

POWDERED METAL MULTI-LOBULAR TOOLING AND METHOD OF FABRICATION

Background

This invention generally relates to multi-lobular tooling for punching a multi-lobular recess into, for example, the head of a fastener. The invention more specifically relates to multi-lobular tooling and tooling blank which are formed of powdered metal. The invention also relates to methods of forming a powdered metal multi-lobular tool.

Multi-lobular tools, often referred to as “punch pins,” are used to punch a multi-lobular recess into, for example, the head of a fastener. Figure 1 illustrates a multi-lobular punch pin 10. In use, the head 12 of the punch pin 10, i.e., having a multi-lobular profile, is punched into a workpiece, such as the head of a fastener, to form a multi-lobular recess.

Typically, punch pins are formed of standard tool steel such as M42 tool steel. Tool steel, by nature, is very nonhomogeneous, and typically contains large, often segregated carbides. Figure 2 provides an image of a punch pin formed of M42 tool steel, where the image was taken with a microscope at 400x, along a transverse cross-section (i.e., along line 2 in Figure 1). Figure 3 is similar, but is an image taken along a longitudinal cross-section (i.e., along line 3 in Figure 1). As shown, carbides (the lighter areas in the image), many of which are relatively large, can be found along either cross-section. With regard to size, in a punch pin formed of conventional tool steel, carbides as large as 10-50 microns or even larger often exist.

The presence of a carbide segregation tends to produce a hard, brittle or weakened plane, wherein the material has a tendency to fracture or splinter. Generally speaking, it is undesirable for a punch pin to contain large carbides and carbide segregation, as carbides provide a point of weakness. This is especially true if a fairly large carbide happens to exist along a lobe of a multi-lobular punch pin. In such case, the carbide may cause the lobe to chip prematurely during use, as shown in Figure 4. Figure 4 provides an image of a punch pin formed of M42 tool steel, where the image was taken with a scanning electron microscope (SEM) at 35x, after the punch pin was used in a number of cycles to punch multi-lobular recesses into workpieces. Not only does it present a possible problem when a large carbide exists on a lobe of a punch pin, but the problem is even more severe the larger the punch pin.

United States Patent No. 6,537,487 discloses a method of molding a powdered metal part using a metal injection molding ("MIM") process. Such a process is relatively complicated and uses a binder. The binder must be removed (i.e., de-binding) during sintering, or prior to sintering. A finished part made with such a process typically is only 95 to 98% dense, and has diminished column strength and limited impact resistance.

Objects and Summary

An object of an embodiment of the present invention is provide a multi-lobular tool and tool blank which are formed of powdered metal, thereby providing that the tool is very homogenous and contains only carbides of an extremely small nature.

Yet another object of an embodiment of the present invention is provide a relatively simple method of fabricating a multi-lobular powdered metal tool, where the method does not require any de-binding steps, either prior to or during sintering.

Briefly, and in accordance with at least one of the foregoing objects, an embodiment of the present invention provides a tool made of powdered metal, such as a modified (in that molybdenum is added) T15 high speed steel (HSS) in powdered form, and having a multi-lobular end profile for punching multi-lobular recesses into workpieces, such as into the heads of fasteners.

Another embodiment of the present invention provides a method of fabricating a tool made of powdered metal, where the tool has a multi-lobular end profile. The method includes steps of: cutting a predetermined length from a rod formed of powdered metal, such as a modified T15 HSS (modified in that molybdenum is added); applying a 47°/45° chamfer to both ends; grinding the outside diameter to a predetermined size; applying oil and extruding a multi-lobular configuration on one end of the cutoff in the extrusion die that is secured in a punch press; stress relieving the part in a heat treat furnace; coining a trademark (if desired) onto the part; grinding the outside diameter to a predetermined size; facing to predetermined length; shaving a nose angle; heat treating to a predetermined hardness; grinding the nose angle to

achieve a desired finish and length; grinding the outside diameter step to a predetermined size and length; and polishing the nose angle to desired finish.

Brief Description of the Drawings

The organization and manner of the structure and operation of the invention, together with further objects and advantages thereof, may best be understood by reference to the following description, taken in connection with the accompanying drawings, wherein like reference numerals identify like elements in which:

Figure 1 is a perspective view of a multi-lobular punch pin;

Figure 2 provides an image of a punch pin formed of M42 tool steel, where the image was taken with a microscope at 400x, along a transverse cross-section (i.e., along line 2 in Figure 1);

Figure 3 is similar to Figure 2 , but where the image has been taken along a longitudinal cross-section (i.e., along line 3 in Figure 1);

Figure 4 provides an image of a punch pin formed of M42 tool steel, where the image was taken with a scanning electron microscope (SEM) at 35x, after the punch pin was used in a number of cycles to punch multi-lobular recesses into workpieces;

Figure 5 provides an image of a punch pin formed of a modified T15 HSS in powdered form, in accordance with an embodiment of the present invention, where the image was taken with a microscope at 400x, along a transverse cross-section (i.e., along line 2 in Figure 1);

Figure 6 is similar to Figure 5 , but where the image has been taken along a longitudinal cross-section (i.e., along line 3 in Figure 1);

Figure 7 provides an image of a punch pin formed of a modified T15 HSS in powdered form, where the image was taken with a SEM at 50x, after the punch pin was used in a number of cycles to punch multi-lobular recesses into workpieces; and

Figure 8 provides a flow chart of a method of fabricating a multi-lobular tool, such as a punch pin, where the method is in accordance with an embodiment of the present invention.

Description

While the present invention may be susceptible to embodiment in different forms, there are shown in the drawings, and herein will be described in detail, embodiments thereof with the understanding that the present description is to be considered an exemplification of the principles of the invention and is not intended to limit the invention to that as illustrated and described herein.

As discussed above, Figures 2-4 relate to a punch pin formed of M42 tool steel. Figures 5-7 provide similar views, but relating to a multi-lobular tool, specifically a punch pin, formed of a modified T15 HSS in powdered form (modified in that molybdenum is added), in accordance with an embodiment of the present invention. As a result of being formed of powdered metal, the punch pin is much more homogenous and contains only carbides (the lighter areas in the images shown in Figures 5 and 6) which are relatively small, compared to carbides which are typically contained in a punch pin formed of tool steel. As a result of being more homogenous and containing only relatively small carbides, the punch pin is very robust and not prone to chipping or otherwise failing during use (i.e., while being used to, for example, punch recesses in the heads of fasteners).

Figure 5 provides an image of the punch pin, where the image was taken with a microscope at 400x, along a transverse cross-section (i.e., along line 2 in Figure 1). Figure 6 is similar to Figure 5, but where the image has been taken along a longitudinal cross-section (i.e., along line 3 in Figure 1). As shown in Figures 5 and 6, the carbides (the lighter areas in the images) are relatively small compared to those present in the tool steel punch pin, as shown in Figures 2 and 3. Specifically, while the carbides present in a punch pin made of tool steel can be 40 microns or more, providing that the punch pin is formed of powdered metal, such as a modified T15 HSS in powdered form, provides that the carbides can be as small as 1-4 microns.

Figure 7 provides an image of the punch pin, where the image was taken with a SEM at 50x, after the punch pin was used in a number of cycles to punch multi-lobular recesses into workpieces. Comparing Figure 7 to Figure 4, the powdered metal punch pin (Figure 7) exhibits merely acceptable wear with no chipping, while the tool steel punch pin (Figure 4) exhibits some chipping at a lobe.

Because large carbides provide a point of weakness, and the lobes of a multi-lobular tool, such as a punch pin, receive a lot of the stress during impact, it is important to provide or insure that large carbides do not exist at a lobe of a multi-lobular tool. Typically, multi-lobular tools, such as punch pins, are formed of tool steel which is very non-homogenous. Providing that the multi-lobular tool is instead made of powdered metal, such as a modified T15 HSS in powdered form, provides that the grain structure of the part is much more homogenous. As such, there is less of a likelihood or even no likelihood, that large carbides will exist in the area of, or on

one of the lobes. As a result, the punch pin is more robust and has improved column strength and impact resistance, and will have a longer useful service life.

Figure 8 illustrates a method of fabricating a powdered metal multi-lobular tool, such as a punch pin as shown in Figures 5-7, where the method is in accordance with an embodiment of the present invention. As shown, the method provides the following steps: cutting a predetermined length from a rod from bar stock formed of powdered metal, such as a modified T15 HSS (modified in that molybdenum is added); applying a 47°/45° chamfer to both ends; grinding the outside diameter to a predetermined size; applying oil and extruding a multi-lobular configuration on one end of the cutoff in the extrusion die that is secured in a punch press; stress relieving the part in a heat treat furnace; coining a trademark (if desired) onto the part; grinding the outside diameter to a predetermined size; facing to predetermined length; shaving a nose angle; heat treating to a predetermined hardness; grinding the nose angle to achieve a desired finish and length; grinding the outside diameter step to a predetermined size and length; and polishing the nose angle to desired finish. The process is relatively simple, and does not require any de-binding steps, as opposed to a metal injection molding process, where a binder must be removed during sintering, or prior to sintering. A finished part made with such an injection metal molding process typically is only 95 to 98% dense. In contrast, a finished part fabricated with the above-described method is theoretically 100% dense, and has improved column strength, impact resistance, and tool life.

To provide the powdered steel bar, before performing the fabricating steps described above, the following process may be used:

1. Molten metal, of the proper composition, is atomized in an inert atmosphere.
2. The resulting powdered metal is sealed in a large steel "can" which is a steel pipe 5 to 6 feet long and 10 to 12 inches in diameter.
3. The sealed can is placed in a hot isostatic press (HIP) which exerts a pressure of 1000 atmospheres at a temperature 2100F.
4. After the HIP process, the steel can is machined off of the now solid and 100% dense P.M. ingot.
5. The P.M. ingot is then processed like a conventionally poured ingot.

While embodiments of the present invention are shown and described, it is envisioned that those skilled in the art may devise various modifications of the present invention without departing from the spirit and scope of the disclosure.

What is claimed is:

1. A tool (10) having a body and a multi-lobular end profile (12) for punching multi-lobular recesses into workpieces, said tool (10) characterized by said body being made of powdered metal.
2. A tool (10) as recited in claim 1, characterized in that said tool (10) is made of high speed steel in powdered form.
3. A tool (10) as recited in claim 2, characterized in that the high speed steel comprises T15 high speed steel.
4. A tool (10) as recited in claim 2, characterized in that the high speed steel includes molybdenum.
5. A tool (10) as recited in claim 3, characterized in that the T15 high speed steel includes molybdenum.
6. A tool (10) as recited in claim 1, characterized in that said tool (10) is configured to punch multi-lobular recesses into the heads of fasteners.

7. A method of fabricating a tool (10) made of powdered metal, where the tool (10) has a multi-lobular end profile (12) for punching multi-lobular recesses into workpieces, said method characterized by: providing a rod formed of powdered metal; cutting a predetermined length from the rod, said predetermined length defining a part; applying a chamfer to at least one end of the part; grinding an outside diameter of the part to a predetermined size; extruding a multi-lobular configuration on one end (12) of the part; grinding an outside diameter of the part to a predetermined size; and forming the part to a predetermined length.
8. A method as recited in claim 7, further characterized by stress relieving the part in a heat treat furnace.
9. A method as recited in claim 7, further characterized by coining a trademark onto the part.
10. A method as recited in claim 7, further characterized by facing the part to a predetermined final length.
11. A method as recited in claim 7, further characterized by shaving a nose angle on the part.

12. A method as recited in claim 7, further characterized by heat treating the part to a predetermined hardness.
13. A method as recited in claim 11, further characterized by polishing the nose angle to desired finish.
14. A method as recited in claim 7, characterized in that the step of cutting a predetermined length from the rod comprises cutting a predetermined length from a rod formed of high speed steel.
15. A method as recited in claim 7, characterized in that the step of cutting a predetermined length from the rod comprises cutting a predetermined length from a rod formed of T15 high speed steel.
16. A method as recited in claim 7, characterized in that the step of cutting a predetermined length from the rod comprises cutting a predetermined length from a rod formed of high speed steel which includes molybdenum.

17. A method as recited in claim 7, characterized in that the step of cutting a predetermined length from the rod comprises cutting a predetermined length from a rod formed of T15 high speed steel which includes molybdenum.
18. A method as recited in claim 7, characterized in that the step of applying a chamfer to at least one end of the part comprises applying a 47°/45° chamfer to both ends of the part.
19. A method as recited in claim 7, characterized in that the step of extruding a multi-lobular configuration on one end of the part further comprises applying oil to the part and extruding the multi-lobular configuration in an extrusion die that is secured in a punch press.