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**APPARATUS AND METHOD OF FORMING
TUBULAR ARTICLES**

Wilfred J. Sharon, 25280 Chatworth Drive,
Euclid, Ohio 44117

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20 Claims

ABSTRACT OF THE DISCLOSURE

An apparatus and method of forming tubular articles from a solid slug. A first solid slug is placed onto an open-ended die bore and forced onto a piercing punch disposed within one end of the die bore to form a tubular finished part. The slug is forced onto the piercing punch by a reciprocable forging punch disposed in the other end of the die bore. In addition to the first slug in process, there is at least one intermediate or second slug disposed in the die bore between the piercing punch and the forging punch. The second slug is partially pierced as well as radially expanded while acting as a deformable forging punch when advancing the first slug. Direct laminar metal grain flow is effected in the transition from slug to finished part. Each slug has a cone-shaped indent on its end adjacent the forging punch, such indent being positioned on the slug longitudinal axis to effect a clean opening through the back of the slug by the piercing punch such that the piercing punch does not carry a thin skin of metal into the second slug.

This invention relates to an apparatus and method of cold forging and more particularly to metal cold forging wherein a slug is forced onto a piercing punch to form a tubular finished part.

Prior cold forging operations of the type in which a part such as a tubular article is formed are notoriously slow in production rate, have difficult high-pressure forming operations resulting in waste material and short tool life, and fail to achieve direct laminar metal grain flow in transition from slug to finished part.

Therefore, it is a primary object of the present invention to provide a new and improved high-speed method and apparatus for forming tubular articles from a solid slug which incorporates the steps of disposing a solid slug in a die bore, in which is positioned a piercing punch, and forcing the slug upon and over the piercing punch to thus form a tubular article therefrom.

A further object of the invention is to provide a method and apparatus for forming a tubular article from a solid slug wherein waste slug material is eliminated.

A further object of the invention is to provide a method and apparatus of the above type using relatively low forming pressures and providing greater forming ease of the finished part plus longer tool life.

A further object of the invention is to provide a method and apparatus of the above type wherein direct laminar grain flow is achieved in transition from slug to finished part.

A further object of the invention is to provide a method and apparatus of the above type that is simple, inexpensive, and highly effective in operation.

Briefly, the foregoing objects are accomplished by the

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provision of a method of forming tubular articles from a solid slug by providing a die having an open-ended die bore, placing an elongated piercing punch longitudinally in forming position in one end of the die bore, thence placing a first slug in the other end of the die bore and forcing the slug onto the punch within the die bore so that the slug is formed into a preconfigured finished part having an open-ended bore interior configuration and an exterior configuration similar to the shape of the die bore longitudinal wall. Direct laminar metal grain flow is achieved in transition from the slug to finished part. The slug is forced onto the piercing punch by a reciprocable forging punch position in the other end of the bore. Reciprocating presses are used to reciprocate the punches in timed relation. Means are provided for feeding the slugs one-at-a-time into the die bore.

In the preferred form, a second slug is disposed between the first slug and the forging punch whereby the forging punch acts against the second slug and the second slug, in turn, forces the first slug onto the piercing punch.

A cone-shaped indent is provided on the end of each slug adjacent the forging punch, such indent being substantially disposed on the slug longitudinal axis. This indent effects a clean opening through the back of the slug by the piercing punch, such that the piercing punch does not carry a thin skin of metal into the second slug.

Thus, with the above method and apparatus a simple, inexpensive, high-speed, cold-forging means is provided which eliminates slug waste, maintains long tool life and effects laminar metal grain flow from slug to finished part.

Other objects and advantages of the invention will be apparent from the following description taken in conjunction with the drawings wherein:

FIG. 1 is a perspective view of a solid slug used to form a tubular part in accordance with the method and apparatus of the invention;

FIG. 2 is a perspective view of one type of tubular part formed from the slug of FIG. 1 in accordance with the method and apparatus of the invention;

FIG. 3 is a fragmentary side elevational view shown partly in section of a cold-forging apparatus constructed in accordance with the invention and showing a step in the method of the invention;

FIG. 4 is a view similar to FIG. 3 and showing another step in the method of the invention; and

FIG. 5 is an enlarged, sectional fragmentary view of the central portion of the apparatus shown in FIG. 3, and showing laminar metal grain flow in transition from slug to finished part.

Although the invention is shown and described herein with reference to the fabrication of cylindrical tubular parts, it will be understood that it may be employed in the fabrication of any type of part having a hollow interior.

The terms and expressions which are employed herein are used as terms of description, and not of limitation, and there is no intention, in the use of such terms and expressions, of excluding any equivalents of the features shown or described, or portions thereof, but it is recognized that various modifications are possible within the scope of the invention claimed.

Heretofore, in apparatus and methods for forming (or more particularly cold forging) tubular articles from a solid slug, it has not been uncommon to find deformations and/or particles of metal at the trailing end of the

article thus formed such as burrs, ridges and the like. Also, a change has occurred heretofore in the metallurgical characteristics of the slug material due to the magnitude of the forces necessary to form the slug into the tubular article.

The novel apparatus and method of the present invention, as will be hereinafter more fully described, overcomes these and other basic deficiencies of prior cold forging processes, and is capable of forming a variety of tubular articles from a solid slug with no waste and/or deformations thereto and with a substantial lower range of forging pressures than has been heretofore possible.

Referring to the drawings, there is shown a metal cold-forging apparatus of the invention for forming an associated solid slug 10 into a hollow preconfigured tubular finished part 12, and including a die 14 having a preconfigured elongated, open-ended die bore 16. The die 14 is encased in a die holding body 18. An elongated reciprocable piercing punch 24 is longitudinally and reciprocally disposed in forming position in one end (i.e. the left end as shown in FIG. 3) of the die bore 16. A reciprocable forging punch 26 is disposed in the other end (i.e. the right end) of the die bore 16 and is adapted to reciprocate into and out of such bore to force a slug 10 onto the piercing punch 24 to form a finished part 12, whereby the part 12 acquires an open-ended bore 30 interior configuration and an annular exterior configuration similar to that of the longitudinal wall of the die bore 16.

The piercing punch 24 is operated by a suitable reciprocable press 36 and the forging punch is operated by a press 38. The punch 24 is releasably secured to the press 36 by the collet 39. Such presses are not further described in detail herein as the same, per se, form no part of the invention.

The forging punch 26 is slidably contained in a bushing 40 which is encased in a bushing housing 42. The housing 42 is secured to the die body 18 by the bolts 44. Disposed between the die body 18 and the housing 42 is a means for feeding the slugs 10, one-at-a-time, into the die bore 16 in the form of a slug feeding structure 46 having a feed chute 47 which contains a slug stop 48 that is secured to the housing 42 with the bolt 49. In practice, the slugs 10 are stacked in the feed chute 47 and rest on the stop 48 when the forging punch 26 is withdrawn from the die bore 16 as shown in FIG. 4. The slugs are fed, one-at-a-time, into the die bore 16 by the punch 26 as shown in FIG. 3.

The piercing punch 24 is slidably contained in a bushing or piercing punch guide 60 (having a guide bore 61), said bushing or guide being encased in a bushing or guide housing 62. The housing 62 is secured to the die body 18 by the bolts 64. Disposed between the die body 18 and the bushing housing 62 is a finished part ejection chute 66, from which the parts drop into a tote box (not shown).

In the preferred form of operation, the die bore 16 contains three slugs during the forming operation, although the method of the invention may be effected with only two slugs (or even one slug) at one time in the bore 16. As shown in FIG. 4, the bore 16 contains a first (partially-formed) slug 10a, a second slug 10b disposed in back of the slug 10a, and a third slug 10c about to be pushed into the bore 16 by the forging punch 26.

In operation, the piercing punch 24 enters the left end of the die bore 16 to a position wherein the punch head 82 enters the partially formed slug 10a. Next, the forging punch 26 pushes the slug 10c (FIG. 4) into the bore 16 and against the slug 10b, so that the three slugs 10a, 10b and 10c are all disposed back-to-back in the bore 16. Next, the forging punch 26 is moved to the left in the bore 16 so that the partially formed part 10a is pushed onto the piercing punch head 82 to form the finished part 12 as shown in FIG. 3. Thus, the third slug acts on the second slug, and the second slug acts on or pushes the first slug onto the piercing punch to form the

finished part, such second slug being partially formed during such operation.

It will be noted that the piercing punch bushing or guide 60 is disposed adjacent and spaced from the left end of the die bore 16 and the finished part 12 has an outside diameter greater than the guide bore 61. Thus, when the piercing punch 24, with the finished part 12 thereon, is reciprocated out of the die bore 16 and into the guide bore 61 (FIG. 4), such finished part 12 abuts the guide 60, is drawn off of the piercing punch and ejected into the space between the guide 60 and the bore 16 formed by the ejection chute 66. Also, it will be noted that the piercing punch head 82 has an enlarged, cone-shaped configuration to enable facile removal of the finished part from the piercing punch.

To hold the partially-formed slug 10a within the die bore 16 as the piercing punch 24 is withdrawn therefrom, the die bore is provided with an annular inwardly extending circumferential shoulder 85 adjacent the left end of the bore and inwardly of the piercing punch (when in forming position).

When the piercing punch 24 is in forming position as shown in FIG. 3, it is positioned just within the left end of the die bore 16 so that a substantial portion of the finished part 12 is disposed outwardly of the left end of the die bore immediately after the part is formed.

The front or forging end of the forging punch 26 has a cone-shaped piercing point 87 thereon that forms a cone-shaped indent 88 in the right end of each slug in the bore 16 during the cold-forging process. Thus, each of the slugs has a cone-shaped indent 88 on the end of such slug adjacent the forging punch 26, such indent being substantially disposed on the slug longitudinal axis. The indent 88 effects a clean opening through the back of the slug by the piercing punch 24 such that the piercing punch does not carry a thin skin of metal into the second slug during the cold-forging process.

Referring now to FIG. 5, it will be noted that as the article 12 is formed from slug to finished part, the longitudinal, laminar grain flow (represented by the dashed lines in the slugs and finished part) that is originally contained in the slugs is retained in the finished part 12, thus maintaining structural strength in such finished part. Thus, there is direct laminar grain flow in the finished part in transition from slug to finished part.

The invention also contemplates the method of forming a hollow or tubular article including providing a die 14 having an open-ended die bore 16, placing an elongated piercing punch 24 longitudinally in forming position in one end of the die bore 16, placing a first slug 10 in the other end of the die bore 16, and forcing such slug onto the punch 24 within the die bore so that the slug is formed into a preconfigured finished part 12 having an open-ended bore 30 interior configuration and an exterior configuration similar to the shape of the die bore longitudinal wall, there being direct laminar grain flow in the part in transition from the slug 10 to such part 12. The method further includes providing a forging punch 26 longitudinally reciprocable into and out of the other end of the die bore 16 for forcing the first slug onto the piercing punch 24, and placing a second slug between the first slug and the forging punch 26, whereby the forging punch acts against said second slug, and said second slug, in turn, forces said first slug onto said piercing punch to form the finished part.

Further steps include removing the piercing punch 24 with the preconfigured part 12 thereon from the die bore one end after the part 12 is formed, and thence removing the part from the piercing punch.

Other steps include providing a reciprocable piercing press 36 for selectively reciprocating the piercing punch 24 into and out of the one end of the die bore 16, and providing a reciprocable forging press 38 for selectively reciprocating the forging punch 26 into and out of the die bore 16.

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A further step includes providing an enlarged cone-shaped head **82** on the forming end of the piercing punch **24** to enable facile removal of the finished part **12** from the piercing punch.

A further step includes providing a cone-shaped indent **88** on the end of each slug adjacent the forging punch **26**, said indent being substantially disposed on the slug longitudinal axis, such indent effecting a clean opening through the back of the slug by the piercing punch **24** such that the piercing punch does not carry a thin skin of metal into the second slug.

A further step includes providing a third slug in the die bore **16**, whereby the third slug acts on the second slug and the second slug acts on the first slug, said second slug being partially formed on the piercing punch **24** when the first slug is fully formed into a preconfigured finished part **12**.

In one method of the invention, the head **82** of the piercing punch **24**, when in forming position, is placed just within the end of the die bore **16** so that a substantial portion of the finished part **12** is disposed outwardly of the end of the die bore **16** immediately after such part is formed. Also included is the step of providing an inwardly extending circumferential shoulder **85** in the die bore **16** adjacent the end of the bore and inwardly of the piercing punch **24** when in forming position to hold the partially formed second slug in position in the die bore when the piercing punch is removed therefrom.

A further step includes providing means for feeding the slugs one-at-a-time into the other (forging punch) and of the die bore **16** when the forging punch **26** is reciprocated out of such die bore.

What is claimed is:

1. A method of forming a hollow article comprising: providing a die having an open-ended die bore, placing an elongated piercing punch longitudinally in forming position well within one end of the die bore, placing a first slug in the other end of the die bore, and forcing said slug onto said punch within the die bore so that the slug is formed into a preconfigured finished part having an open-ended bore interior configuration and an exterior configuration similar to the shape of the die bore longitudinal wall, there being direct laminar grain flow in the part in transition from the slug to such part.

2. The method of claim 1 and further including providing a forging punch longitudinally reciprocable into and out of the other end of the die bore for forcing said first slug onto said piercing punch, and placing a second slug between the first slug and the forging punch, whereby the forging punch acts against said second slug, and said second slug, in turn, forces said first slug onto said piercing punch to form the finished part.

3. The method of claim 2 and further including removing said piercing punch with the preconfigured part thereon from the die bore one end after the part is formed, and thence removing the part from the piercing punch.

4. The method of claim 3 and further including providing a reciprocable piercing press for selectively reciprocating said piercing punch into and out of the one end of said die bore, and providing a reciprocable forging press for selectively reciprocating said forging punch into and out of said die bore.

5. The method of claim 4 and further including providing an enlarged cone-shaped head on the forming end of said piercing punch to enable facile removal of the finished part from the piercing punch.

6. The method of claim 5 and further including providing a cone-shaped indent on the end of each slug adjacent the forging punch, said indent being substantially disposed on the slug longitudinal axis, said indent effecting a clean opening through the back of the slug by the piercing punch such that the piercing punch does not carry a thin skin of metal into the second slug.

7. The method of claim 3, and further including providing a third slug in said die bore, whereby the third slug

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acts on said second slug and said second slug acts on said first slug, said second slug being partially formed on the piercing punch when the first slug is fully formed into a preconfigured finished part.

8. The method of claim 5 wherein the head of the piercing punch when in forming position is placed just within the one end of said die bore so that a substantial portion of the finished part is disposed outwardly of the one end of the die bore immediately after such part is formed.

9. The method of claim 7 and further including providing an inwardly extending circumferential shoulder in the die bore adjacent said one end and inwardly of the piercing punch when in forming position to hold the partially formed second slug in position in the die bore when the piercing punch is removed therefrom.

10. The method of claim 1 and further including providing means for feeding the slugs one-at-a-time into said other end of the die bore when the forging punch is reciprocated out of such die bore.

11. An apparatus for forming associated slugs into hollow preconfigured finished parts comprising, a die having an elongated open-ended die bore, an elongated piercing punch longitudinally disposed well within one end of said die bore, an associated first slug being initially disposed in said die bore adjacent said piercing punch, and a reciprocable forging punch reciprocable into and out of the other end of the die bore for forcing the first slug onto said piercing punch in the die bore so that the slug acquires an open-ended bore interior configuration and an exterior configuration similar to that of the die bore longitudinal wall, there being direct laminar grain flow in the part of transition from slug to such part.

12. The structure of claim 11 and further including a reciprocable forging press for selectively reciprocating said forging punch into and out of said die bore.

13. The structure of claim 11 wherein said piercing punch is longitudinally reciprocable into and out of said die bore, a reciprocable piercing punch press for reciprocating the piercing punch, and means for feeding slugs one-at-a-time into said other end of the die bore when the forging punch is reciprocated out of such die bore.

14. The structure of claim 11 wherein a second slug is disposed between the first slug and the forging punch, whereby the forging punch acts against said second slug and said second slug forces said first slug onto said piercing punch to form the finished part.

15. The structure of claim 11 wherein a piercing punch guide having a guide bore is disposed adjacent and spaced from the one end of the die bore, said piercing punch being longitudinally reciprocable in the guide bore, the finished part having an outside diameter greater than the guide bore, whereby when the piercing punch with the finished part thereon is reciprocated out of the die bore the finished part abuts the guide and is thus drawn off of the piercing punch and ejected into the space between the guide and the die.

16. The structure of claim 15 wherein said piercing punch has an enlarged cone-shaped head to enable facile removal of the finished part from the piercing punch.

17. The structure of claim 12 wherein each of the slugs has a cone-shaped indent on the end of the slug adjacent the forging punch, said indent being substantially disposed on the slug longitudinal axis, said indent effecting a clean opening through the back of the slug by the piercing punch such that the piercing punch does not carry a thin skin of metal into the second slug.

18. The structure of claim 14, and further including a third slug in said die bore, whereby the third slug acts on said second slug and said second slug acts on said first slug, said second slug being partially formed on the piercing punch when the first slug is fully formed into a preconfigured finished part.

19. The structure of claim 11 wherein the head of the piercing punch when in forming position is placed just

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within the one end of said die bore so that a substantial portion of the finished part is disposed outwardly of the one end of the die bore immediately after such part is formed.

20. The structure of claim 19 and further including an inwardly extending circumferential shoulder in the die bore adjacent said one end and inwardly of the piercing punch when in forming position to hold the partially formed second slug in position in the die bore when the piercing punch is removed therefrom.

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