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(54) BI-METALLIC METAL INJECTION MOLDED HAND TOOL AND MANUFACTURING METHOD

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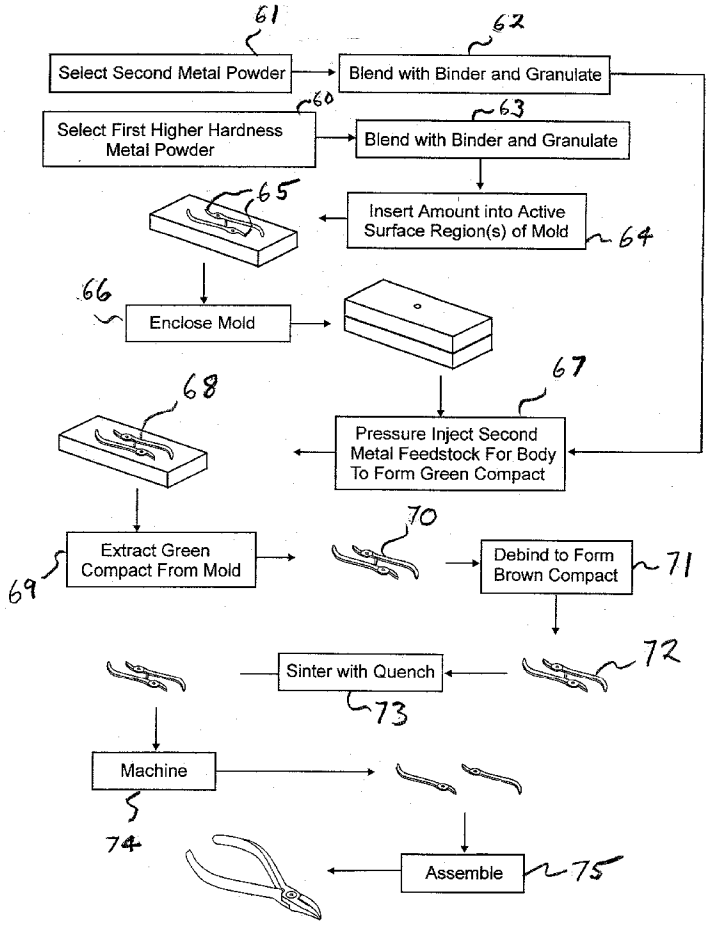
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(57) **ABSTRACT**

An injection molded metallic hand tool having a body portion made of a first metal and an active surface portion made of higher hardness metal more capable of operating on the work subject. For example, in a pair of pliers, the serrated jaws have gripping teeth active surface portion is made from a durable, high strength metal such as tool steel alloy and the remainder or body portion is made from stainless steel alloy. The tool is made through a metal injection molding process wherein an amount of high hardness metal particles is first placed or injected into the corresponding tip portion of the mold, then higher strength metal particles are injected to fill the remainder of the mold. In this way, complex bi-metallic parts may be inexpensively injection molded. This also creates an alloy matrix bond between the two different metal portions.



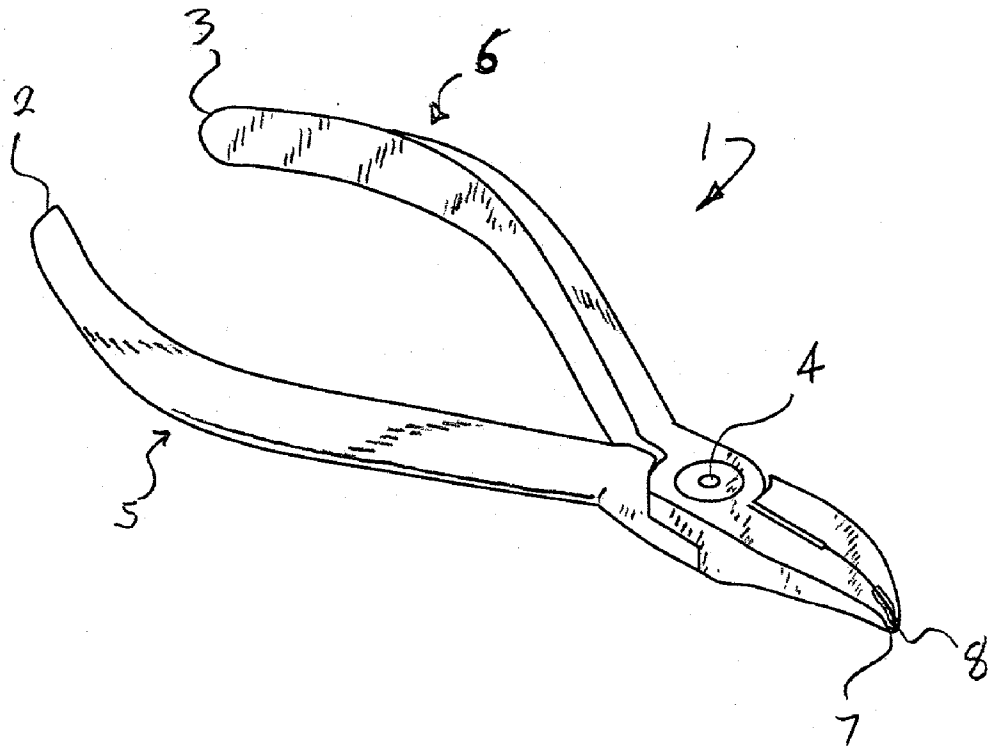


FIG. 1
Prior Art

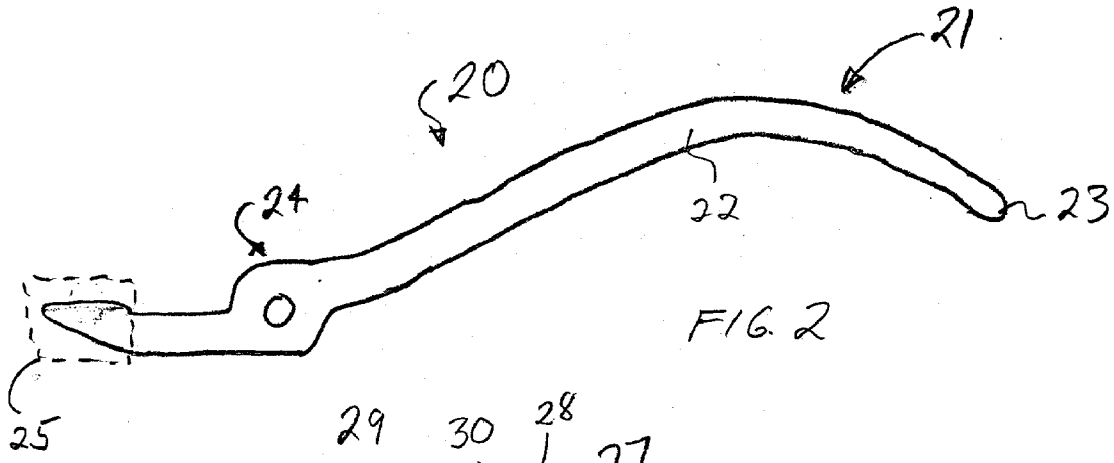


FIG. 2

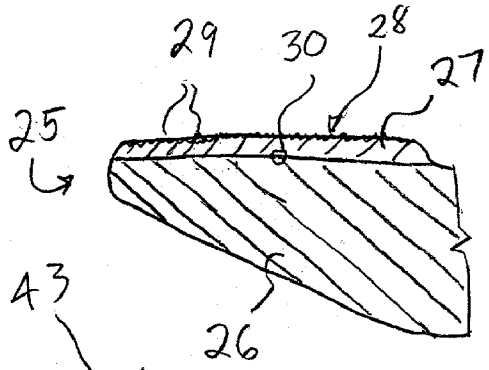


FIG. 3

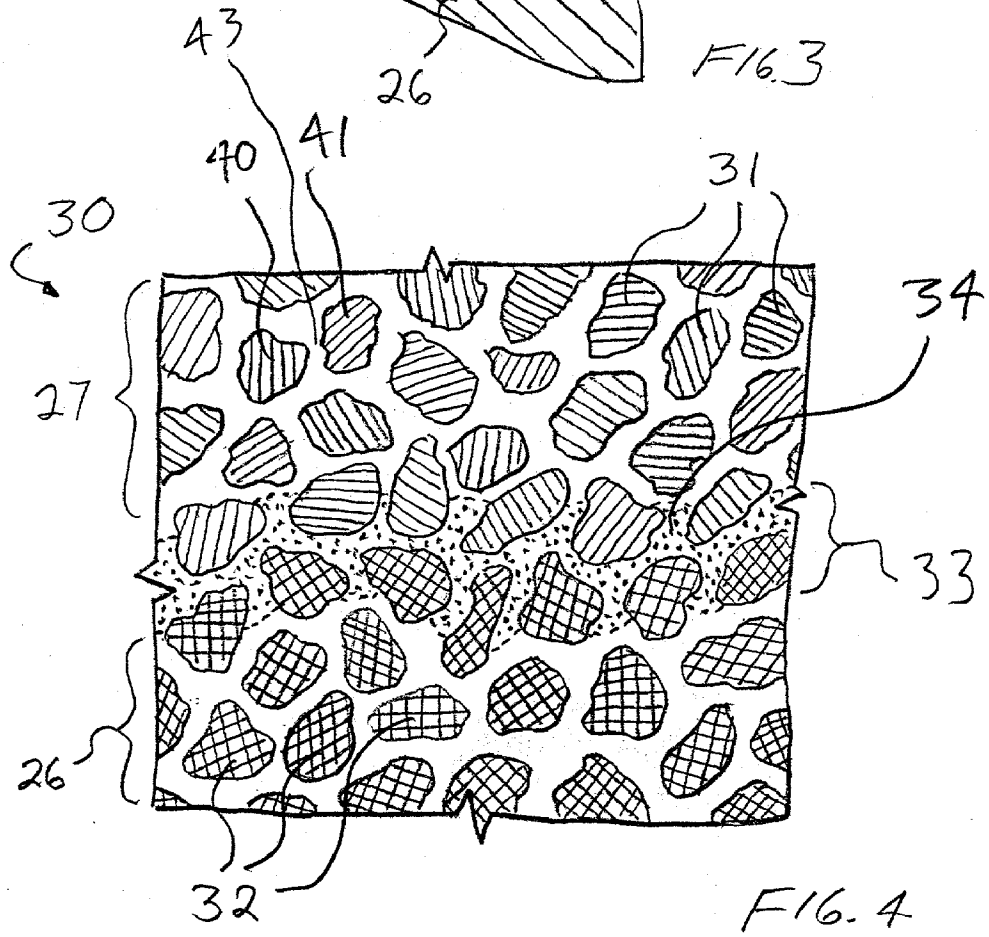


FIG. 4

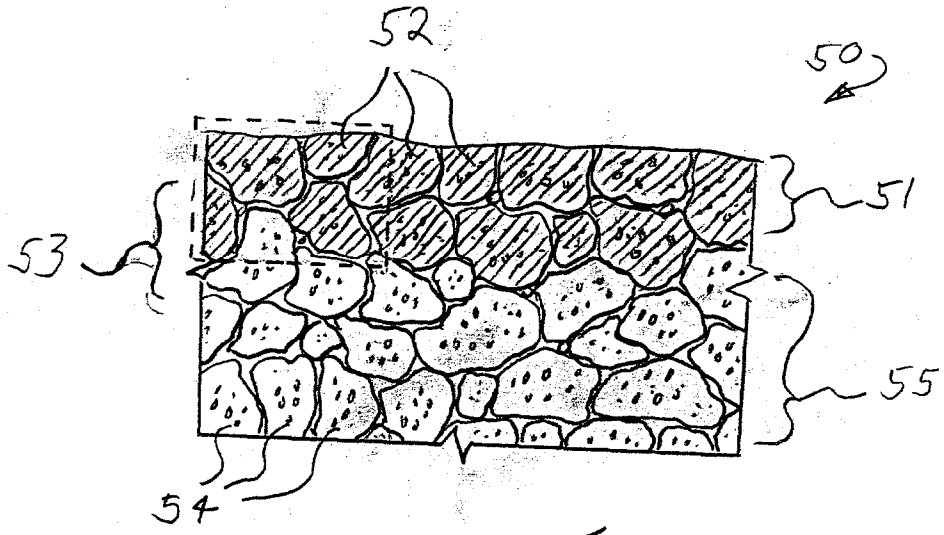


FIG 5

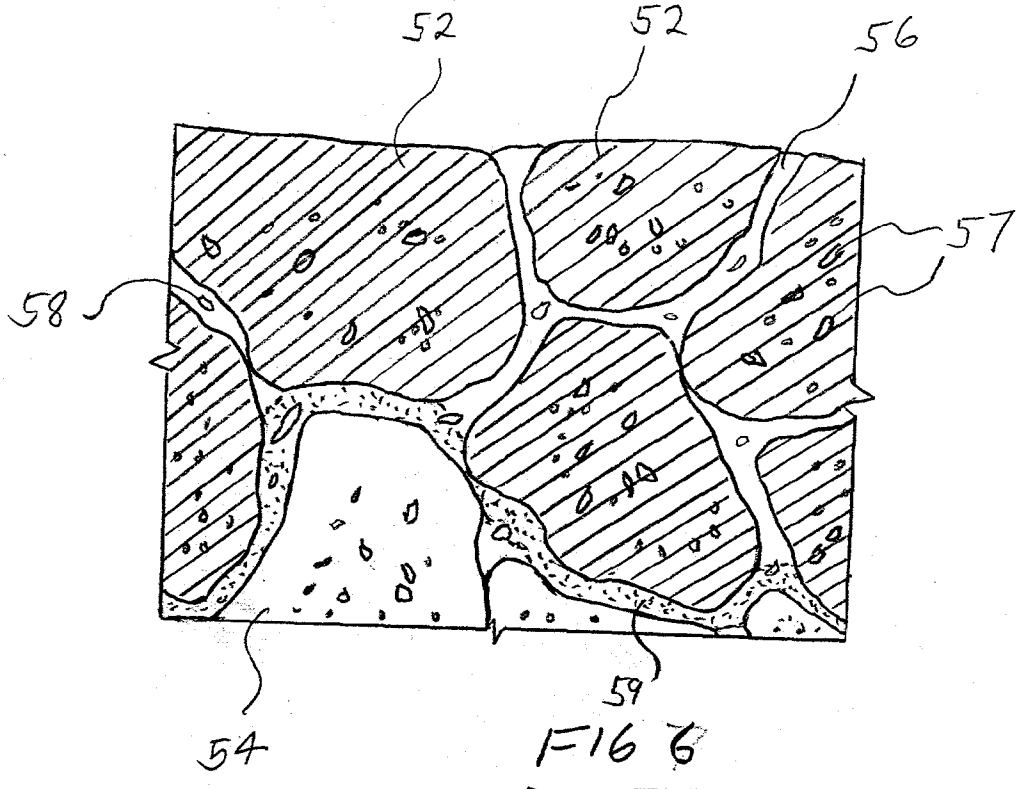


FIG 6

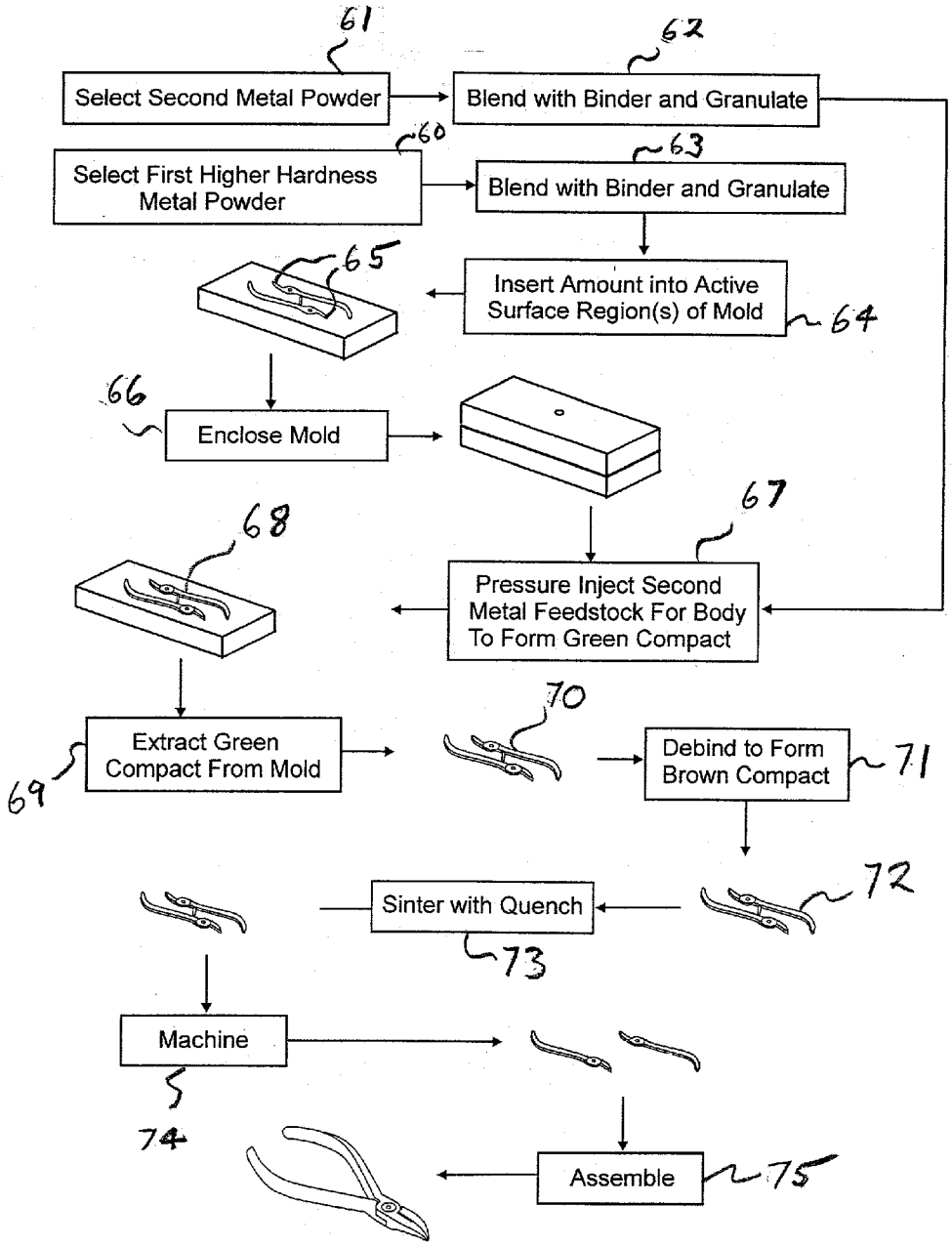

61
Select Second Metal Powder
62
Blend with Binder and Granulate
60
Select First Higher Hardness Metal Powder
63
Blend with Binder and Granulate
65
Insert Amount into Active Surface Region(s) of Mold
64
66
Enclose Mold
68
67
Pressure Inject Second Metal Feedstock For Body To Form Green Compact
70
Extract Green Compact From Mold
69
Debind to Form Brown Compact
71
72
Sinter with Quench
73
Machine
74
Assemble
75

FIG. 7

BI-METALLIC METAL INJECTION MOLDED HAND TOOL AND MANUFACTURING METHOD

PRIOR APPLICATION

[0001] The present application claims the benefit of co-pending U.S. Provisional Patent Application Serial No. 60/304,561 filed Jul. 11, 2001 fully incorporated herein by this reference.

FIELD OF THE INVENTION

[0002] This invention relates to materials science and powder metallurgy, and more particularly to the manufacturing of injection molded metal parts including hand tools.

BACKGROUND OF THE INVENTION

[0003] Although the present invention is applicable to many areas of technology requiring bi-metallic parts, its details will be described in terms of its application to hand tools, and particularly with respect to the fabrication of hand tools having two or more portions requiring different physical capabilities.

[0004] For example, one area of technology having such a need is the medical, dental and electronic industries which require precision hand tools for manipulating or cutting wires. The tools must be light-weight, strong, capable of precise placement under difficult conditions such as in a patient treatment room, and sharp enough to grip or cut stainless steel wires with a minimal controlling force. This has led to the development of a tool having a high hardness tip portion for forming the active surface for cutting in the case of wire cutters or gripping in the case of pliers, and a strong, non-brittle, inexpensive handle portion.

[0005] For clarity, the rest of this specification will describe the invention as it applies to orthodontic pliers. Those skilled in the art will readily appreciate application to other hand tools.

[0006] Referring now to **FIG. 1, a** typical pair of orthodontic pliers **1** is shaped to have two corresponding matable halves **2,3** joined at a hinge **4**. Each half has a handle portion **5,6** and a tip portion **7,8** such that when mated the opposing tips have corresponding gripping teeth which form the active surface portion of the pliers which face each other to pinch and grab hold of a wire strand between them.

[0007] As disclosed in Kelly, et al., U.S. Pat. No. 5,133,812, it has been found that the teeth preferably have a hardness of between about 62 and 67 on the Rockwell c (Rc) hardness scale. If too soft, the grip edge too readily deforms and looses its sharpness. If too hard, the edge becomes brittle and subject to early fracture.

[0008] To achieve an economical combination of gripping teeth hardness and tool body handle strength, it has become common practice to make the plier body from high grade stainless steel onto which is brazed a high hardness tool steel tip or cap which is then machined to form a hardened gripping surface.

[0009] The tool is typically formed by selecting the body material from high grade stainless steel such as type 410, 420 or 425M stainless steel. A blank forging with the basic shape of the body is rough grinded, sanded and polished into the preferred shape. The tip ends of the body halves are grinded flat.

[0010] A relatively hard T15 tool steel cobalt chromium alloy is formed into a small, frangible planar cap, which is then heat treated and subsequently brazed to the tip end of the plier tool. The tool with the attached hardened tips is then rough ground. Thereafter, the frangible tip web is broken, and a finishing grind, buffing and polishing step performed. A stainless steel screw is used to hingedly join together both members and final precision assembly is completed to attain proper tightness in the pivot action and the gripping teeth surface etched with a diamond hone.

[0011] This manufacturing process can takes weeks, and because each part is individually machined, sanded, brazed, polished and plated, the parts are costly and often deviate in size and shape due to process variability.

[0012] While the finished tool is of high quality, it has two significant disadvantages. First, because some industries require specific sterilization procedures such as autoclave and chemiclave, the tools are exposed to harsh environments which can cause corrosion. Past attempts to control this problem involve plating the finished tool with nickel and chromium as disclosed in Cera , U.S. Pat. No. 5,301,431. This plating process increases the cost of the tool, and is not completely effective. As the tool is used the protective plating quickly wears away along the gripping or edge of the tip subjecting the exposed surface to corrosion.

[0013] Further, because autoclave sterilization subjects the tool to high temperatures, those structures in direct contact with one another having disproportionate thermal expansion characteristics can cause stresses which may weaken the bond between them.

[0014] Second, in order to avoid tempering the hardened tool steel tips as they are brazed to the tool body, a low temperature foil brazing medium such as silver or nickel alloy brazing foil is typically used to effect the braze at temperatures of about 1500 degrees F. as disclosed in Kelly, et al., Supra. While the low temperature brazing foil preserves the hardness of the plier tips, it is difficult to get the foil to properly wet the bonding surfaces resulting in a weak bond.

[0015] Metal powder injection molding is a low cost way to produce complex and precision-shaped parts such as hand tools from a variety of materials as disclosed in Trusty, Sr., U.S. Pat. No. 6,185,771 incorporated herein by this reference. It is common for this process to produce equivalent parts for much less than the cost of conventional machining or casting.

[0016] There is therefore a need for a hand tool having a high strength body portion and a high hardness active surface portion which does not suffer from the above identified problems.

SUMMARY OF THE INVENTION

[0017] The principal and secondary objects of this invention are to provide an inexpensive manufacturing process for forming bimetallic parts wherein the two metal portions having different mechanical characteristics are rigorously bonded together.

[0018] It is a further object of the invention to provide an inexpensively manufactured, corrosion resistant hand tool having a high hardness active surface tip portion rigorously bonded to a high strength, corrosion resistant handle portion.

[0019] These and other objects are achieved by selecting a first metal powder feedstock formulation for providing a particular characteristic such as high hardness, and placing an amount of it in a portion of a mold corresponding to that portion of the finished structure requiring that characteristic. A second metal powder feedstock formulation providing a particular characteristic different from the first metal feedstock is selected and injected into the mold to form a compact which is then debound, sintered, machined and assembled to form the finished structure. The two feedstocks are selected to be mutually compatible and alloy for an alloy to for between the two types of metals in the two feedstocks. In this way, the two different metal portions are bonded by a matrix of metal material which is essentially an alloy of the two metals. A sintering profile is selected which maintains the desired characteristics of the two metal portions. This generally requires that the time and temperatures of the profile do not allow complete melting of the metal particles.

[0020] In general terms, the combination of the two powder types forms a stratified composite of substantially unfused particles of the first material separate from substantially unfused particles of the second material, wherein particles residing near the boundary of the two materials exist interspersed, suspended and agglutinated in a fused aggregate of the first and second materials. In the case of the first and second materials being metals, the fused aggregate is an alloy of the metals.

BRIEF DESCRIPTION OF THE DRAWING

[0021] **FIG. 1** is a diagrammatic perspective view of a pair of orthodontic pliers of the prior art.

[0022] **FIG. 2** is a diagrammatic top view of one half of an orthodontic plier type tool of the invention.

[0023] **FIG. 3** is a diagrammatic cross-sectional view of the tip portion of the tool of **FIG. 2** according to the invention.

[0024] **FIG. 4** is a diagrammatic cross-sectional microscopic view of the interface zone between the two metal regions of **FIG. 3** according to the invention.

[0025] **FIG. 5** is a diagrammatic cross-sectional microscopic view of the interface zone between the two metal regions in an embodiment of the invention where active surface region is only a few particles thick.

[0026] **FIG. 6** is a diagrammatic cross-sectional microscopic view of the composite of **FIG. 4** magnified within the dotted box.

[0027] **FIG. 7** is a flow chart pictogram of the preferred manufacturing steps of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT OF THE INVENTION

[0028] It is clear to those skilled in the art that the invention is applicable to the manufacture of other traditionally bi-metallic structures apart from hand tools such as drill bits, mechanical parts, such as gears, and fasteners, auto and aircraft parts, sporting goods such as golf clubs and shoe spikes, and is particularly applicable to difficult-to-machine, complex structures which would benefit from portions being made from different materials but being well bonded together.

[0029] Referring now to the drawing, there is shown in **FIGS. 2 through 4** a half **20** of a pair of orthodontic pliers having a body portion **21** which comprises an elongated handle **22** extending from a rear end **23** through a hinge region **24** to a tip end region **25**.

[0030] As shown in **FIG. 3**, the tip end region **25** has a body portion **26** made from high strength, corrosion resistant body material bonded to an active surface portion **27** made from high hardness material from which is formed the active surface **28** of the tool in the form of a plurality of gripping teeth **29**. The active surface portion **27** bonds to the body portion **26** along an interface region **30**.

[0031] As shown in **FIG. 4**, the interface region **30** exhibits a microscopic structure which is generally a stratified composite of substantially unfused particles **31** of the first metal (identified in the drawing by a first fill pattern) separate from substantially unfused particles **32** of the second metal (identified in the drawing by a second fill pattern), wherein particles residing near the boundary zone **33** of the two metals exist interspersed and suspended in an agglutinating alloy matrix **34** formed by components of the first and second metals. In this way, it can be said that the active surface portion and body portion of the tool are bonded together by a common alloy matrix bond. This bond also serves to minimize local stresses due to disproportionate thermal expansion characteristics of the two adjacent metals.

[0032] The term "substantially unfused" means that although some adjacent particles **40,41** are bonded by a surrounding matrix **43**, both particles maintain their own crystalline orientation, as indicated by the differently oriented fill pattern shading lines.

[0033] Some particles may have a portion of their surface area in intimate contact due to coincidental interlocking and deformation caused by any press-forming or the pressurized injection molding process. However, there has been no complete fusion of the structures of adjacent particles. Indeed, as above, the internal body of each particle retains its distinct crystalline orientation and remains substantially unfused with the adjacent particle.

[0034] Therefore, the crystalline orientation of adjacent particles, even in the boundary region, can be said to be substantially dissimilar. The term "substantially dissimilar" is used because it is possible for coincidental alignment of the orientation of adjacent particles, and it is possible that some peripheral co-mingling of orientation may occur.

[0035] The term "interspersed" means that substantially all of the space between adjacent particles is occupied by agglutinating, matrix material, whether alloy or not.

[0036] Referring now to **FIGS. 5 and 6**, there is shown an alternate embodiment of the invention wherein the composite **50** has a microscopic structure such that the active surface portion **51** is composed of first metal particles **52** (indicated by a lined fill pattern) only a few particles in thickness before the composite transitions at a boundary zone **53** to

particles of the second metal **54** (indicated by no fill pattern) to form the body portion **55**. As with the previous embodiment the particles remain substantially unfused and interspersed in an agglutinating matrix **56**. Particle voids **57** exist in the particles and matrix voids **58** exist in the agglutinating matrix. In the boundary zone **53** the matrix comprises material which is alloy **59** (indicated by a dotted fill pattern) formed by components of the first and second metals, and which serves to form the alloy matrix bond.

[**0037**] Referring to **FIG. 7**, the preferred process for forming the example pair of orthodontic pliers will now be described. The process generally involves selection and formulation of the metal feedstocks for the two portions of the pliers, pretreatment of the mold with the first high-hardness metal feedstock, injection of the second metal feedstock to form the green compact, debinding to form the brown compact, sintering and quenching, then final machining and assembly of the finished part.

[**0038**] When sintered, the different metals impart the preferred mechanical properties to specific areas of the tool. The jaws contain a higher concentration of tool steel and exhibit a high hardness. The handle portion of the pliers or cutters contain a higher concentration of stainless steel powder which exhibits a high resistance to corrosion and tensile strength.

[**0039**] Feedstock Formulation: The constituents of the molding compositions or feedstocks are blended and pelletized to create a compound that can be readily placed in the mold or is compatible with the function of a standard plastic injection molding machine. Although the feedstock is a compound, those skilled in the art appreciate that the terms "metal" and "metal particles" can at various times during the process refer to the feedstock.

[**0040**] The feedstock for injection molding of metal powder is comprised in major part of the metal particles and in minor part of a binding system. Elemental or prealloyed metal powders are hot blended with an organic binder. The blend is allowed to solidify, then is de-agglomerated or pelletized using a granulator, leaving clusters of particles ready for injection.

[**0041**] The first metal powder feedstock formulation which is intended to form the active surface portion of the tool is selected 60 from high intrinsic hardness metals relative to the metal used for the body portion and capable of forming an alloy with it. In addition, hard metals commercially available as gas-atomized powders are preferred. Candidate metals therefore include tool steels of the A, D, T, and M types including D1, D2, M3, A2, and A4 type tool steels, or combination of metal alloys including chromium nitrite, titanium nitrite or zirconia nitrite. A description of the various characteristics of tool steels can be found in Marks' Standard Handbook for Mechanical Engineers, McGraw-Hill 1978 incorporated herein by this reference. Additional candidates include carbide material such as cobalt tungsten carbide, or those materials having a metal such as nickel or iron bonded in combination with a refractory hard metal carbide such as titanium carbide or tantalum carbide, or tungsten carbide.

[**0042**] The second metal powder which is intended to form the body portion of the tool which must exhibit higher strength and corrosion resistance is preferably selected 61 from high grade corrosion resistant stainless steels such as martensitic type steels including 403, 410, 414, 416, 416(Se), 420, 420F, 431, 440A, 440B, and 440C type stainless steels, or combination of metal alloys which achieve the above criteria.

[**0043**] The stainless steel metal powder used in the second metal feedstock for the plier handles, and the tool steel metal alloy used for the first metal on the tips of the pliers have similar metallic and chemical properties which enable them to adequately bond together and form an alloy.

[**0044**] Those skilled in the art will appreciate that, depending on the application, other materials having different characteristics may be used. For example, a relatively light-weight metal can be used to form the body portion of a golf club head and an impact resistant metal can be used to form the striking face portion, or a heavier weight metal can be used to form head weights for adjusting the center of gravity on the head. The only requirement is that both metals are compatible in forming a common alloy matrix.

[**0045**] Preferred powders have a very fine average particle size of less than 25 microns, more preferably ranging between about 10 and 22 microns, and most preferably between about 15 and 20 microns.

[**0046**] Selected metal powders are then blended **62,63** with a binder system and granulated. The preferred binding system is an organic based binding system which comprises polypropylene ("PP"), polyethylene ("PE"), polyvinyl alcohol ("PVOH"), and appropriate processing aids, namely a plasticizer composed of glycerin and water; a release agent such as TNT-33PA commercially available under the brand name MOLD WIZ from Axel Plastics Research Laboratories, Inc. of Woodside, N.Y.; and a debinding agent such as steric acid.

[**0047**] Commercially available binding systems include: a water soluble cross linkable binder agent available from Thermat Precision Technology, Inc. of Corry, Pa. under the brand name THERMAT PRESTINE which is partly debound in water, cross linked and thermally debound; a water soluble PVOH and glycerin binder from Planet Polymer Technologies, Inc. of San Diego, Calif. under the brand name AQUAMIM, which is partly debound in water, cross linkable and thermally debound; a water and agar based binder available from Allied Signal Corporation of Morristown, N.J.; an acetyl-based system available from BASF A.G. of Wyandotte, Mich. which is debound in a gaseous acid-containing atmosphere; and a wax based binder such as as a parafin wax and oil based system commercially available from Pathways Thermal Technology of Corona, Calif.

[**0048**] The proportion of the metal powder in the feedstock is at least about 70% by weight, more preferably at least about 80%, and most preferably at least about 90% or more by weight.

[**0049**] Pretreatment: The mold cavity is partially filled or inserted **64** with an amount of the first metal particles placed in a region or regions **65** corresponding to the active surface portion or portions of the tool. The pretreatment can be in the form of placement of a cohesive, preformed piece or coupon manually or automatedly placed into the region of the mold. A typical coupon would consist of a quadrangular body measuring 100×50×2 millimeters. Alternately, a flowable

amount of pellets can be painted, sprayed, injected to form a coating on the intended regions of the mold.

[0050] The thickness of the coupon or coating is determined by the application but will typically not exceed 2 millimeters.

[0051] For orthodontic pliers the thickness is preferably no more than 1 millimeter, more preferably between about 0.001 and 0.020 inch, and most preferrably between about 0.001 and 0.005 inch. This first metal pretreatment amount binds with the second metal feedstock subsequently injected into the mold. The prefilling or pretreating of the mold cavity localizes the first metal to the tips of the green compact where high hardness and wear resistance are desired.

[0052] The mold is then enclosed **66** in anticipation of injection of the second metal feedstock.

[0053] Molding: The second metal feedstock is then injected **67** into the mold to form the green compact **68** of the tool. Preferably, the second metal feedstock is preheated to between about 250-390 degrees Fahrenheit prior to injection in order to enhance activation of the binder when contacting the first metal pretreatment. Thus the binders used for the first and second metal feedstocks should be compatible. This also provides for a simplified debinding step.

[0054] Molding is done in a specially equipped plastic injection molding machine modified to mold the feedstocks **10**. into an oversized shape of the tool called a "green part", "green preform", or "green compact". The compact has the same geometry as the end product, but is between about 14% and 20% larger in size. This allows the molding of intricate detailed features into the oversized compact, including threads, holes, radii, contoured surfaces, logos, and text. After extraction **69** of the compact **70** from the mold, and depending on its strength, the compact may also be machined.

[0055] Debinding: The compact is then subjected to a debinding step **71** to remove between about 75% and 90% percent of the binder material. Several different well known binder removal methods are available depending on the chemical and physical properties of the binder formulation used. The preferred method for the present embodiment involves immersion of the green compact in a solvent or a water bath, depending on the binder used, for a duration of time sufficient to dissolve an adequate amount of binder.

[0056] The result of debinding produces what is commonly called a "brown part", "brown preform", or "brown compact"**72** which consists of a porous matrix of metal powder and a small amount of binder, just sufficient to allow the part to retain its shape and hold together and to permit handling and transport of the same to the sintering furnace or oven.

[0057] Sintering: The brown compact is sintered **73** in a furnace or oven through a complex, microprocessor controlled profile of temperatures, pressures and/or atmospheres depending on the material being processed and the physical properties desired. Sintering is generally carried out according to standards conventional in the art. At the lower temperatures in the sintering cycle the residual PP or PE binder material in the brown preform is vaporized harmlessly into an inert or hydrogen atmosphere within the furnace. Because the vaporization characteristics of the polymers is known, the sintering temperature profile for a given article can be predetermined to provide for the proper rate of vaporization of the polymer to insure substantially complete volatizing of the polymer and adequate densification of the tools.

[0058] As the sintering profile temperatures increase, neck growth of powder particles begins, bringing the particles closer together, reducing porosity, and forming the metal matrix which suspends and bonds the particles together. The higher temperatures of the sintering profile continue this trend, ultimately densifying the metal to approximately 98% of theoretical density. Densification results in shrinkage of between about 14% and 25% depending on the solids loading of the first and second metal feedstocks. This shrinkage is predicable and compensated for by precisely over-sizing the green compact.

[0059] The sintering profile incorporates a heat treatment quench at the end of the final sintering portion of the sintering profile which hardens the body of the plier to between about 35 and 55 Rc and the active surface tip portion to between about 55 and 65 Rc.

[0060] If additional hardness is required after sintering, the pliers or just the tip portions can be heat treated using conventional heat treatment methods like induction heat treatment or flame hardening, increasing the treated areas hardness to between about 65 and 70 Rc.

[0061] Machining: The tool is then machined **74** prior to final assembly. Specifically, machining such as the drilling or tapping of holes may be performed. Further, various finalization steps may be performed depending on the application. This can include plating, soldering, anodizing, chromating, phosphating, zincating, resurfacing through machining, sputtering, spraying, vapor depositing and etching, and printing. The surfaces can be ground or lapped, sanded and polished if necessary, to precisely bring them to final smoothness and finish. The tool is then finally assembled **75** to complete the manufacturing process.

EXAMPLE 1

[0062] This example produced an orthodontic plier having a hardened tip portion and a strong, corrosion resistant body portion.

[0063] An amount of T15-type tool steel powder was selected having at least 90% of its particles measure less than 20 microns. This was blended in a twin screw type blender with a water soluble PVOH and glycerin binder for about 120 minutes to form a slurry. The slurry was dried to form pellets of the first metal feedstock material.

[0064] An amount of 420-type stainless steel powder was selected having an average particle size of about 20 microns. This was blended in a twin screw type blender with a water soluble PVOH and glycerin binder for about 120 minutes to form a slurry. The slurry was dried to form pellets of the second metal feedstock material.

[0065] A small amount of the first metal feedstock was loaded into a "hot glue gun"-type applicator and spread into the tip portion of a mold to a thickness of about 2 millimeters.

[0066] An amount of second metal feedstock pellets was loaded into a hopper and heated to form an injectable fluid. A portion of this fluid was injected into the mold under a pressure of about 1500 pounds per square inch and allowed to cool for about one minute to form a green compact weighing about 120 grams.

[0067] The green compact was then immersed in a water debinding bath for about 240 minutes to form a brown compact which was about 4% lighter in weight than the green compact.

[0068] The brown compact was then placed in a CM continuous sintering oven and subjected to the following approximate sintering profile:

[0069] Stage 1: 390° C., 60 minutes, hydrogen atmosphere;

[0070] Stage 2: 580° C., 60 minutes, hydrogen atmosphere;

[0071] Stage 3: 1050° C., 60 minutes, hydrogen atmosphere;

[0072] Stage 4: 1300° C., 60 minutes, hydrogen atmosphere; and

[0073] Stage 5: 0° C., 5 minutes, hydrogen atmosphere.

[0074] The tool was then machine polished, through holes reamed to a finished dimension and assembled to form the finished pliers.

[0075] The pliers exhibited approximately 99% theoretical density. The handle portion exhibited a tensile strength of about 285000 pounds per square inch. The active surface jaw portion exhibited a hardness of about 62 Rc.

[0076] In this way, complex bimetallic parts may be inexpensively injection molded. The advantages of the invention over prior structures and methods are many. First, unlike certain types of machining-intensive manufacturing, the injection molding process inexpensively produces more uniformity from part to part. Furthermore, the process produces little wasted metal shavings inherent in the machining process.

[0077] Additionally, the process of powder injection molding allows the manufacturer to combine metal powders into the feedstock creating alloys which enhance selectivity of the mechanical properties of the tools. Different metal alloys which previously had to be brazed or welded together in subsequent operations, now can be incorporated into the part as it is molded.

[0078] It is estimated that the entire manufacturing process in the above example can be completed in 24 to 30 hours instead of weeks using prior methods and result in tools exhibiting the same or similar mechanical properties of forged tools with tool steel brazed tips at a dramatically reduced cost.

[0079] The process provides design flexibility and delivers tolerances of about +/−0.002 to 0.003 inches per linear inch. Because the parts are sintered to near theoretical density, the parts produced by the process have properties which are virtually the same as those as wrought materials.

[0080] While the preferred embodiments of the invention have been described, modifications can be made and other embodiments may be devised without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. A process for forming a metal injection molded part which comprises:

selecting a first flowable amount of first metal particles in suspension, and a second flowable amount of second metal particles in suspension;

placing said first amount into a region of a mold;

injecting said second amount into said mold after said placing to form a compact; and

sintering said compact to form said part.

2. The process of claim 1, wherein said first metal has a hardness greater than said second metal.

3. The process of claim 1, wherein said process further comprises pressing to form said compact.

4. The process of claim 1, wherein said injecting is performed at a pressure sufficient to form said compact.

5. The process of claim 1, wherein said first metal comprises tool steel selected from the group consisting of: A, d, t, and m type tool steels and alloys thereof.

6. The process of claim 1, wherein said first metal comprises a metal carbide.

7. The process of claim 1, wherein said second metal comprises stainless steel and alloys thereof.

8. The process of claim 1, wherein said sintering occurs at a temperature and for a time such that not all of said particles become fully molten.

9. The process of claim 1, wherein said sintering comprises heating said compact through a heat profile; and terminally quenching said compact to adjust the hardness of the part.

10. The process of claim 1, wherein said placing comprises coating a portion of said mold with said amount.

11. The process of claim 1, wherein said placing comprises forming said first amount into a preformed coupon; and inserting said coupon into said mold.

12. The process of claim 1, wherein said sintering results in said part having a density of between about 98% and 100% theoretical density.

13. The process of claim 1, wherein said first and second metals are capable of forming a common alloy.

14. A hand tool made from the process of claim 1.

15. A method for forming an enhanced bond between two metallic structures comprises:

selecting an amount of first metal particles to form a first of said structures;

selecting an amount of second metal particles to form a second of said structures;

placing said first amount into a region of a mold;

placing said second amount into said mold in contact with said first amount along an interface;

heating said first and second amounts to a temperature sufficient to partially melt particles of both first and second metals and allow liquidus intermingling of said first and second metals along said interface to form a common alloy matrix thereby bonding said particles.

16. A hand tool comprises:

a tip portion comprising particles of a first metal;

said tip portion being bonded at an interface zone to a body portion comprising particles of a second metal;

wherein said first and second particles are agglutinated by a metal matrix extending across said interface.

17. The tool of claim 16, wherein said metal matrix comprises an alloy of said first and second metals.

18. The tool of claim 16, wherein said first metal is harder than said second metal.

19. The tool of claim 16, wherein said tool has a density of between about 98% and 100% theoretical density.

20. The tool of claim 16, wherein said first metal comprises a tool steel selected from the group consisting of A, D, M, and T type tool steels and alloys thereof.

21. The tool of claim 16, wherein said first metal comprises a refractory metal carbide.

22. The tool of claim 16, wherein said second metal comprises stainless steel and alloys thereof.

23. The tool of claim 16, wherein said first and second particles have substantially dissimilar crytaline orientations.

24. A tool comprises:

a first portion made from sintered particles of a first metal;

a second portion made from sintered particles of a second metal different from said first metal;

wherein said first portion is bonded to said second portion by a metal matrix alloy formed by said first and second metals.

25. The tool of claim 24, wherein each of said sintered particles maintains a unique crystalline structure relative to any adjacent particles.

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