United States Patent [19]
Hoagland et al.

[11] **3,827,269**
[45] **Aug. 6, 1974**

[54] **ROLL FORMING APPARATUS**

[75] Inventors: **Milton B. Hoagland**, Troy; **Lawrence P. Wroblewski**, Detroit, both of Mich.

[73] Assignee: **General Motors Corporation**, Detroit, Mich.

[22] Filed: **Nov. 6, 1972**

[21] Appl. No.: **303,832**

[52] U.S. Cl. .... **72/108**, 29/121 R, 72/102, 72/191, 72/197, 204/129.1, 204/129.65
[51] Int. Cl. **B21d 37/06**
[58] Field of Search........ 29/148.4 D, 121 R; 204/6, 204/129.1, 129.65; 156/8, 10; 72/102, 108, 191, 197, 199

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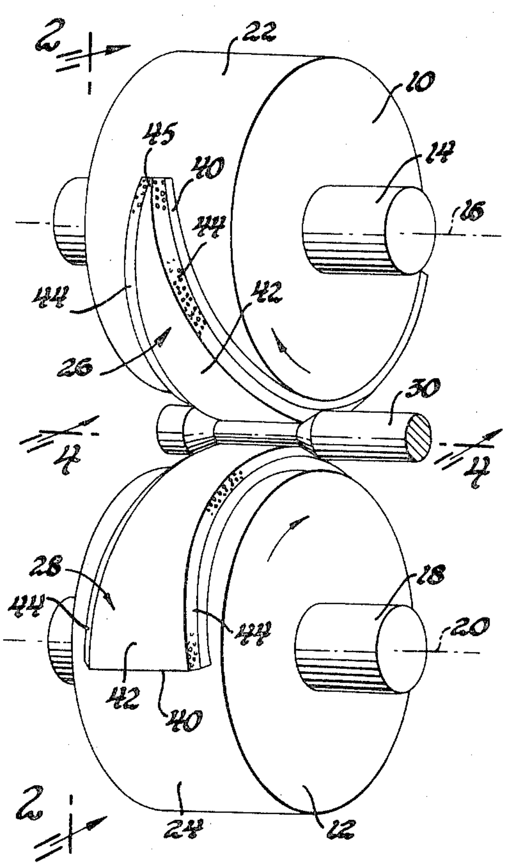
Primary Examiner—Charles W. Lanham
Assistant Examiner—Joseph A. Walkowski
Attorney, Agent, or Firm—Saul Schwartz

[57] **ABSTRACT**

An improved die for a "wedge roll" type roll forming machine including a pair of vertically spaced rolls adapted for rotation in the same direction and defining a pair of mounting surfaces adapted for rigidly supporting the dies, the improved dies including a generally triangular forming surface bounded along the leading converging edges by a pair of driving surfaces disposed at an angle with respect to the forming surface, each of the driving surfaces having formed thereon a plurality of randomly spaced and irregularly shaped raised projections having flat top surfaces, tapered sides and substantial column rigidity under compression forces.

3 Claims, 11 Drawing Figures



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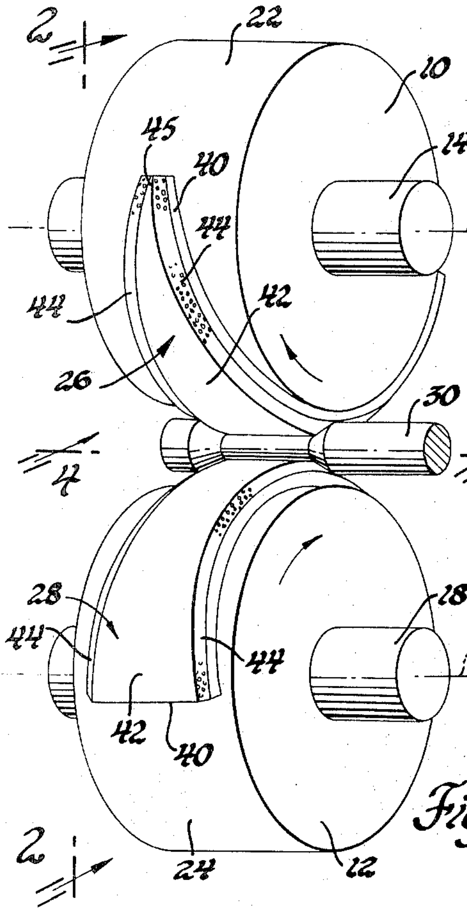


Fig.1

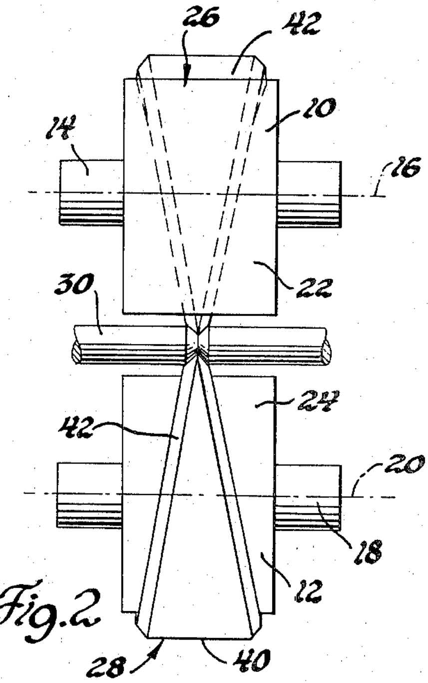


Fig.2

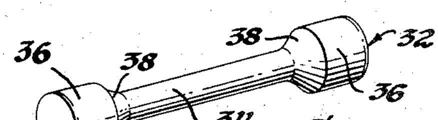


Fig.3

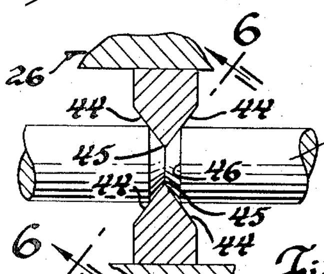


Fig.4

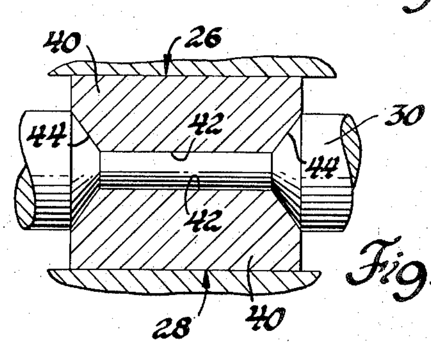


Fig.5

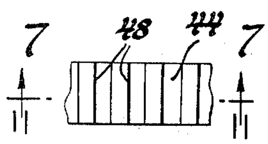


Fig.6 PRIOR ART

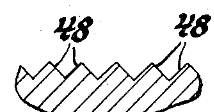
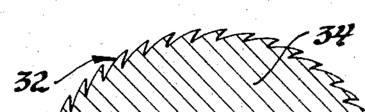


Fig.7 PRIOR ART



PRIOR ART Fig.10

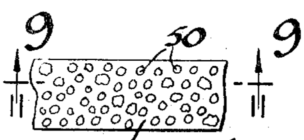


Fig.8

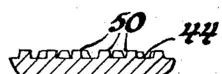


Fig.9

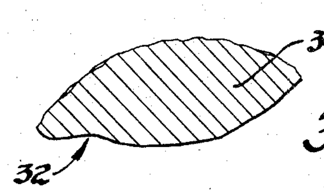


Fig.11

ROLL FORMING APPARATUS

This invention relates generally to metal working apparatus and more particularly to an improved tool configuration for roll forming objects exhibiting circular transverse cross-sections.

In metal working, the process known generally as "hot rolling" typically involves heating of a metal billet to a particular temperature and then forcing the billet between a pair of heavy rolls which rolls change the shape of the billet, as for example from a rectangle to a flat sheet. One "hot rolling" process, employed exclusively for producing objects which exhibit circular transverse cross-sections at any point along their length, is known as "wedge rolling." Generally, in "wedge rolling," a length of bar stock is induction heated and fed between a pair of vertically spaced rolls each of which rotates in the same direction. Each roll has a wedge shaped die rigidly mounted on the outside diameter thereof. The tips of the wedge shaped dies engage the heated bar at substantially the same instant at diametrically opposed locations and proceed to roll the bar about its longitudinal axis. As the dies further engage the bar, the outside diameter of the latter is reduced and metal is caused to flow lengthwise of the bar until the desired shape is achieved whereupon chisels on the dies sever the formed object from the remainder of the bar.

In order to effect the lengthwise material flow, of course, considerable force must be applied by the dies to the bar. Also, the dies must be prevented from slipping relative to the bar. Both functions are accomplished by a pair of angled, converging friction or driving surfaces formed on the dies, the driving surfaces typically having formed thereon serrations to effect positive engagement between the driving surfaces and the bar being formed. The serrations, however, tend to leave undesirable finish marks on the formed object which render the process unsuited for certain applications. Metal working apparatus according to this invention represents a reduction to practice of a die particularly adapted for the "wedge rolling" process which generates an improved surface on the finished object.

Accordingly, the primary feature of this invention is that it provides an improved metal working apparatus. Another feature of this invention is that it provides an improved metal working apparatus particularly adapted for use in a "wedge rolling" type "hot rolling" process. Yet another feature of this invention is that it provides an improved die for roll forming objects exhibiting only circular transverse cross-sections without generating objectionable surface markings on the objects. A further feature of this invention resides in the provision of an improved "wedge rolling" die having a pair of converging driving surfaces with a plurality of randomly spaced raised projections thereon, the projections effecting positive engagement between the die and the object being roll formed and the random spacing of the projections minimizing the probability that the impression on the object made by one projection will be exactly repeated and, therefore, exaggerated by another projection on a succeeding revolution of the object. A still further feature of this invention resides in the provision on the driving surface of the "wedge rolling" die of a plurality of randomly spaced raised projections each having a generally flat top surface and tapering sides, each raised projection having very substantial column rigidity. Still another feature of this invention resides in the process by which the raised projections are formed on the driving surfaces of the dies, the process including the steps of masking a plurality of randomly spaced dots on the driving surfaces with a resistant material and then electro-chemically treating the exposed surface area thereby to etch away the unmasked surface portion so that a plurality of raised projections remain after the masking material is removed.

These and other features of this invention will be readily apparent from the following specification and from the drawings wherein:

FIG. 1 is a fragmentary, perspective view of a "wedge rolling" machine including a pair of improved dies according to this invention;

FIG. 2 is a view taken generally along the plane indicated by lines 2—2 in FIG. 1;

FIG. 3 is a perspective view of a typical object formed by the improved "wedge rolling" dies shown in FIG. 1;

FIG. 4 is a sectional view taken generally along the plane indicated by lines 4—4 in FIG. 1 but showing the initial engagement condition between the "wedge rolling" dies and the bar being formed;

FIG. 5 is a similar to FIG. 4 but showing further engagement between the "wedge rolling" dies and the bar being formed;

FIG. 6 is an enlarged fragmentary view taken generally along the plane indicated by lines 6—6 in FIG. 4 but showing a typical driving surface configuration of heretofore known "wedge rolling" dies;

FIG. 7 is a sectional view taken generally along the plane indicated by lines 7—7 in FIG. 6;

FIG. 8 is a view similar to FIG. 6, but showing the driving surface of a "wedge rolling" die according to this invention;

FIG. 9 is a sectional view taken generally along the plane indicated by lines 9—9 in FIG. 8;

FIG. 10 is a fragmentary, enlarged transverse sectional view of an object "wedge roll" formed by dies constructed in a heretofore known manner; and

FIG. 11 is similar to FIG. 10 but showing the surface of the object "wedge roll" formed by improved dies according to this invention.

Referring now to FIGS. 1, 2 and 3 of the drawings, thereshown is a portion of a conventional "wedge roll" type forming machine including an upper roll 10 and a lower roll 12. The upper roll 10 is supported on an upper spindle 14 for rotation as a unit therewith about an axis 16 and the lower roll 12 is similarly supported on a lower spindle 18 for rotation as a unit with the latter about an axis 20, the axes 16 and 20 being aligned in a common vertical plane. The rolls 10 and 12 define, respectively, outer cylindrical mounting surfaces 22 and 24 which are adapted, by conventional means, for rigidly supporting respective ones of a pair of dies according to this invention and designated generally 26 and 28.

In the plane of the axes 16 and 20, the mounting surfaces 22 and 24 are vertically spaced to admit therebetween a length of cylindrical metal bar stock 30. As seen best in FIG. 2, the diameter of the bar stock 30 is sufficiently small to provide clearance between the bar and the mounting surfaces 22 and 24 but sufficiently large to effect interference between the bar and the dies 26 and 28 when the latter are rotated as a unit with the rolls **10** and **12**. As is more fully described hereinafter, the dies **26** and **28** engage the bar **30** from above and below and, in a well known manner, effect reduction in the diameter of the bar between the dies while simultaneously effecting an elongation of the bar. By this well known process, the dies **26** and **28** are effective to produce an object of finite length which exhibits a circular transverse cross-section at any point along its length. A typical object which might be produced by the dies **26** and **28** is indicated at **32** in FIG. **3** and includes a narrow diameter shank portion **34** bounded on opposite ends by a pair of large diameter end portions **36**, the shank portion merging into the end portions at respective ones of a pair of tapered shoulder portions **38**.

Referring particularly to FIGS. **1**, **2**, **4** and **5**, the dies **26** and **28** are identical in configuration and each includes a base portion **40**, a forming surface **42**, and a pair of driving surfaces **44** disposed at an angle with respect to the forming surfaces **42** and converging in wedge fashion from one end of the die to the other. Accordingly, each forming surface **42** is generally triangular in configuration. The dies **26** and **28** are rigidly attached to the rolls **10** and **12** on the mounting surface **22** and **24**, respectively, in predetermined orientation such that as the rolls are rotated in the same direction, as indicated by the arrows in FIG. **1**, the apices of the forming surfaces engage the bar **30** at substantially the same instant at diametrically opposed locations on the bar so that the latter is effectively captured between the dies.

As best seen in FIG. **4**, at the apices of the forming surfaces **42** the dies **26** and **28** effectively define knife edges **45** so that upon initial engagement between the dies and the bar a V-shaped groove **46** is roll formed in the latter. The sides of the groove **46**, of course, are formed by the driving surfaces **44** which surfaces also effect frictional engagement with the bar to initiate rotation of the latter. As the dies **26** and **28** move further into the bar **30** corresponding to continued rotation of the rolls **26** and **28**, the distance between the driving surfaces **44** increases and the forming surfaces **42** move progressively past the bar. As seen best in FIG. **5**, the bar stock material, as for example carbon steel, is caused to flow lengthwise of the bar until the dies pass completely over and under the bar whereupon the completed object **32** is severed from the remainder of the bar by conventional chisels, not shown, mounted on the rolls.

The bar, as is conventional, is roll formed in a red-hot condition. Considerable driving force, however, is still necessary and is transmitted from the dies **26** and **28** to the bar through the driving surfaces **44**. To prevent slipping or relative movement between the dies and the bar, the driving surfaces normally are provided with means for improving the frictional or driving engagement with the bar. More particularly, referring to FIGS. **6** and **7**, dies heretofore known typically include a plurality of serrations **48** on the driving surfaces **44**, the serrations being of a triangular tooth-like configuration with regular, well-defined peaks and valleys. The serrations **48**, however, when engaging the bar, tend to leave complementary, tooth-like impressions in the surface of the bar which impressions are rolled over and flattened down by the driving surface of the die during succeeding revolutions of the bar. As seen best in FIG. **10**, the rolling over of the tooth-like impressions merely tends to flatten down or bend over the peaks of the impressions so that the valleys thereof remain intact and apt to create undesirable stress risers if the object **32** is subjected to tensile forces of torsional moments.

Referring now to FIGS. **1**, **8** and **9**, the dies **26** and **28** incorporate special provisions for minimizing or completely eliminating the tendency of heretofore known dies to leave undesirable impressions or tracks in the formed object. More particularly, the driving surfaces **44** of the dies **26** and **28** according to this invention have formed thereon a plurality of randomly-spaced raised projections **50**. As seen best in FIG. **9**, each raised projection **50** is in the form of a short, relatively stubby column with a generally flat top surface and, in horizontal cross-section, each projection **50** is generally irregular in configuration. The minimum cross-sectional dimension of each projection, however, substantially exceeds the height of the projection so that the projections exhibit very substantial column rigidity.

To form the raised projections **50**, the driving surfaces **44** of the dies are preferably subjected to a conventional electro-chemical etching process. More particularly, the driving surfaces **44**, after being machined, are masked or painted with a conventional, readily available chemically resistant substance, the masking being in the form of a plurality of randomly-spaced and irregularly shaped dots. The friction surfaces so treated are then submerged in an electro-chemical etching solution and subjected to an electrical current which removes material from the unmasked surface portions to a predetermined depth, the depth being dependent upon the length of time to which the surfaces are subjected to the electro-chemical process. Upon completion of the etching process, the masked areas are treated with a rinse solution which removes the masking material.

As recited hereinbefore, the raised projections **50** formed by the electro-chemical machining process are generally irregular in transverse cross-sectional configuration, are randomly spaced on the driving surfaces, and are, in effect, very rigid columns. Further, each projection is substantially equal in height to all the other projections and terminates in the flat top surface. Still further, as a result of the electro-chemical machining, the sides of each projection extending between the friction surface **44** and the top surface of the projection exhibit a masked taper similar to a draft angle commonly found in molded or cast projections, the significance of the taper appearing more clearly hereinafter.

Describing now the operation of the dies **26** and **28**, the rolls **10** and **12** are initially positioned with the dies located remote from the longitudinal axis of the bar stock **30** so that the latter, heated to a red hot condition, can be fed between the rolls in the plane of the axes **16** and **20**. Rotation of the rolls in the direction indicated by the arrows, FIG. **1**, brings the dies **26** and **28** into engagement on the bar **30** from above and below, respectively. Initially, as recited hereinbefore, the dies create a V-shaped groove in the bar the sides of which groove are formed by the driving surfaces **44**. As the driving surfaces penetrate the bar the raised projections **50** on the former penetrate the sides of the groove being defined in the bar by the wedge configuration of the dies, the projections thereby effecting a substantially positive connection between the dies and the bar to effect rotation of the latter without any slippage relative to the former.

The projections **50,** of course, leave complementary impressions in the bar **30.** The randomness of the spacing of the projections, however, minimizes the probability that on any succeeding revolution of the bar one projection will exactly coincide with an impression made by another projection on a previous revolution of the bar so that the probability of the impressions being reinforced or exaggerated on succeeding revolutions of the bar is minimized. In addition, as the dies penetrate further into the bar, the side surfaces of the groove containing the impressions of the projections are flattened by the forming surfaces **42** of the dies. The forming surfaces are flat and tend to press the raised portions of the impressions left by the raised projections down into the surface of the bar. Since the projections are, in effect, stubby columns, the corresponding impressions are relatively shallow, relatively wide craters. When flattened by the forming surfaces **42** the bar stock material is compressed and caused to flow into the craters thereby to remove potential stress concentration centers by eliminating sharp, well-defined valley-like impressions on the bar.

With respect to the tapering sides of the raised projections **50** recited hereinbefore, the dies **26** and **28** have the advantage of being self-cleaning. That is, the heated bar **30** may have scale or the like on the surface thereof which conceivably, could collect between the projections to reduce the effectiveness of the latter. The taper of the projections, however, facilitates the expulsion of this scale since there are no sharp, right angle corners in which the scale can collect and become trapped. Further, the electro-chemical machining process produces the taper in a very efficient and economical manner. Another substantial benefit accruing from the rise of the electro-chemical machining process in this application is that it is insensitive to the hardeners of the die. That is, after the die is machined it is subjected to a conventional hardening process whereby its useful life is substantially extended. When after considerable service it becomes necessary to remachine the driving surfaces **94** to renew the projections **50,** the surfaces can be electro-chemically processed without first softening the die as would be necessary with conventional machining techniques heretofore employed to generate friction increasing protrusions on the driving surfaces of the dies.

Having thus described the invention, what is claimed is:

1. In an apparatus for roll forming objects exhibiting only transverse circular cross-sections, said apparatus including a pair of oppositely moving surface elements adapted for rigidly mounting a pair of dies, each of said dies defining a generally wedge shape forming surface bounded along the leading converging edges by respective ones of a pair of driving surfaces disposed at an angle with respect to said forming surface and adapted for driving engagement on said object being roll formed, the improvement comprising, means on each of said dies defining on each of said driving surfaces a plurality of randomly spaced and randomly located raised projections of substantially uniform height, each of said raised projections defining a column having a generally flat top surface portion and substantial column rigidity under compression forces.

2. In an apparatus for roll forming objects exhibiting only circular transverse cross-sections, said apparatus including a pair of oppositely moving surface elements adapted for rigidly mounting a pair of dies, each of said dies defining a generally wedge shape forming surface bounded along the leading converging edges by respective ones of a pair of driving surfaces disposed at an angle with respect to said forming surface and adapted for driving engagement on said object being roll formed, the improvement comprising, means on each of said dies defining on each of said driving surfaces a plurality of randomly spaced and randomly located raised projections of substantially uniform height, each of said raised projections defining a generally flat top surface portion the combined surface areas of which equal generally about one-half of the combined total surface areas of said driving surfaces and each of said raised projections having substantial column rigidity under compression forces, and means on each of said raised projections defining a side portion thereof disposed at an angle with respect to said flat top surface portion.

3. The improvement recited in claim **2** wherein each of said raised projections has a height of about 0.010 to 0.020 inches.

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