

AN IMPROVED COLD FORMING SYSTEM AND METHOD

Field of the Invention

- 5 The invention relates to the fabrication of metal work pieces using cold form processes.

Background of the Invention

- 10 In selecting processes for the fabrication of a metal work piece, several variables need to be taken into account to find the most efficient and economic means.

- One of the first decisions to be made is the selection of the forming process, i.e. whether the article will be formed above its crystallisation temperature and so "hot formed" or below the crystallisation temperature and therefore "cold formed". Among the advantages provided by cold forming are that no heating is required, therefore removing this portion of the infrastructure required, and having the article immediately available without requiring a cooling period.
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- Further, better dimensional control and surface finish may result from cold forming together with better reproducibility of the article.
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Thus for articles where a defined shape is important and more so for instances, where a three dimensional shape is required, then cold forming the article may represent a more efficient and economic alternative to hot forming.

However, in the case of an article having a complex shape and requiring high tolerance, there are limited cold forming options.

- 5 Roll forming a particular shape is useful for a continuous process, where a two dimensional prismatic shape is required. However, roll forming does not provide an option where the shape and size of the article varies with length of the article.

Complex three dimensional shapes can be provided through punching or coining
10 whereby the shape is sheared from the parent material die. Such arrangements are useful for batch processing where individual units of complex shape are required. The difficulty comes in whereby imparted stresses to the article are applied by the punching presses.

- 15 With the roll forming process, complex shape may be applied progressively through sequential rollers in order to achieve the desired shape. Such a sequential process is not known for punching processes and so leading to very high internal stresses within the part. It is possible to achieve sequential steps for a punching process, however, this would require significant investment in infrastructure for varying dies to bring the part
20 to the desired shape.

Further with a roll former, the sequential formation of the shape is continuous as distinct from a theoretical sequential punching process whereby the article would need to be transferred between each punching station leading to a multi-step process. Thus apart

from the increased infrastructure cost, the process cost in transferring the article would add significantly to the cost of each article and time of production.

Thus a cost effective way of cold forming a complex shape such as a three dimensional shape for an article is not known in the prior art.

Summary of Invention

In a first aspect the invention provides a device for cold forming a metal work piece comprising a roller die having a first die formed in a circumferential face;
a linear die having a second die formed on a receiving surface for receiving the work piece; a press for applying a load to the roller die; wherein the roller die, whilst under load from the press, is arranged to roll across the linear die so as to have the first and second dies applied to opposed faces of the work piece, and so progressively cold form the work piece.

In a second aspect the invention provides a method for cold forming a metal work piece, the method comprising the steps of: providing a roller die having a first die formed in a circumferential face; providing a linear die having a second die formed on a receiving surface; said receiving surface receiving the work piece; applying a load to the roller die; and simultaneously rolling the roller die across the linear die so as to have the first and second dies applied to opposed faces of the work piece; and consequently progressively cold forming the work piece.

The invention provides a different cold forming process to that of the prior art whereby the benefits of a progressive application of load to a work piece provides for a staggered approach to the formation of the article against a linear die. The invention provides for a batch process whereby individual articles are formed and thus the roller die and linear
5 die are able to have varying shapes in which to impart the shape to the article. This may also provide for the creation of complex shapes with all the benefits of cold forming, being high tolerance and good surface finish as compared to hot forming.

Applications for such a work piece may include turbine blades for gas turbines or
10 aerofoils for aerospace applications.

In a preferred embodiment, the first die varies in shape along the circumferential path around the roller die. Thus the roller die is capable of imparting a non prismatic shape to an upper surface of the work piece.
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In an alternative arrangement, the second die varies in shape along a longitudinal axis of the linear die. In this embodiment the linear die is capable of imparting a non prismatic shape to the work piece on an underside. When both embodiments are used together, greater flexibility in shape formation becomes possible such that the first and second
20 dies may correspond with each other or alternatively, be independent so as to further create more complex shapes.

It will be appreciated that in order to drive the roller die along the linear die, it may be necessary to apply a considerable force to the roller die. The roller die may therefore be

driven and further may have a horizontal application force to assist the roller die drive. For instance, the external application of force may come from a horizontal press arranged to bias the roller die so as to roll across the linear die.

- 5 To assist in the application of vertical force to the roller die, press roller may be used intermediately pressed and the roller die and arranged such that the press roller and roller die are in mutual rolling engagement. Said rolling engagement may be through intermeshing of gears mounted circumferentially around each roller.

10 Brief Description of Drawings

- It will be convenient to further describe the present invention with respect to the accompanying drawings that illustrate possible arrangements of the invention. Other arrangements of the invention are possible and consequently, the particularity of the
- 15 accompanying drawings is not to be understood as superseding the generality of the preceding description of the invention.

Figure 1 is an elevation view of a rolling mill according to one embodiment of the present invention;

- 20 Figure 2 is a sectional elevation view of a rolling mill unit according to a further embodiment of the present invention;

Figure 3A is a sectional view of a work piece formed by a process according to one embodiment of the present invention, and;

Figure 3B is a sectional view of a work piece formed by a process according to one embodiment of the present invention.

Detailed Description

5 Figure 1 shows a rolling mill 5 that has been modified in order to implement the present invention. The rolling mill 5 includes a rolling mill unit 10 which incorporates features of the present invention. The rolling mill 5 includes a vertical actuator 20 having a platen 22 applying a downward force to the rollers of the rolling mill unit 10. In order to achieve the rolling movement so as to impart the shape to the work piece, a
10 horizontal cylinder 15 having a platen 16 drives the rollers along the table 24 on which the linear die is located. Thus the present invention, being a synergistic roller/linear die arrangement may be used within a modified conventional rolling mill.

To better illustrate the key features of the present invention, Figure 2 shows the rolling
15 mill unit 10 whereby a roller die 25 is positioned on a table 35. The table 35 includes a linear die 30 having a receiving surface upon which a work piece 40 is placed. The downward force 50 applied by the vertical cylinder is transmitted through a press roller 45 which bears onto the roller die 25. The two rollers 25, 45 are then driven horizontally by the horizontal cylinder 55 such that the roller die 25 comes into rolling
20 contact with the work piece 40.

The roller die 25 includes a circumferential recess 60 which forms a first die to be applied to the work piece 40. In the present invention the recess 60 varies around the circumference of the roller die 25 and so is able to impart a shape to the work piece 40

which varies along its length or circumferential axis. Thus complex shapes can be imparted to the work piece 40 using this arrangement. By placing the work piece 40 on a linear die 30, having a second die, the vertical force 50 not only imparts a shape according to the roller die 25 on a top face but the bottom face of the work piece 40 is
5 similarly shaped by the second die of the linear die 30 as the vertical force 50 is applied.

Whilst the rolling mill unit 10 according to the present invention could be used to “coin” a work piece 40, that is have different patterns embossed onto the work piece 40, a more useful application would permit the roller die 25 and the linear die 30 to have
10 corresponding shapes so as to cold form the work piece 40 to a complex shape such as a complex three dimensional shape. This may also permit variation in thickness of the article. Thus with other batch process cold forming techniques, such as punching, whereby a work piece has a shape imparted to it, complex shapes of varying thickness are not possible. The need for a progressive application of force to the work piece in
15 order to achieve the desired shape without significant internal stresses precludes such processes.

By contrast the present invention permits a progressive application of force through the roller die and so allows the flow of material and plastic formation of the work piece to
20 form a desired shape under load.

For particularly complex three dimensional shapes, it may be necessary to reapply the linear die and roller die to the work piece and so have a staged cold forming of the work piece under certain circumstances.

According to the current embodiment shown in Figure 2, in order to control the relative position of the roller die and linear die so as to achieve high dimensional stability for complex shapes, a rack and gear arrangement may also be incorporated.

To this end the roller die 25 includes a peripheral gear 65 mounted circumferentially about the roller which is in meshed engagement 75 with a peripheral gear 70 of the press roller 45. Thus the relative position of the press roller and roller die is maintained through the meshing 75 of the gears 65, 70. Further the press roller gear 70 is in meshed engagement with a rack 80 which is mounted to the platen 22. The press roller gear 70 meshes 85 with the rack 80 and so movement of the rollers 25, 45 is accurately controlled and tracked through the rack gear arrangement.

Figures 3A and 3B show two work pieces fabricated according to the present invention. In particular Figure 3A shows an aerofoil 90 formed according to the cold forming process of the present invention. In this case, the upper face 92 of the work piece 90 is applied by a roller die, projecting into the surface of the figure. Similarly, the profile of the lower face 100 is formed by a linear die onto which the work piece is placed. By designing the roller die and linear die accordingly, the end effects applied to the work piece 90 form the rounded ends 110, 105. Further the selective thickness variation along the orthogonal axis 115 yields a substantially different effect on the right side 95 compared to the opposed side, resulting on a substantially variable thickness along the orthogonal axis.

For Figure 3B, the work piece 120 demonstrates substantially varying thickness between a central portion 125, 130 and the end portions 140. The transition fillet 135 between the portions is also accurately formed so as to limit stress concentration between the portions.

In a still further alternative, Figures 3A and 3B may also be different views of the same work piece. The device and method according to the present invention is capable of forming a work piece whereby Figure 3A is a cross-sectional view of the central portion 125, 130 of Figure 3B with the upper face 92 of Figure 3A corresponding to upper face 125 of Figure 3B. Thus, in this alternative form, the work piece has been formed according to the present invention varying in profile along both respective axes 115, 145 of Figures 3A and 3B.

Claims:

1. A device for cold forming a metal work piece comprising
a roller die having a first die formed in a circumferential face;
5 a linear die having a second die formed on a receiving surface for receiving the work
piece;
a press for applying a load to the roller die;
wherein the roller die, whilst under load from the press, is arranged to roll across the
linear die so as to have the first and second dies applied to opposed faces of the work
10 piece, and so progressively cold form the work piece;
such that the first die varies in shape along a circumferential path around said roller die,
and along an orthogonal axis of said work piece;
wherein the roller die includes a gear mounted circumferentially around said roller die
and the linear die includes a rack such that said gear and rack are in mesh engagement
15 to facilitate rolling of said roller die across said linear die;
wherein said press roller includes a gear mounted circumferentially around said press
roller such that the press roller gear is in mesh engagement with the roller die gear;
further including a rack mounted parallel to the linear die rack and in mesh engagement
with the press roller gear.
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2. The device according to claim 1 wherein the second die varies in shape along a
longitudinal path along of said linear die, and along an orthogonal axis of said work
piece.

3. The device according to any one of the preceding claims further including a horizontal press arranged to bias the roller die to roll across the linear die.
4. The device according to any one of the preceding claims further including a
5 press roller intermediate the press and the roller die through which the load is applied to the roller die.
5. A method for cold forming a metal work piece, the method comprising the steps of:
- 10 providing a roller die having a first die formed in a circumferential face, such that the first die varies in shape along a circumferential path around said roller die and along an orthogonal axis of said work piece;
providing a linear die having a second die formed on a receiving surface
said receiving surface receiving the work piece;
15 applying a load to the roller die;
and simultaneously rolling the roller die across the linear die so as to have the first and second dies applied to opposed faces of the work piece;
and consequently progressively cold forming the work piece;
wherein the roller die includes a gear mounted circumferentially around said roller die
20 and the linear die includes a rack such that said gear and rack are in mesh engagement to facilitate rolling of said roller die across said linear die;
wherein said press roller includes a gear mounted circumferentially around said press roller such that the press roller gear is in mesh engagement with the roller die gear;
further including a rack mounted parallel to the linear die rack and in mesh engagement
25 with the press roller gear.