bolt **20** engage the threads **66** of the threaded hole **30** of the flange **42** of the shaft mount **16**, the shoulder **22** of the bolt **20** enters the neck **54** of the hole **28** of the body **18**. Since the inner diameter **26** of the hole **28** is within 0.001 inches to the outer diameter **24** of the shoulder **22**, the body **18** begins to align to the shaft mount **60** as two or more bolts **20** engage the threaded holes **44** of the shaft mount **16**.

(49) Optionally, to further secure the shaft mount **16** to the shaft **14**, the shaft mount **16** may have one or more socket set screws **68** that engage the shaft **14**. In particular, the shaft mount **16** may have an extended length. A threaded hole **70** may be formed in the extended length. Preferably, a plurality of threaded holes **70** are symmetrically formed about the central axis **46** to maintain rotational balance of the pulley assembly **10** during rotation. By way of example and not limitation, threaded holes **70** may be placed on opposed sides of the central axis **46**. Alternatively, three holes **70** may be disposed 120° apart from each other about the central axis **46** or four holes may be disposed 90° apart from each other about the central axis **46**. After the shaft mount **16** is mounted to the shaft **14**, the socket set screws **68** are threaded into the threaded holes **70** and engaged to the shaft **14**. Preferably, the socket set screws **68** have a knurled end to further engage the shaft **14**.

(50) To mount the pulley assembly **10** to the shaft **14** of the supercharger **12**, the shaft mount **16** (see FIG. **2**) is heated to a temperature above the temperature of the shaft **14** of the supercharger **12**. In doing this, the heat enlarges the inner diameter **36** of the shaft mount **16** so that the inner diameter **36** of the shaft mount **16** when heated is greater than the outer diameter **40** of the shaft **14**. While the shaft mount **16** is heated to an elevated temperature, the shaft mount **16** is placed over the shaft **14** so that the shaft **14** is now disposed within the hole **38** of the shaft mount **16**. As the shaft mount **16** cools down, the inner diameter **36** of the shaft mount **16** decreases. When the temperature of the shaft mount **16** is equal to the temperature of the shaft **14**, the inner diameter **36** of the shaft mount **16** is equal to the outer diameter **40** of the shaft **14**. Since the inner diameter **36** of the shaft mount **16** is less than the outer diameter **40** of the shaft **14** (when the shaft mount **16** and the shaft **14** are at the same temperature and the shaft mount **16** is not mounted to the shaft **14**), the inner surface defining the inner diameter **36** of the shaft mount **16** compresses upon the outer surface of the shaft **14** when the shaft mount **16** is mounted to the shaft **14** of the supercharger **12**.

(51) To further ensure that the shaft mount **16** is retained on the shaft **14**, socket set screws **68** may be threaded into the threaded holes **70** formed in the extended length of shaft mount **16**. A distal tip of each of the socket set screws **68** may have knurls to further engage the shaft **14** and mitigate inadvertent movement between the shaft mount **16** and the shaft **14**.

(52) The body **18** is then disposed over the shaft mount **16** so that the shaft mount **16** is disposed within the cavity **55** of the body **18**. The bolts **20** are inserted through the countersunk holes **28** of the body **18** and threadedly engaged to the threaded holes **44** formed in the flange **42** of the shaft

mount **16**. As the bolts **20** are tightened, the neck **54** of the bolts **20** seat into the neck **54** of the body **18**. Due to the tight tolerances between the shoulders **22** of the bolts **20** and the necks **54** of the countersunk holes **28** of the body **18**, the body **18** begins to align to the shaft mount **16**. The user tightens the bolts **20** to securely attach the body **18** to the shaft mount **16**, and in turn, to the shaft **14** of the supercharger **12**.

(53) To remove the pulley assembly **10** from the shaft **14** of the supercharger **12**, the user loosens the bolts **20** to remove the body **18** from the shaft mount **16**. The purpose of removing the body **18** from the shaft mount **16** is to provide the user with access to the socket set screws **68**, if used. The user loosens and removes the socket set screws **68** from the shaft mount **16**. The user may then reinstall the original body **18** or install a sacrificial body **72** (see FIG. **2**). The sacrificial body **72** may incorporate the counter sunk holes **28** and an enlarged distal flange **74**. The enlarged distal flange **74** is used to pull the body **18** and shaft mount **16** off of the shaft **14**. The user may then pull the pulley assembly **10** from the shaft **14** with the puller.

(54) Referring back to FIG. **1**, the body **18** of the pulley assembly **10** may have an outer surface **32**. The outer surface **32** may have a plurality of grooves **76** circumscribing the body **18** about the rotational axis **46**. In the embodiment shown in the figures, the pulley assembly **10** has a plurality of grooves. However, it is also contemplated that the various aspects described herein may be applied to a pulley have a single groove or a pulley or tensioner having a cylindrical surface. The outer surface **32**, and in this instance, the grooves **76** engage a belt that wraps around the body **18** and fits within the grooves **76**. The outer surface **32** of the body **18** may be smooth so that during use, the belt wrapped around the body **18** may inadvertently slip so that the linear speed of the outer surface **32** of the body **18** is not equal to the linear speed of the belt driving or driven by the pulley assembly **10**. To mitigate slippage between the belt and the outer surface **32** of the body **18**, friction patches or lines **34** may be formed on the outer surface **32** of the body **18**. Although the friction patches or lines **34** are described as being applied to the pulley assembly **10**, the friction patches or lines **34** may also be applied in the same manner, with the same materials and machines and the same methods to a bead seat **212** of a wheel rim **200**, **200***a* (see FIG. **18**), a flat drum pulley **204** (see FIG. **24**), a flat surface and a V groove pulley **206** (see FIG. **25**). In relation to the wheel rim **200**, **200***a*, the goal is to prevent slippage between the tire **202** (instead of the belt) and the rim **200**, **200***a* (instead of the pulley). The formation of a surface to increase a coefficient of friction on the wheel rim **200**, **200***a*, the flat drum pulley **204** and the groove pulley **206** will be discussed below.

(55) In particular, referring now to FIGS. **4** and **5**, particulate matter or substance may be fused to the outer surface **32** of the body **18** and have a coefficient of friction with the belt greater than the coefficient of friction between the smooth outer surface **32** of the body **18** and the belt. The particulate matter may be coated over the outer surface **32**. A laser beam **78** of the laser **80** may be directed to selective locations on the outer surface **32** of the body **18** to fuse the particulate matter to the outer surface **32** of the body **18**. Preferably, the particulate matter when fused to the outer surface **32** has a coefficient of friction with the belt greater than the coefficient of friction between the smooth outer surface **32** of the body **18** and the belt. Moreover, the particulate matter provides a slightly raised surface so that the edges of the friction lines **38** create additional friction between the friction lines **34** and the belt. The fusing of the particulate matter to the outer surface **32** of the body **18** is a physical bonding process wherein the particulate matter is heated and permanently bonded to the outer surface **32** of the body **18**.

(56) To coat the particulate matter onto the outer surface **32** of the body **18**, the particulate matter is applied **82** (see FIG. **4**) to the outer surface **32** of the body **18**. The particulate matter may be applied **82** to the outer surface **32** of the body **18** either by way of an aerosol **100** or airbrushing **102**. If the particulate matter is delivered or coated onto the outer surface **32** of the body **18** with an aerosol **100**, the aerosol can **100** is purchased in a prepackaged form. The user sprays the entire outer surface **32** of the body **18**, and more particularly, sprays the grooves **76**. In the event that the

particulate matter is formed on the wheel rim **200**, **200***a* or the flat drum pulley **204**, the particulate matter is disposed (e.g. sprayed or coated) on the bead seat **212** of the rim **200**, **200***a* or the interface surface where the belt rides on the flat drum pulley **204**. If the particulate matter is delivered or coated onto the outer surface **32** of the body **18** by way of airbrushing **102**, the particulate matter is mixed with denatured alcohol then sprayed on the outer surface **32** with a sprayer. Two types of particulate matter may be utilized when air brushing. A first type is one sold under the trademark Thermark. A second type is one sold under the trademark Cernark. For low production runs, the Thermark particulate matter is preferred since un-fused particulate matter on the outer surface **32** is easily removed by wiping with a damp wet rag. However, for large production runs, Cernark is preferred since the particulate matter may be applied to the outer surface **32** of the body **18** and stored for an extended period of time.

(57) If Thermark is used, then the user applies the particulate matter shortly before fusing **82** the particulate matter to the outer surface **32** of the body **18**. If Cermark is used, then the user may optionally store **84** the coated bodies **18** in storage for an extended period of time. When desired, the user takes the coated bodies **18** out of storage and fuses **82** the particulate matter to the outer surface **32** of the body **18**. Regardless of whether Thermark or Cermark is utilized, the particulate matter may be fused **82** to the outer surface **32** (or bead seat **212** of rim or interface surface of the drum pulley) of the body **18** with a laser beam **78**. The laser beam **78** heats up the particulate matter and the outer surface **32** of the body **18**. The heat permanently attaches the particulate matter to the outer surface **32** of the body **18** so that the particulate matter does not rub off as the belt runs over the outer surface **32** of the body **18**.

(58) Generally, the particular matter may be provided as a powder. The powder may be delivered by aerosol or a spray gun. The material of the powder may be a metallic material. More particularly, the powder may be any form of a metallic oxide material. By way of example and not limitation, the metallic material may be tungsten, carbides (e.g., tungsten carbide, titanium carbide, silicon carbide, carbide.c++, calcium carbide, boron carbide), cobalt, titanium, aluminum, steel or combinations thereof. The average size of the of the powdered material may be up to about 100 microns, and is preferably up to about 35 microns with a minimum size being 2 microns. The texture of the fused material may be increased or decreased by respectively using larger or smaller sized powdered oxide material. During tests, a powder metallic oxide material having a size of about 35 microns has created a 0.007 inch texture to the outer surface **32**.

(59) To form the friction lines or patches **34**, the body **18** (or rim **200**, **200***a* or drum pulley) may be attached to a chuck **86** after applying the particulate matter to the outer surface **32**. The chuck **86** may have a plurality of arms **88** with serrated teeth. The plurality of arms **88** may be inserted within the internal cavity **55** of the body **18** and expanded outward. Upon outward expansion, the arms **88** automatically center the body **18** onto the chuck **86**. The chuck **86** and the body **18** are placed on a rotary table or an indexer that controls the rotational movement **90** of the chuck **86** and the body **18** about rotational axis **46**. The laser **80** is capable of traversing longitudinally along the central or rotational axis **46** in the direction of arrows **92**, **94**. Preferably, the laser beam **78** of the laser **80** intersects and is perpendicular to the central or rotational axis **46**. Additionally, the laser **80** may be a direct beam laser **80**.

(60) The laser beam **78** may be traversed longitudinally along the axis **46** and simultaneously, the body **18** may be rotated about axis **46** so that the laser beam **78** traces the pattern of lines, circles, curves, patches and other shapes (straight, curved or combinations thereof) to form a mark, word, pattern on the outer surface **32** of the grooves of the body **18**. In FIG. **1**, the friction lines **34** are shown as being linear along the longitudinal length of the central axis **46**. However, other types of patterns and shapes are also contemplated. It is also contemplated that the laser beam **78** may trace a random series of lines, circles, curves, patches, indentations and other shapes (straight, curved or combinations thereof). Nevertheless, these random series may still be considered a pattern since the circle would be a pattern.

(61) After fusing **82**, the particulate matter to the outer surface **32** of the body **18**, the excess particulate matter which is not fused to the outer surface **32** of the body **18** may be removed **96** and reclaimed **98** for subsequent use. More particularly, the body **18** may be placed in a wash tank such as an ultrasonic tank. Fluid within the ultrasonic tank is heated up to 200° F. and the tank is vibrated. The fluid is run through a filter and the particulate matter that was not fused to the body **18** is reclaimed **98** and reused at a later time.
(62) The direct beam laser **80** produces a laser beam **78** having a focal depth **104**. Preferably, the focal depth **104** is greater than a distance **106** between a peek **108** and valley **110** of the grooves **76** formed in the body **18**. The laser **80** and laser beam **78** are positioned so that the focal depth **104** covers the entire distance **106**. By way of example and not limitation, the focal depth **104** of the laser beam **78** may be about 0.200 inches. In this manner, the laser beam **78** heats up the particulate matter and the surface **32** along the entire height of the grooves **76** to provide optimal friction lines **34**.
(63) It is also contemplated that the process of forming the friction lines **34** as discussed above and in relation to FIGS. **4** and **5** may be repeated over existing friction lines **34** as shown by process line **112** (see FIG. **4**). In particular, after fusing **82**, the particulate matter to the surface **32** of the body **18**, additional particulate matter may be applied **82** to the outer surface **32** of the body **18**. The additional particulate matter may be fused **82** to the layer of fused particulate matter and to the bare metal of the body **18**. The process may be repeated to increase the thickness of the layers of particulate matter on the outer surface **32** of the body **18**.
(64) Other types of lasers **80** may also be utilized to fuse **82** the particulate matter to the outer surface **32** of the body **18**. By way of example and not limitation, a Galvo laser which utilizes one or more lenses to position the laser beam **78** on the outer surface **32** of the body **18** may be utilized. In this manner, the throughput is higher than a direct laser beam **78** or a CO2 laser beam in that the lenses can create multiple friction lines **34** in one pass.
(65) The process of forming the friction lines **34** is discussed in relation to FIGS. **4** and **5** with the process of producing an emboss on the outer surface **32** of the body **18** (or rim or drum pulley). However, it is also contemplated that a deboss may be formed on the outer surface **32** of the body **18** (or rim or drum pulley) by removing material. In particular, the Galvo laser may be utilized to remove material from the outer surface **32** of the body **18**. The Galvo laser utilizes one or more lenses to redirect the laser beam **78** instead of moving the laser head **80** to position the laser beam **78** on the outer surface **32** of the body **18**.
(66) In addition to forming the deboss on the outer surface **32** with the laser **80**, it is also contemplated that the deboss may be formed with a micro end mill. The same is true if the deboss was formed on the rim or drum pulley. Regardless of whether the deboss is formed with a laser **80** or a micro end mill, the body **18** (or rim or drum pulley) is mounted to the chuck **86**. The chuck **86** and the body **18** are mounted to an indexer or a rotary table which controls the rotational angle of the body **18** as the micro end mill or the laser **80** removes material from the outer surface **32** of the body **18**. In another aspect, it is also contemplated that the body **18** may remain stationary while the micro end mill or the laser **80** both rotate about the body **18** and also traverse longitudinally along the axis **46**.
(67) The friction lines or patches **34** were described as being formed on a rotary table or indexer that is coordinated with the laser. However, it is also contemplated that the friction lines or patches **34** may be formed manually. By way of example and not limitation, the part could be mounted to a chuck or a holding mechanism that the user may move by hand.
(68) In another aspect, referring now to FIG. **6**, the friction lines or patches may be formed on other types of pulleys (e.g. adjustable pulleys, drum pulleys), and also on tensioning rollers having a cylindrical flat surface (e.g. drum pulleys). By way of example and not limitation, the friction lines or patches **34** may be formed on inner surfaces **118** of first and second parts **120**, **122** of a variable diameter pulley **124** of a continuously variable transmission. When the belt **126** is closer to the

rotational axis **128**, the revolutions per minute of the pulley **124** is higher than when the belt **126** is further away from the rotational axis **128**.

(69) Referring now to FIG. **7**, to form the friction lines or patches **34** on the inner surface **118**, the first and second parts may each be individually mounted to the chuck **86**. The part **120** or **122** is positioned with the inner surface **118** perpendicular to the laser beam **78**. The form the patch or lines **34**, the laser **80** is traversed laterally in the direction of arrows **92** and **94** and the chuck **86** is rotated in direction of arrow **90** about rotating axis **46**.

(70) Referring now to FIG. **8**, a different set up between the part **120**, **122** and the laser beam **78** is shown. Instead of the part **120**, **122** being oriented so that the laser beam **78** is perpendicular to the inner surface **118**, the inner surface **118** may be oriented at a skewed angle with respect to the laser beam **78**. In FIG. **8**, the rotational axis of the part **120**, **122** is set up so as to be perpendicular to the laser beam **78**. Since the laser beam **78** has a particular focal depth **104** which is the location of the laser beam effective for heating up the particular matter and the inner surface **118** to fuse the two together, the laser **80** cannot simply be laterally traversed in a linear as shown in FIG. **7** if the angle of the inner surface **118** is too large so that the entire surface **118** is within the focal depth **104** of the laser beam. If the laser is moved to the left **94** or right **92**, the laser beam **78** is effective at fusing the particulate matter to the inner surface **118** as long as the inner surface **118** is within the focal depth of the laser beam. Right before the inner surface **118** comes out of the focal depth of the laser beam **78**, the laser may be traversed up **128** or down **130** to reposition the focal depth of the laser beam on the inner surface **118**. To form the friction lines or patches **34**, the laser **80** is traversed sideways **92**, **94** and vertically **128**, **130** in a staggered fashion. This technique can also be used for pulleys that have a deep groove wherein the distance **106** between the peak **108** and the valley **110** of the deep groove is greater than the focal depth **104** of the laser beam **78**.

(71) Referring now the FIGS. **9-13**, a method and apparatus for forming the deboss on the outer surface **32** of the body **18** in order to increase a coefficient of friction of the outer surface **13** of the body **18** is shown. The same method and apparatus may be used to form the deboss on a bead seat **212** of a rim **200**, **200***a* or an interface surface of a drum pulley. Referring back to formation of the deboss on the body **18**, in particular, the laser beam **78** of the laser **80** may create a plurality of kerfs **150** (see FIG. **12**). These kerfs **150** form the deboss on the outer surface **32** of the body **18**. This is accomplished with a roughing pass of the laser beam **78** on the outer surface **32** of the body **18**. Additional passes of the laser beam **78** on the outer surface **32** of the body **18** may be made for different purposes. These additional passes may be a smoothing pass wherein excessively sharp protrusions formed during the roughing pass are rounded out or knocked down and an annealing pass which raises the temperature of the surface **32** of the body **18** in order to harden the outer surface **32** of the body **18** and/or recast material **166** formed during the roughing pass. More particularly, the laser **80** may perform 1) the roughing pass, 2) smoothing pass, 3) the roughing and smoothing passes, 4) the roughing, smoothing and annealing passes or 5) the annealing pass on the outer surface **32** of the body **18**.

(72) As shown in FIG. **9**, the laser **80** is disposed above the body **18** having the surface **32** on which the deboss which increases the coefficient of friction is to be formed. A direction of the laser beam **78** can be controlled by lenses and mirrors in order to cover an area **152** of the outer surface **32** of the body **18**. Due to the curvature of the outer surface **32**, the laser beam cannot cover the entire outer surface **32** of the body **18**. The body **18** may be rotated about central axis **46** or the laser **80** may be rotated about the body **18** with respect to the central axis **46** in order to deboss the entire circumference of the body **18**. The same applies if the deboss was formed on a bead seat of a rim **200**, **200***a* or drum pulley **204**. Preferably, the body **18** and the laser **80** are stationary while the laser beam **78** is performing one or more of the roughing pass, smoothing pass and annealing pass on the area **152** being worked on by the laser beam **78** of the laser **80**. After the laser beam **78** works the area **152** with one or more of the roughing pass, smoothing pass and annealing pass, either the laser **80** and/or the body **18** rotates so that the laser beam **78** can work one or more of the

passes on a different area **152** on the circumference of the outer surface **32** of the body **18**.

(73) Referring now to FIG. **10**, a cross-sectional view of the body **18** shown in FIG. **9** with respect to the laser **80** is shown. Preferably, the laser beam **78** is centrally aligned to the central rotational axis **46** of the body **18** (or rim **200**, **200***a* or drum pulley **204**) in that the laser beam **78** is not skewed. The laser beam **78** may be skewed to the left or right as shown in dashed lines **154**, **156** as well as along a length of the central axis **46**. Theoretically, the laser beam **78** may be skewed to the left **154** or right **156** so that the laser beam **78** is tangent to the left and right sides of the body **18**. However, at such an excessive skewed angle, the power of the laser beam **78** is less or non-effective. As such, the laser beam **78** is skewed to the left and right **154**, **156** to a smaller angle **158** so that the focal depth or depth of field **164** of the laser beam **78** coincides with or encompasses the outer surface **32** of the body **18** at a valley **160** and peak **162** of a groove formed on the body **18**. The body **18** shown in FIGS. **9-11** is that of a pulley **10**, **204** having a plurality of grooves that define the valley and peaks **160**, **162**. However, the method and apparatus for forming the deboss may be used on a variety of other surfaces including but not limited to a pulley having a single groove such as one that is incorporated into a continuously variable transmission (CVT) or a flat pulley **200** (see FIG. **24**). More broadly speaking, the method and apparatus for forming the deboss may be used on any surface that contacts a belt or requires an increased coefficient of friction (e.g., rim **200**, **200***a*). Likewise, the laser beam **78** is skewed to the left and right **164**, **156** to a smaller angle **158** so that the focal depth or depth of field **164** of the laser beam **78** coincides with and encompasses the outer surface **32** of the body **18**. For the flat pulley (idler or drive pulley; e.g., see FIG. **24**), there are no valleys and peaks. As such, the curvature of the pulley is accounted for in determining the acceptable angle **158**. For a CVT, the laser beam **78** may be applied to the surface **118** by forming the deboss on the first and second parts **120**, **122** separately as discussed above during the emboss process. In particular, the laser debosses the first part and the second part separately which are then assembled together at a later time.

(74) Referring now the FIG. **11**A, a top view of the area **152** which is worked by the laser beam **78** of the laser **80** is shown. FIG. **11**A illustrates the pulley **10** but other pulleys and rotating objects may replace the pulley **10** such as a wheel rim **200**, **200***a*, drum pulley **204** and groove pulley (see FIG. **25**). In this regard, the laser beam creates a series of straight line dashes at an angle **172** with respect to the central axis **46** of the body **18**. In FIG. **11**A, the grooves of the pulley are not shown for clarity. Also, FIG. **11**A is a top view of only the area **152** worked by the laser beam **78** of the laser **80**. The laser beam **78** can be adjusted to pass over the area **152** at different angles. By way of example and not limitation, the preferred angles are 0° 30°, 45°, 60°, 90°, 120°, 125°, 150°. These angles are known as the crosshatching angles **172**. The laser beam **78** of the laser machine **80** creates a series of parallel short line dashes. A distance between the short line dashes is referred to as a crosshatching size **174** (see FIG. **12**). The laser beam **78** may be adjusted to run at a particular speed measured in inches per second.

(75) Referring now to FIG. **12**, the laser **80** is shown emitting a laser beam **78** onto the outer surface **32** the body **18** (or wheel rim **200**, **200***a* or pulley **204**, **206**). The laser beam **78** vaporizes the outer surface **32** in order to create an indentation or a kerf **150**. In other words, kerf may be an elongated groove but kerf may also encompass an indentation. This is the deboss formed by the laser beam **78**. When the laser beam **78** vaporizes a portion of the outer surface **32** of the body **18**, as shown in FIG. **12**, recast material **166** lines an interior of the kerf **150** and/or extends outward above the outer surface **32** of the body **18** outside of the kerf **150**. The recast material may be described as being at the kerf **150**. The outward extensions are shown by peaks **168** of the recast material **166**. The kerf **150** is defined by a width **170** at the peaks **168**. It is also contemplated that the kerf width **170** may be measured at the outer surface **32** including the recast material **166** as shown by dimension line **170***a*. The kerfs **150** are shown in FIG. **12** as being formed vertically straight up-and-down. However, the laser **80** from the position shown in FIG. **12** emits the laser beam **78** at a skewed angle. The first kerf **150** would not be formed straight up-and-down. The

drawing is shown in this fashion in FIG. **12** because the drawing is not to scale since the distance between the laser **80** and the outer surface **32** and the distance **174** between kerfs **150** are not to scale. In actuality, the distance **174** is measured in thousandths of an inch whereas the distance between the laser **80** and the surface **32** is measured in inches if not feet.

(76) Referring now to FIG. **11**B, a length of the kerf **150** and a gap between kerfs **150** may be defined by a pulse width **178** and a speed of the laser beam **78** which are adjusted on the laser **80**. The pulse width **178** is defined by a length of time that the laser **80** is generating the laser beam **78** over a period **180** of fixed time. Laser beams **78** pulse at regular intervals. The pulses are defined by the period **180** of fixed time. The pulse width **178** of the laser beam **78** and the linear speed of the laser beam **78** on the surface **32** defines a length of the kerf **150**. After the laser **80** is turned off so that no laser beam **78** is emitted from the laser **80**, the laser **80** is turned back on after the period **180** of fixed time from the beginning **182** of the prior pulse width **178**. This defines the gap between kerfs **150**. The kerf may be an elongate groove. In this instance, the length of the kerf is longer than the width of the kerf. However, it is also contemplated that the kerf may have its length and width be equal to each other. Other shapes are also contemplated for the kerf. For example, the kerf may form a polygonal shape (e.g, multiple straight grooves joined end to end), curved shape (e.g., non straight grooves). The polygonal shape and the curved shape may be closed to form an shape such as a square, pentagon, circle, elipse. The kerf may be formed as a combination of straight and curved lines as well.

(77) The kerfs may be formed into a pattern. For example, the kerfs may be formed as a series of equally spaced apart straight or curved grooves, dots, indentations or combinations thereof. The pattern may also be formed based on an image or shape. For example, an image or shape may be dithered and the kerfs instead of being elongate grooves may be a plurality of dots or indentations which are spaced apart from each other so that when all of the dots or indentations are viewed by a person represents the image or shape.

(78) The kerfs may alternatively be formed as one or more indentations, dots, straight lines, curved lines which are spaced apart from each other randomly. In other words, the spacing between the indentations, dots, straight lines, curved lines may be random so that they do not form a pattern when all of the indentations, dots, straight lines, curved lines are viewed. Nevertheless, this series of kerfs may be considered to be a pattern since the individual kerf has a pattern (e.g., straight line, dot, curved line, etc.). It is also contemplated that the each kerf may be different than every other kerf in shape, size, and relative position so as to be random.

(79) Regardless of whether the kerf is formed into a pattern or randomly, it is preferred that the surface roughness between a surface of a first part (e.g., pulley, flat surface, table top surface) which contacts a surface of a second part (e.g., belt, container) is about the same (e.g., plus or minus 10% to 30%) regardless of where the surface of the second part is contacting the surface of the first part. By way of example and not limitation, when a belt contacts a pulley, the belt contacts a portion of the pulley. This may be referred to as the contact patch between the belt and the pulley. As the pulley rotates, the surface of the belt and the surface of the pulley comes into contact with each other then spreads apart. Nevertheless, the area of the contact path remains about the same as the pulley rotates. The surface roughness, or in other words, the coefficient of friction between the belt and the pulley remains constant through out the rotation of the pulley.

(80) The laser **80** may be rated at a particular wattage. By way of example and not limitation, the laser **80** may be a 70 watt laser **80**.

(81) Referring now to the chart below, the laser **80** may be adjusted differently for each of the roughing pass, smoothing pass and annealing pass. When the laser **80** makes the roughing pass, the laser **80** is set to the roughing setting shown below. In this regard, the roughing setting may create a plurality of kerfs **150** having a kerf width **170** between about 0.004 inches and about 0.0021 inches. The laser beam **80** may pass over the area **152** two times. During the first pass, the laser beam **78** may have a crosshatching angle **172** of about 45°. During the second pass, the laser beam **78** may

have a crosshatching angle **172** of about 180°. The laser beam **78** runs parallel with respect to the central axis **46** of the body **18**. The laser **80** may be set at 90% power for a 70 watt laser **80**. The pulse width **178** of the laser beam **78** may be set to 420 ns. The laser beam **78** travels on the surface **32** of the body **18** at around 80 inches per second during the roughing pass. The roughing pass creates a plurality of kerfs **150** and projects the recast material **166** upward to form peaks **168**. The setting for the roughing pass may be set so as to create an aggressive texture in that the peaks **168** may tear a belt running on the pulley during use of the pulley. As such, the roughing pass may be followed up with a smoothing pass.
(82) TABLE-US-00001 TABLE 1 Settings of laser machine for 17-4 stainless steel Stainless steel Roughing Smoothing Annealing setting setting Setting Kerf width 0.004 0.0038 0.0026 including recast inches inches inches material Kerf width not About .0021 About .0022 About .0019 including recast inches inches inches Cross hatching 45/180 45 45 angles (parallel degrees degrees degrees lines to fill an area, 180 degrees, 90 degrees, 45 degrees and 120 degrees. (Option of outlining area)) Size of cross Min. distance Smaller Greater hatching between parallel than kerf than kerf lines is width of the width of greater than roughing annealing the kerf width of setting setting the roughing setting plus 0.0005 inches to 0.004 inches (preferably, 0.004 inches or double the kerf width for a kerf width of 0.002 inches) Power of machine 90% of 90% of 55% of and % wattage 70 watt 70 watt 70 watt Pulse width 420 200 30 nanoseconds nanoseconds nanoseconds (34 waveform) (2 waveform) (22 waveform) Speed 80 inches per 60 inches per 35 inches per second second second
(83) The smoothing pass rounds out the peaks **168** of the recast material **166**. In order to do so, the kerf width **170** is set to be smaller than the kerf width **170** during the roughing pass. In our example, the kerf width **170** for the smoothing pass is set to be about equal to the kerf width **170** during the roughing pass. The crosshatching angle **172** is set to the crosshatching angle **172** of the roughing pass. In our example, the roughing pass had two different crosshatching angles **172**. The crosshatching angle **172** during the smoothing pass may be set to either one of the crosshatching angles **172** used during the roughing pass. The distance **174** of the crosshatching may be smaller than the kerf width **170** of the roughing pass. The reason is that the laser beam **78** during the smoothing pass needs to hit a significant amount of peaks **168** to round out or knock down the peaks **168**. In order to account for any misalignment between the laser beam **78** and the kerfs **150** made during the roughing pass, reducing the crosshatching size **174** to be smaller than the kerf width **170** of the roughing pass enables the laser **80** to round out a significant portion (i.e., more than 25%, 50% or 75%) of the peaks **168** of the recast material **166**. The smoothing pass is not meant to generate new indentations in the surface **32** of the body **18**. Rather, the smoothing pass is designed to round off the peaks **168** of the recast material **166**. In this regard, the pulse width is significantly reduced so that less energy is introduced into the surface **32** of the body **18**. Also, the speed of the laser is reduced in order to ensure that a significant portion of the peaks **168** generated during the roughing pass are rounded out or knocked down.
(84) After the roughing and smoothing passes, it is also contemplated that the surface **32** may be annealed by adjusting the laser **80** with the annealing setting shown above. The annealing pass may also be used to add color to the exterior surface. In annealing the surface **32** of the body **18**, the annealing takes place on the surface **32** of the body **18** to a depth of about a few thousandths of an inch below its exterior. Referring now to FIG. **13**, as the laser beam **78** passes over the outer surface **32** of the body **18**, the laser beam **78** introduces heat into the outer surface **32** of the body **18**. The center of the laser **78** introduces the most amount of energy into the outer surface **32** of the body **18**. As such, this position increases the temperature of the outer surface **32** the greatest amount. As one measures the temperature going away from that position on the surface **32**, the temperature of the surface **32** decreases as shown in FIG. **13**. When the laser beam **78** creates a hatching pattern, the laser beam **78** forms a series of parallel lines separated by distance **174**. In particular, the laser beam **78** introduces heat into the outer surface adjacent to a first line and raises

the temperature of the outer surface **32** in the same manner as before. However, there may be a slight overlap **184** so that the heat introduced into the outer surface **32** by the first line may be additive to the heat introduced into the outer surface **32** by the second line. The dashed line **186** shows the temperature fluctuation on the outer surface. The annealing settings on the laser **80** are set so that the temperature of the outer surface remains within a narrow band **188** sufficient to raise the temperature of the outer surface **32** to anneal or harden the outer surface **32** on the area **152** thereof or create a consistent discoloration thereof. The temperature range to anneal the outer surface for 17-4 stainless steel may be about 800 degrees Fahrenheit to about 1500 degrees Fahrenheit, and more preferably between about 900 degrees Fahrenheit to about 1150 degrees Fahrenheit.

(85) The settings for the roughing pass and the smoothing passes illustrate a power saturation of the laser beam which is applied to the surface being treated. As discussed above, the roughing pass cuts a groove into the surface being treated. Moreover, recast material is ejected which is attached to the surface of the groove and the area immediately adjacent to the groove. In contrast, the smoothing pass may form (e.g., vaporize) a groove in the surface to be treated. However, the smoothing pass predominantly smooths out the sharp edges and points in the recast. The setting of the laser shown in Tables 2-19 below forms a groove in the surface to be treated in a single pass for aluminum and stainless steel. However, the settings may be varied to form a groove in other materials in a single pass. These other materials may include but are not limited to composites, plastics, polymers, diamonds and other nonorganic materials. Recast may be disposed in the groove and the surface outside of the groove immediately adjacent to the groove. This recast may have sharp or rough enough to increase a coefficient of friction of the surface being treated but also not to tear into a rubber belt (e.g., Gates belt for an automobile).

(86) The settings specified in Tables 2-10 (shown below) are for a laser machine Model Number 200 Watt Air Cooled EP-Z manufactured by SPI for aluminum 7075-T6. Although aluminum 7075-T6 has been specified the settings disclosed herein may be utilized for a wide variety of aluminums. The specific settings shown in Table 2 provide a certain level of power saturation as a function of wave form, power density, beam spot size and speed to allow for comparable coefficients of friction with a single pass of the laser beam compared to the combination of roughing and smoothing passes described herein. Table 2 shows a laser machine with the power watt set to 200 watts, wave form set to 54, power density set to 1.24 mJ, beam spot size set to 10 um, and the speed of the laser set to 140 inches per second. With these settings, the surface of the material (e.g., aluminum 7075-T6) is modified to have kerfs. Each kerf has a kerf width **170***a* (see FIG. **12**) of about 0.002362 inches, kerf depth **171** (see FIG. **12**) of about 0.0045 inches, recast wall width **173** (see FIG. **12**) of about 0.001102 inches, recast edge to edge wall **175** (see FIG. **12**) of about 0.003937 inches, recast wall height **177** (see FIG. **12**) of about 0.004 inches which produces a created surface roughness or RA of 22 to 35 um from a surface initially having a surface roughness of about 2.5 um. Table 3 and Table 4 shows the kerf data when varying the laser speed setting of the laser machine. In Table 3, the laser speed is set to 100 inches per second, and the created surface roughness RA is about 22 to 35 um. In Table 4, the laser speed is set to 70 inches per second, and the created surface roughness RA is about 22 to 35 um.

(87) Tables 5-7 show the kerf data and created surface roughness when the laser machine is set to the same settings as in Tables 2-4 but the power watt is set to 150 watts. Tables 8-10 show the kerf data and created surface roughness when the laser machine is set to the same settings as in Tables 2-4 but the power watt is set to 100 watts. For settings shown in FIGS. **2-10**, the laser of the laser machine may be passed over the surface once and produce the created surface roughness RA identified in Tables 2-10.

(88) TABLE-US-00002 TABLE 2 Power Watt 200 W Recast Recast Recast Created Kerf Kerf Wall Edge to wall Surface Data Width Depth Width Edge Wall height RA Wave 54 0.0023622 0.0045 0.00110236 0.00393701 0.004 22-35 um PWR 1.24 mJ Density Beam 10 um Spot Size Speed 140

IPS

(89) TABLE-US-00003 TABLE 3 Power Watt 200 W Recast Recast Recast Created Kerf Kerf Wall Edge to wall Surface Data Width Depth Width Edge Wall height RA Wave 54 0.00251969 0.005 0.00114173 0.00425197 0.005 22-35 um PWR 1.24 mJ Density Beam 10 um Spot Size Speed 100 IPS

(90) TABLE-US-00004 TABLE 4 Power Watt 200 W Recast Recast Recast Created Kerf Kerf Wall Edge to wall Surface Data Width Depth Width Edge Wall height RA Wave 54 0.0023622 0.006 0.00188976 0.00543307 0.006 22-35 um PWR 1.24 mJ Density Beam 10 um Spot Size Speed 70 IPS

(91) TABLE-US-00005 TABLE 5 Power Watt 150 W Recast Recast Recast Created Kerf Kerf Wall Edge to wall Surface Data Width Depth Width Edge Wall height RA Wave 54 0.00244095 0.004 0.00059055 0.00338583 0.0035 22-35 um PWR 1.24 mJ Density Beam 10 um Spot Size Speed 140 IPS

(92) TABLE-US-00006 TABLE 6 Power Watt 150 W Recast Recast Recast Created Kerf Kerf Wall Edge to wall Surface Data Width Depth Width Edge Wall height RA Wave 54 0.00232284 0.0045 0.00070866 0.00374016 0.004 22-35 um PWR 1.24 mJ Density Beam 10 um Spot Size Speed 100 IPS

(93) TABLE-US-00007 TABLE 7 Power Watt 150 W Recast Recast Recast Created Kerf Kerf Wall Edge to wall Surface Data Width Depth Width Edge Wall height RA Wave 54 0.00212598 0.005 0.00114173 0.00452756 0.005 22-35 um PWR 1.24 mJ Density Beam 10 um Spot Size Speed 70 IPS

(94) TABLE-US-00008 TABLE 8 Power Watt 100 W Recast Recast Recast Created Kerf Kerf Wall Edge to wall Surface Data Width Depth Width Edge Wall height RA Wave 54 0.00188976 0.0025 0.0003937 0.00295276 0.002 22-35 um PWR 1.24 mJ Density Beam 10 um Spot Size Speed 140 IPS

(95) TABLE-US-00009 TABLE 9 Power Watt 100 W Recast Recast Recast Created Kerf Kerf Wall Edge to wall Surface Data Width Depth Width Edge Wall height RA Wave 54 0.00185039 0.0035 0.0007874 0.00322835 0.003 22-35 um PWR 1.24 mJ Density Beam 10 um Spot Size Speed 100 IPS

(96) TABLE-US-00010 TABLE 10 Power Watt 100 W Recast Recast Recast Created Kerf Kerf Wall Edge to wall Surface Data Width Depth Width Edge Wall height RA Wave 54 0.00173228 0.004 0.00106299 0.0038189 0.004 22-35 um PWR 1.24 mJ Density Beam 10 um Spot Size Speed 70 IPS

(97) The settings specified in Tables 11-19 (shown below) are for a laser machine Model Number 200 Watt Air Cooled EP-Z manufactured by SPI for stainless steel 17-4PH H900. Although stainless steel 17-4PH H900 is specified similar settings may be utilized on a wide range of stainless steels. The specific settings shown in Table 11 provide a certain level of power saturation as a function of wave form, power density, beam spot size and speed to allow for comparable coefficients of friction with a single pass of the laser beam compared to the combination of roughing and smoothing passes described herein. Table 11 shows a laser machine with the power watt set to 200 watts, wave form set to 54, power density set to 1.24 mJ, beam spot size set to 10 um, and the speed of the laser set to 140 inches per second. With these settings, the surface of the material (e.g., stainless steel 17-4PH H900) is modified to have kerfs. Each kerf has a kerf width **170***a* (see FIG. **12**) of about 0.0016 inches, kerf depth **171** (see FIG. **12**) of about 0.004 inches, recast wall width **173** (see FIG. **12**) of about 0.0016 inches, recast edge to edge wall **175** (see FIG. **12**) of about 0.0049 inches, recast wall height **177** (see FIG. **12**) of about 0.005 inches which produces a created surface roughness or RA of 22 to 35 um from a surface initially having a surface roughness of about 2.5 um. Table 12 and Table 13 shows the kerf data when varying the laser speed setting of the laser machine. In Table 12, the laser speed is set to 100 inches per second, and the created surface roughness RA of 22 to 35 um. In Table 13, the laser speed is set to 70 inches per

second, and the created surface roughness RA of about 22 to 35 um.

(98) Tables 14-16 show the kerf data and created surface roughness when the laser machine is set to the same settings as in Tables 11-13 but the power watt is set to 150 watts. Tables 17-19 show the kerf data and created surface roughness when the laser machine is set to the same settings as in Tables 11-13 but the power watt is set to 100 watts. For settings shown in FIGS. **11-19**, the laser of the laser machine may be passed over the surface once and produce the created surface roughness RA identified in Tables 11-19.

(99) TABLE-US-00011 TABLE 11 Power Watt 200 W Recast Recast Recast Created Kerf Kerf Wall Edge to wall Surface Data Width Depth Width Edge Wall height RA Wave 54 0.00165354 0.004 0.0015748 0.00492126 0.005 22-35 um PWR 1.24 mJ Density Beam 10 um Spot Size Speed 140 IPS

(100) TABLE-US-00012 TABLE 12 Power Watt 200 W Recast Recast Recast Created Kerf Kerf Wall Edge to wall Surface Data Width Depth Width Edge Wall height RA Wave 54 0.0019685 0.005 0.00125984 0.00472441 0.0035 22-35 um PWR 1.24 mJ Density Beam 10 um Spot Size Speed 100 IPS

(101) TABLE-US-00013 TABLE 13 Power Watt 200 W Recast Recast Recast Created Kerf Kerf Wall Edge to wall Surface Data Width Depth Width Edge Wall height RA Wave 54 0.00393701 0.0065 0.00066929 0.00496063 0.002 22-35 um PWR 1.24 mJ Density Beam 10 um Spot Size Speed 70 IPS

(102) TABLE-US-00014 TABLE 14 Power Watt 150 W Recast Recast Recast Created Kerf Kerf Wall Edge to wall Surface Data Width Depth Width Edge Wall height RA Wave 54 0.0015748 0.0035 0.00137795 0.00468504 0.004 22-35 um PWR 1.24 mJ Density Beam 10 um Spot Size Speed 140 IPS

(103) TABLE-US-00015 TABLE 15 Power Watt 150 W Recast Recast Recast Created Kerf Kerf Wall Edge to wall Surface Data Width Depth Width Edge Wall height RA Wave 54 0.0019685 0.004 0.0011811 0.00362205 0.003 22-35 um PWR 1.24 mJ Density Beam 10 um Spot Size Speed 100 IPS

(104) TABLE-US-00016 TABLE 16 Power Watt 150 W Recast Recast Recast Created Kerf Kerf Wall Edge to wall Surface Data Width Depth Width Edge Wall height RA Wave 54 0.00370079 0.005 0.00070866 0.00476378 0.0015 22-35 um PWR 1.24 mJ Density Beam 10 um Spot Size Speed 70 IPS

(105) TABLE-US-00017 TABLE 17 Power Watt 100 W Recast Recast Recast Created Kerf Kerf Wall Edge to wall Surface Data Width Depth Width Edge Wall height RA Wave 54 0.00098425 0.015 0.00149606 0.00338583 0.001 22-35 um PWR 1.24 mJ Density Beam 10 um Spot Size Speed 140 IPS

(106) TABLE-US-00018 TABLE 18 Power Watt 100 W Recast Recast Recast Created Kerf Kerf Wall Edge to wall Surface Data Width Depth Width Edge Wall height RA Wave 54 0.0011811 0.003 0.00137795 0.00318898 0.002 22-35 um PWR 1.24 mJ Density Beam 10 um Spot Size Speed 100 IPS

(107) TABLE-US-00019 TABLE 19 Power Watt 100 W Recast Recast Recast Created Kerf Kerf Wall Edge to wall Surface Data Width Depth Width Edge Wall height RA Wave 54 0.00173228 0.004 0.0015748 0.00354331 0.0015 22-35 um PWR 1.24 mJ Density Beam 10 um Spot Size Speed 70 IPS

(108) The various settings described herein were for stainless steel and aluminum. However, the general principles of forming the roughing setting, smoothing setting and the annealing settings may be applied to other types of metallic materials such as alloys of iron and carbon, steel, magnesium alloy, sheet metal, aluminum, carbon steel, etc. with different settings per their own material characteristics. The settings are for a model 70W_EP_Z from SPI Lasers, LLC. FIG. **14** is a table of settings for 17-4 stainless steel and aluminum. The table illustrates a slightly different setting for 17-4 stainless steel compared to the chart above in that the smoothing pass may be

accomplished with two passes instead of one pass as discussed above. The table in FIG. **14** illustrates two different settings for aluminum. The first setting sets the laser so that the aluminum material is in a sense micro machined with a slight recast material protruding upward, whereas the second setting sets the laser to have more recast material protrude upward compared to the first setting. The first and second settings may illustrate a range of settings for aluminum.

(109) The various aspects described herein are in relation to the formation of an emboss and deboss of a textured surface on a surface of a pulley having a plurality of grooves wherein the pulley grooves engage a belt in order to transmit power from a first shaft upon which the pulley is mounted to a second shaft generally parallel to the first shaft. Moreover, the various aspects described herein for the emboss and deboss of a textured surface have also been described in relation to forming the embossed/debossed textured surface on pulleys of a continuously variable transmission or CVT. The embossed/debossed textured surface is formed on first and second parts of a pulley of the CVT, and more particularly on a gripping surface which is where the belt engages for transmitting power between the first and second shafts. More broadly, it is also contemplated that the method and apparatus for forming the emboss or debossed textured surface may be applied to other applications including but not limited to the following applicational uses. The embossed or debossed textured surface may be formed on a pulley having a helical groove or a straight or helical gear, flat cylindrical pulley, etc. By way of example and not limitation, a drum such as the drum shown in FIG. **24** may have a plurality of belts mounted thereto for transmitting power to or from the drum to a second shaft. The embossed or debossed textured surface may be formed on the drum where the drum engages the belt. The embossed or debossed textured surface may also be formed on a spindle of a lathe. Broadly speaking the embossed or debossed textured surface may be formed utilizing the method and apparatus as described herein on a surface that is used to engage a belt or other power transmission means to increase the coefficient of friction of the surface in order to prevent slippage between the power transmission means and the surface.

(110) Referring now to FIGS. **15-25**, a friction patch or lines may be applied to a wheel rim **200** so that a tire **202** does not slip and cause the tire to be unbalanced because of tire slippage on the rim **200** (see FIGS. **15-23**), a flat pulley **204** (see FIG. **24**) or a pulley **206** with grooves (see FIG. **25**). The friction patch may be formed by the emboss or deboss methods described above including but not limited to laser infusing particulates on the surface or milling or laser removing material from the surface.

(111) More particularly, referring now to FIGS. **15-23**, formation of the friction patch on the wheel rim **200** will be described in relation to the deboss method and apparatus discussed in relation to FIGS. **9-13** above. FIG. **15** illustrates a racecar **208**. The racecar starts from 0 miles per hour and accelerates and reaches a high speed as fast as possible in a few seconds. In order to do this, the drive wheels create a high amount of torque in order to propel the racecar **208** forward. The highest level of torque is achieved when the racecar **208** first accelerates from standstill. The goal is to achieve the highest level of torque with minimal slippage between the tire **202** and the road **210**. Unfortunately, in generating the highest level of torque, a small amount of slippage may occur between the tire **202** and the rim **200**. As shown in FIG. **16**, when the racecar **208** accelerates forward, the wheels rotate counterclockwise. Unfortunately, even if there is a small amount of slippage between the rim **200** and the tire **202**, the wheel (i.e., tire and rim) eventually becomes unbalanced. On a typical race day, the car may be involved in multiple races. Each race generates slip between the rim **200** and the tire **202** so that by the end of the day, the slip may be about 4 linear inches. At the start of the race day, the tire **202** is balanced on the wheel rim **200**. In this way, when the racecar **208** reaches a high-speed, the wheel does not wobble due to any imbalance. Unfortunately, when the rim **200** and the tire **202** slips with respect to each other when the racecar **208** starts out of the gate, the tire rotates and the wheel is now unbalanced. As the racecar **208** reaches its top speed, the wheel may begin to wobble because of the unbalance. Throughout the day, the tire **202** slips on the rim **200** and becomes more and more unbalanced.

(112) Referring now to FIG. **17**, a cross-sectional view of the wheel including the tire **202** and the rim **200** is shown. FIG. **18** illustrates a motorcycle rim **200***a* and a passenger car rim **200**. The rims **200**, **200***a* has a bead seat **212** and a flange **214**. The bead seat **212** is between the bead hump **215** and the flange **214**. The friction patch may be formed on the bead seat **212** and/or the flanged surface **214**. The friction patch may be formed with laser by performing a roughing pass over the bead seat **212** and/or the flange surface **214**. Optionally, a smoothing pass may also be performed on the bead seat **212** and the flange **214**. Moreover, as an additional optional step, an annealing pass may also be performed on the bead seat **212** and the flanged **214**. The roughing pass, smoothing pass, and annealing pass may be formed 360° around the rim **200**, **200***a*. To conduct the passes on the rim **200**, the rim **200** may be mounted to a laser as discussed above. Although a friction patch may be applied to the bead seat and flange, it is also contemplated that friction lines may be applied thereto in that they are intermittent patches or lines about a circumference of the wheel rim **200**, **200***a*. Although the friction patch has been described as being formed as a laser-induced deboss, it is also contemplated that the friction patch may be formed with a laser-induced emboss method described above as well as mechanically forming the friction patch within end mill.
(113) Referring now to FIG. **19**, a top view of the bead seat **212** and flange **214** is shown. The friction patch or lines **216** are shown. Only two (2) of the friction lines **216** are shown for the purposes of clarity. The friction lines **216** may be formed about the entire circumference of the wheel rim **200**, **200***a*. They may be spread apart evenly throughout the circumference of the rim. The friction lines **216** may be formed so that they **216** are skewed with respect to a rotating axis of the wheel rim **200**, **200***a*. For example, the friction lines **216** may be skewed in a backward direction with respect to a rotational axis **218** of the wheel rim **200**, **200***a*, as shown in FIG. **19**. Alternatively, the friction lines **216** may be skewed in a forward direction with respect to a rotational rotation **218** of the wheel rim **200**, **200***a*, as shown in FIG. **20**. The friction lines **216** mitigate slippage between the tire and the rim **200**, **200***a*. If there is slippage between the tire and the rim, then such slippage is minimal (e.g. less than ½ inch, more preferably less than ⅛ inch for automotive drag racing situation). Moreover, if there is slippage between the tire and the rim, the friction lines **216** may tear into the tire. Any portion of the tire that is removed by the friction lines **216** may be urged out to the side **220** of the wheel rim because of the backwards slant of the friction lines **216**. For the forward skewed friction lines **216** shown in FIG. **20**, the torn up tire may be urged into the tire because of the forward slant of the friction lines **216**. The bits of torn up tire may works its way to the outside or the inside of the rim by way of the smooth portion of the rim between the friction lines **216** without the friction lines **216**. The skew angle between the friction lines **216** and the rotational axis **218** may be between 20 degrees to 80 degrees. At zero degrees skew angle, the friction lines **216** would be parallel to the rotational axis **218**. Preferably, the skew angle between the friction lines **216** and the rotational axis **218** may be 45 degrees. The friction lines **216** may have a width **222** of about 1/32″ to ½ “and may have a gap **224** away from an adjacent friction line **216** between about 1/32” to ½ “. Preferably, the width **222** of the friction lines **216** is 1/32” and the gap **224** is about 1/32″. Instead of friction lines **216**, a friction patch may be formed continuously about the wheel rim **200**, **200***a*. The friction lines shown in FIGS. **21-23** are not spaced apart but are close together so as not to form a significant space so that torn up tire can work its way to the outside or the inside of the rim. In FIG. **21**, the friction lines have a backwards slant. Alternatively, the friction lines may have a forward slant. In FIG. **22**, the friction lines have a combination backwards and forward slant formed into a V shape. In FIG. **23**, the friction lines have a cross hatch.
(114) Referring now to FIGS. **21** and **22**, the friction patch formed via laser infusing particulates into the surface or laser debossing material from the surface may be formed on an exterior surface of a flat round drum pulley **204** or a V-shaped groove pulley **206**.
(115) In another aspect, and with reference to FIGS. **26-37**, it is contemplated that a friction surfaces described herein may be applied to an exterior surface **307** (i.e., preferably on at least

opposed sides) of a socket **301** of a fastening tool **300** so that when the socket **301** needs to be pulled off a head of a fastener, the user may do so with his or her hand instead of having to dislodge the socket **301** first with a blunt object, such as a hammer. The friction surface may be applied to the exterior surface with the laser induced friction process described above both in terms of a laser induced emboss and laser induced deboss described herein. Put simply, the friction surface may be a laser induced emboss and/or laser induced deboss (i.e., kerf with recast material). By way of example and not limitation, the friction surface may be formed with a laser by lasering the friction surface (including lines) using the roughing and smoothing passes described herein as well as the single pass lasering discussed herein. The settings on the laser machine may be adjusted to further decrease a coefficient of friction of the resultant roughing and smoothing passes and the single lasering pass discussed herein so that a person's skin is not damaged by gripping the tool on the laser induced friction surface of the tool.

(116) With further reference to FIG. **26**, a perspective view of a fastening tool **300** having a socket **301** and a socket wrench **303** with laser induced friction surfaces **305**, **309** is shown. As shown, the socket **301** may have formed thereon a friction surface or lines **305**. Similarly, the socket wrench **303** may comprise of a friction surface or lines **309**. The friction surfaces **305**, **309** increase the coefficient of friction on the surface of the socket **301** and the socket wrench **303** to help the user better grip and pull off the fastening tool from a head of a fastener when stuck together. The friction surface or lines **305**, **309** may be formed on at least opposed sides of the socket or it may circumscribe the socket so that the user can grip anywhere on opposed sides of the socket to pull of the socket from a head of a fastener.

(117) The friction surfaces or lines **305**, **309** may be formed using the methods described herein (i.e., laser induced deboss and/or laser induced deboss). By way of example and not limitation, the friction surfaces **305**, **309** may be formed by fusing particulate matter to the outer surface **307** of the socket or the outer surface **311** of the socket wrench with a laser. By way of example and not limitation, the friction surfaces **305**, **309** may be formed by lasering a plurality of kerfs with recast material. By way of example and not limitation, the plurality of kerfs having recast layers may be formed into patterns as describe herein. Additionally, the kerfs and recast material creating the friction surfaces **305**, **309** may be formed at an angle or alternatively in linear patterns.

(118) Referring now to FIG. **27** and FIG. **28**, a front and rear perspective views of a socket **301** are shown. Generally, the socket **301** comprises a body with an outer surface **307** and a first and second openings **313**, **315**, where the first opening **313** has a first inner surface **321** configured to engage with a head portion of a fastener and the second opening **315** has a second inner surface **317** configured to engage with a socket wrench **303**. The socket **301** described herein may embody many different types of sockets that include, but not limited to, a four-point, six-point, eight-point, or twelve-point socket, a universal-fit socket, a bit socket, an impact socket, a spline socket, a spark plug socket, or possibly an insulated socket. Socket adapters and extensions may also benefit from having a friction surface on their outer surface.

(119) With reference to FIG. **27**, the first opening **313** may also be known as the socket head opening and is used to grip and tighten or loosen a fastener. The socket head opening **313** has a shape for a head portion of a fastener to fit inside. The socket head opening **313** comprises an inner surface **321** with a plurality of internal walls **325** and pointed intersections **327** between where the internal walls meet **325**. The inner surface **321** of the socket head opening **313** is configured to engage a head of a fastener for tightening or loosening. The number of the internal walls **325** and pointed intersections **327**, or points, depend on the type of fastener the socket **301** is designed to fasten. By way of example and not limitation, the socket head opening **313** would comprise of six internal walls **325** and six pointed intersections **327** orientated in a hexagon shape if the socket is designed to fasten a hex bolt, which has a hexagonal head. By way of example and not limitation, the socket head opening **313** may comprise internal walls **325** and intersections **327** designed to fasten a hex bolt, where the doubling of internal walls and pointed intersections allows for an easier

connection to the head of a fastener. In the art, sockets are categorized by the number of pointed intersections that are present in the inner surface **321** of the socket head opening **313**, which correspond to the type of fastener head the socket **301** can tighten and loosen. The pointed intersections **327** of a socket may range from four to twelve points. There also exists universal sockets that are designed to fasten a variety of fasteners with different types of fastening heads. Another way that sockets are categorized is by the size of the socket head opening **313**, which the size could be in metric or the imperial system. The friction surface may be formed with the laser induced deboss and emboss methods described herein which may be referred to as the laser induced friction surface or lines.

(120) With reference to FIG. **28**, the second opening **315** may also be known as the drive socket opening that is used to attach the socket **301** (see FIG. **26**) to a socket wrench **303**, as described herein. The drive socket opening has a shape for a shaft of the socket wrench to fit inside. By way of example and not limitation, the drive socket opening **315** may be a square shaped hole. The drive socket opening **315** may come in at least five sizes: ¼″, ⅜″, ½″, ¾″, and **1**″. The drive socket opening **315** comprises of an inner surface **317** configured for a drive shaft or drive square of the socket wrench **303** to fit inside and engage and lock with the socket **301**. By way of example and not limitation, the inner surface **317** of the drive socket opening **315** may have an engagement surface **319**, such as a notch or groove, for the shaft of the socket wrench, which may comprise a ball bearing, to engage or lock with the socket. By way of example and not limitation, a plurality of engagement surfaces may exist on the inner surface **317** and inside the drive socket opening. By way of example and not limitation, the engagement surface **319** may be substituted with a drive socket side hole penetrating from the inner surface **317** to the outer surface **307** of the body.

(121) The body of the socket **301** has an outer surface **307** that is in between the outer periphery of the socket head opening **313** and the outer periphery of the drive socket opening **315**. The outer surface **307** of the socket is typically cylindrical but other shapes are also contemplated such as cubical, triangular, and hexagonal. The socket may also be made from a steel alloy such as chromium-vanadium steel or chromium-molybdenum steel but may be manufactured from other materials such as titanium alloy, aluminum alloy, or material used in 3D printing. By way of example and not limitation, the outer surface **307** of the socket **301** may be chrome plated for corrosion resistance and other beneficial features.

(122) As shown in FIG. **29**, the outer surface may have a stepped collar portion **329** that tapers the outer surface **307** of the socket to transition between the drive socket opening **315** and the socket head opening **313**. The outer surface **307** may have an identifier portion **331** that specifies the features of the socket. Such features may include the brand name of the socket, the drive socket opening size, the socket head opening size, or the amount of pointed intersection the socket has. In FIG. **29**, the identifier portion **331** is shown as a generic dashed square area but such dash square area may have letters, numbers, symbols to identify the socket. The laser induced friction surface may be formed as the letters, numbers and symbols to serve as the identifier portion **331** and specify the features of the socket **301**, such as the size of the socket. Second, the user can use the laser induced friction surface to pull off the socket **301** from the head of the bolt if it is stuck on the bolt head. The identifier portion **331** can circumscribe the outer surface **307** of the socket so that the laser induced friction surface is on opposed sides of the outer surface **307**. Also, it is contemplated that two identifier portion **331** may be formed on opposed sides of the outer surface **307**. The identifier portions **331** on opposed sides may be identical or be different from each other. In this way, when the user grips the socket, they can grip the opposed sides to get a good purchase on the socket. It is also contemplated that the internal walls **325** or the pointed intersections **327** of the inner surface **321** of the socket head opening **313** may also have friction surfaces or lines.

(123) The laser induced friction surfaces or lines **305** may be orientated in any orientation that allows the user to grip the socket **301** with his or her hands and remove the socket from the head of the fastener, which the term hands includes the fingers and the palm of the hand. At a minimum,

there may exist two opposing friction surfaces or lines **305** on the outer surface **307** of the socket **301** for the user to grip with his or her fingers, which the term fingers include the user's thumb. The two opposing friction surfaces or lines **305** may both be part of a continuous surface or line running along the outer surface **307** or be two different surfaces or lines. As discussed herein the friction lines may be axially aligned to a rotating axis of the socket or circumferential. It is also contemplated that the friction lines may be oblique to the rotational axis of the socket. Alternatively, the laser induced friction surface may cover the whole outer surface **307** of the socket **301**. By way of example and not limitation, the laser induced friction surfaces or lines **305** may be on the chrome plating that covers the outer surface **307** of the socket.

(124) Referring now to FIGS. **30**A and **30**B, a perspective view and front view of the socket is shown where the laser induced friction surfaces or lines may run longitudinally along a rotational axis of the body of the socket. There may be at least two longitudinal friction surfaces or lines **333***a, b* running across the body and on opposite sides of the outer surface **307** so that a user can grip the socket **301** with only two digits (i.e., fingers). The at least two longitudinal friction surfaces or lines may run across the whole length of the socket **301** or only partially across the length. The at least two longitudinal friction surfaces or lines may be considered as a single line if the two opposing lines both run across the full length of the outer surface **307** of the body and terminate at the socket head opening **313** and the drive socket opening **315**. More longitudinal friction surfaces or lines may be added to the outer surface of the socket to give the user a better grip of the socket when trying to pull the socket off the fastener head. By way of example and not limitation, the outer surface may have a first pair of longitudinal friction surfaces or lines **333***a, b* running across the outer surface **307** that are opposite to each other and a second pair of longitudinal friction surfaces or lines **333***c, d* running across the outer surface **307** that are opposite to each other. The first pair and second pair of longitudinal friction lines may be symmetrically spaced apart from each other. The outer surface may have additional number of longitudinal frictional lines such as between 3 to 24 longitudinal lines. Similarly, the additional number of longitudinal lines may be symmetrically spaced apart from each other.

(125) Referring now to FIGS. **31**A and **31**B, in another aspect, a perspective view and front view of the socket is shown where the laser induced friction surfaces or lines may run along the circumference of the outer surface **307** of the socket and be orientated parallel to the socket head opening **313** and drive socket opening **315**. There may be only one circumferential friction surface or line **335***a* running along the periphery of the outer surface **307** or a plurality circumferential friction surfaces or lines **335***a, b*. By way of example and not limitation, there may exist on the outer surface **307** at least two circumferential friction surfaces or lines **335***a, b* running along the circumference of the socket and spaced apart from each other. Additional circumferential friction surfaces may be added, such as the outer surface may have between 3 to 24 circumferential friction surfaces. By way of example and not limitation, the circumferential friction surfaces or lines **335***a, b* may occupy only an arc surface or a portion of the circumference of the outer surface. By way of example and not limitation, the circumferential friction surface **335***a* may cover the whole outer surface of the socket.

(126) The plurality of kerfs of the laser induced friction surfaces or lines may also form patterns or be skewed at an angle. By way of example and not limitation, the plurality of kerfs may form a circular, rectangular, or curved pattern that form the friction surface. The pattern of the kerfs of the friction surface may form a mark, word, or symbol. By way of example and not limitation, the plurality of kerfs may be aligned relative to each other in a linear pattern. By way of example and not limitation, the plurality of vaporized kerfs may be skewed with respect to a rotational axis of the socket. By way of example and not limitation, the skewing of the plurality of kerfs may be at a 30, 45, 60, 90, 120, 125, or 150 degree angle with respect to the rotational axis of the socket known as crosshatching angles.

(127) Referring now to FIGS. **32**, a block diagram of a method for removing a socket that is stuck

to a fastener is shown. A user of the socket may first undertake a dislocation step **337** where the user dislocates the socket from the socket wrench to better grip the socket in the gripping step **339**. By way of example and not limitation, the user may not need to undertake the dislocation step **339** and can try to pull the socket off the fastener while the socket is attached to the socket wrench.

(128) After the dislocation step **337** and during the gripping step **339**, the user may grip at least a portion of the socket that has the laser induced friction surfaces or lines. The user may use one hand or two hands to grip the socket at or near the friction surfaces. By way of example and not limitation, the user may use at least two fingers to grip the friction surfaces, which the term fingers include the user's thumbs. By way of example and not limitation, the user may use the palm of his or her hand in addition to his or her fingers to grip the socket at or near the friction surfaces or lines. The user may only use the palm of his hand to grip the friction surfaces or lines. By way of example and not limitation, the user may wrap his or her hands around the circumference of the socket that has the friction surfaces during the gripping step **339**. By way of example and not limitation, the user may only grip two opposite surfaces of the socket that have the friction surfaces. By way of example and not limitation, the user may also grip the fastener with his or her hand if the fastener has been unfastened but is stuck to the socket.

(129) The friction surfaces or lines used in the gripping step **339** may be formed on the outer surface of the socket as described elsewhere herein. In an example, the friction surfaces or lines may be laser induced and have a plurality of kerfs with recast material. The form, shape, and orientation of the friction surfaces or lines may be as described elsewhere herein.

(130) After gripping the socket at the friction surfaces or lines, the user may then pull and detach the stuck socket from the fastener during the pulling step **345**. The pulling is done while the user is gripping the friction surfaces or lines of the socket. The user may pull the socket in the opposite direction relative to where the fastener is located. By way of example and not limitation, the user may twist the socket about the rotational axis of the socket while also pulling. By way of example and not limitation, the user may shake the socket while pulling to help unstuck the socket from the fastener.

(131) The friction surfaces and lines have been described as being formed on opposed side surfaces of a socket of a socket wrench. However, it is also contemplated that the friction surfaces and lines may be formed on only one side of the socket. Moreover, the friction surfaces and lines may be formed on other components of the socket wrench including but not limited to the ratchet wrench (see FIG. **26**), universal joint **347** (see FIG. **33**), extension bar **349** (see FIG. **34**), bit adapter **351** (see FIG. **35**), soft flexible extension **353** (see FIG. **36**), and sliding bar **355** (see FIG. **37**). By way of example not limitation, in FIG. **26**, the friction surfaces or lines **309** is shown on a head portion of a socket wrench. The friction lines or surfaces **309** may be formed on one side of the head portion of the socket wrench (e.g., rachet wrench) or formed on opposite side surfaces of the head portion of the socket wrench. In this manner, the user may grip the head portion of the socket wrench and grip the socket on the friction lines or surfaces **309**, **305** of the socket wrench and the socket to pull the socket **301** off of the socket wrench **303**. The friction lines or surfaces may also be applied to one or opposed external side surfaces of the universal joint, extension bar, bit adapter, soft flexible extension, and sliding bar, and more particularly, to an external surface thereof where the user can grip these components.

(132) Refer now to FIG. **33**, friction lines or surfaces **305**, **309** are shown on an external surface of a female portion of the universal joint **347**. The friction lines or surfaces **305**, **309** may be formed on one side surface or on opposed side surfaces thereof. The friction lines or surfaces **305**, **309** are also shown on a male portion of the universal joint **347**. The friction lines or surfaces **305**, **309** may be formed on one side surface or on opposed side surfaces thereof.

(133) Referring now to FIG. **34**, friction lines or surfaces **305**, **309** are shown on an external surface of a shaft of the extension bar **349** as well as on a female portion of the extension bar **349**. The friction lines or surfaces **305**, **309** may be formed on one or on both opposed surfaces thereof.

(134) Referring now to FIG. **35**, friction lines and surfaces **305**, **309** are shown on an external surface of a mid-portion of the bit adapter **351**. The mid portion of the bit adapter **351** is the only portion that is exposed and where the user can grip the bit adapter during use of the bit adapter **351**. The friction lines or surfaces **305**, **309** may be formed on one or both side surfaces thereof. The friction lines or surfaces **305**, **309** maybe formed around the entire circumference of the mid portion of the bit adapter **351**.
(135) Referring now to FIG. **36** friction lines or surfaces **305**, **309** are shown on male and female end portions of the soft flexible extension **353**. The friction lines or surfaces **305**, **309** may be formed on one side surface or on both side surfaces thereof.
(136) Referring now to FIG. **37**, friction lines or surfaces **305**, **309** are shown on both handles of a sliding bar **355** as well as a main body of the sliding bar **355**. The friction lines or surfaces may be formed on one or both sides of the handles. The friction lines and services **305**, **309** may be oriented longitudinally with respect to the handles or it may circumscribe circularly about the handles. The friction lines and surfaces formed on the main body of the sliding bar **355** may be oriented vertically or circumscribe the main body horizontally.
(137) The friction lines and/or surfaces **305**, **309** may be formed on any gripping surface of a tool including but not limited to a handle of a tool.
(138) In forming the friction patches on the tool, the same may be formed with both the roughing pass and the smoothing pass but also only the roughing pass. One or more passes for the roughing pass and/or the smoothing pass are contemplated. As shown in the table below there may be 13 roughing passes or 13 roughing passes in combination with one or more and up to 13 smoothing passes. The greater number of passes, the less the coefficient of friction so that the grip doesn't hurt or feel uncomfortable to the skin of the person's hand. For the polymer parts of the tool where a friction patch is applied, the laser settings may have the following settings. The setting set forth below represent approximate settings and guidelines for a polymer material. For other materials such as stainless steel, the settings listed in Table 1 may be used as a guideline. The laser may be applied to the polymer and metallic parts of the firearm in a cross hatch pattern or as simple parallel lines. The polymer part may also create a recast with the settings provided below. The recast assists in providing for more grip and better purchase of the gripping surface of the tool (e.g., socket).
(139) TABLE-US-00020 TABLE 2 Settings of laser machine for a polymer material of a firearm Polymer Roughing Smoothing setting setting Roughing Smoothing (multiple (multiple setting setting passes) passes) Kerf width 0.01791 0.00406 0.02149 0.01169 including recast inches inches inches Inches material Kerf width not 0.00453 0.00146 0.00504 0.00311 including recast inches inches inches inches Cross hatching 90/180 90/180 90/180 90/180 angles (parallel deg deg deg deg lines to fill an area, 180 degrees, 90 degrees, 45 degrees and 120 degrees. (Option of outlining area)) Size of cross Min. distance Smaller than n/a n/a hatching between kerf width of parallel lines is the roughing greater than setting the kerf width of the roughing setting plus 0.010 inches to 0.050 inches (preferably, 0.025 inches or double the total kerf width for a kerf width of 0.0358 inches) Power of machine 100% of 70 78% of 70 100% of 70 78% of 70 and % wattage watt watt watt watt Pulse width 10 175 10 175 nanoseconds nanoseconds nanoseconds nanoseconds (28 waveform) (03 waveform) (28 waveform) (03 waveform) Speed 75 inches per second Passes needed to 1 1 13 13 obtain optimum results
(140) The above description is given by way of example, and not limitation. Given the above disclosure, one skilled in the art could devise variations that are within the scope and spirit of the invention disclosed herein, including usage of other types of lasers. Further, the various features of the embodiments disclosed herein can be used alone, or in varying combinations with each other and are not intended to be limited to the specific combination described herein. Thus, the scope of the claims is not to be limited by the illustrated embodiments.

## Claims

1. A socket for a socket wrench comprising: a metal body having an outer surface between an outer periphery of a drive socket opening and an outer periphery of a socket head opening, the drive socket opening having a first shape for a drive shaft of the socket wrench to fit inside and engage with an inner surface of the drive socket opening, the socket head opening having a second shape for a head portion of a fastener to fit inside and engage an inner surface of the socket head opening, the inner surface of the socket head opening comprising a plurality of internal walls and a plurality of intersections between where the internal walls meet; and the outer surface of the socket having a laser induced friction surface having a vaporized kerf with recast material, the vaporized kerf with recast material being on opposed sides of the metal body to facilitate removal of the socket from the socket wrench, wherein the coefficient of friction from the recast being so that a person's skin is not damaged by gripping the tool on the laser induced friction surface.
2. The socket of claim 1, wherein a first surface and a second surface of the laser induced friction surface run longitudinally across the outer surface of the metal body.
3. The socket of claim 1, wherein the laser induced friction surface runs across a circumferential section of the outer surface of the metal body.
4. The socket of claim 3, wherein the laser induced friction surface is a first laser induced friction surface and a second laser induced friction surface runs across a second circumferential section of the outer surface.
5. The socket of claim 1, wherein the laser induced friction surface defines a size identifier portion of the socket.
6. The socket of claim 1, wherein the plurality of vaporized kerfs of the laser induced friction surface are skewed with respect to a rotational axis of the socket.
7. The socket of claim 6, wherein the plurality of vaporized kerfs are skewed at a 45-degree angle with respect to the rotational axis of the socket.
8. The socket of claim 1, wherein the outer surface of the metal body is chrome plated.
9. The socket of claim 1, further comprising a second laser induced friction surface having a first surface opposite to a second surface of said second laser induced friction surface.
10. The socket of claim 1, wherein the laser induced friction surface defines at least one of a letter, number, symbol or combinations thereof which forms the identifier portion of the socket.
11. A method for removing a socket of a socket wrench that is stuck to a fastener, the method comprising: dislocating the socket wrench from the socket; gripping a first surface and an opposed second surface of the socket with a person's bare hand, the first and second surfaces having a vaporized kerf with recast material on an outer surface of a metal body of the socket; and pulling on the socket using the person's bare hands while gripping in the opposite direction of where the fastener is located, and wherein the recast material being sufficiently smooth so that a person's skin is not damaged by gripping the first and second surfaces and pulling on the socket.
12. The method of claim 11, wherein the pulling on the socket is accompanied by twisting the socket.
13. The method of claim 11, wherein the pulling on the socket is accompanied by shaking the socket.
14. The method of claim 11, wherein the gripping of the laser induced friction surface and the pulling on the socket is done with bare fingers of a hand.
15. The method of claim 11, wherein the gripping of the laser induced friction surface and the pulling on the socket is done with a bare palm of a hand.
16. The method of claim 11, wherein the laser induced friction surface runs along the circumference of the outer surface of the socket.
17. The method of claim 11, wherein the first and second surfaces of the laser induced friction

surface run longitudinally across the outer surface of the metal body.

18. The method of claim 11, wherein the laser induced friction surface is forms a size identifier portion of the socket.

19. The method of claim 11, wherein the laser induced friction surface defines at least one of a letter, number, symbol or combinations thereof which forms the identifier portion of the socket.