

PATENT SPECIFICATION

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(54) PLATE SLOTTING ROTARY TOOL

(71) We, AMPLIFORM PTY. LIMITED, an Australian Company registered under the laws of the State of South Australia, Commonwealth of Australia, of Wilson Street, Royal Park, State of South Australia, Commonwealth of Australia, do hereby declare the invention for which we pray that a patent may be granted to us and the method by which it is to be performed, to be particularly described in and by the following statement:-

This invention relates to a rotary tool assembly for the slotting of a plate or work-piece of metal which has a constant cross-sectional shape throughout its length, to form therein a series of spaced parallel slots each having parallel side walls and curved end walls so as to make the work-piece suitable for subsequent expansion into an expanded metal product.

In the United States Patent 3,903,769 entitled "Means and Method of Slotting Strip Material", standing in the name of COMALCO (J & S.) PTY. LTD., a former name of the Applicant herein, there was described a means and method of slotting strip material wherein the strip material was passed between an anvil roller and a set of rotary knives to form a series of rows of spaced staggered slots in relatively thin webs between relatively thick beads, so that the work-piece could be subsequently stretched or expanded to make a mesh or truss-like configuration.

In this invention there is provided a work-piece slotting rotary tool for the forming of rows of spaced staggered slots in relatively thin webs between relatively thick beads of a work-piece having a constant cross-sectional shape, comprising a frame, a first set of bearings in the frame, an anvil roller shaft journaled for rotation in the first bearings, an anvil roller carried on its said shaft, a second set of bearings in the frame, a rotary cutter shaft journaled for

rotation in the second bearings and parallel to but spaced from the anvil roller shaft, a plurality of rotary cutter knives on the rotary cutter shaft, each cutter knife having at least one radially outstanding blade staggered with respect to the blade or blades of adjacent said cutter knives, power means coupled to both said shafts for rotationally driving the shafts in opposite directions, and support means on the frame for supporting said work-piece between the anvil roller and the rotary cutter knives, characterised in that the anvil roller comprises a plurality of axially spaced radially outstanding flanges the peripheral annular surfaces of which constitute work-piece support surfaces which are engageable by the work-piece beads to support the work-piece during the formation of said slots therein, and that the roller surfaces between the work-piece support surfaces define with respective work-piece webs, slug clearance spaces which exceed one and one half times the web thickness.

Further in this invention there is provided a method of forming rows of spaced staggered slots in relatively thin webs between relatively thick beads of a work-piece having a constant cross-sectional shape with a slotting tool according to claim 2 of the appended claims, characterised by driving said anvil roller in one direction and said cutter shaft in the reverse direction at speeds such that the peripheral speed of said annular work-piece support surfaces exceeds the pitch speed of the rotary cutter knives by between 5% and 10%, feeding said work-piece between said anvil roller and said rotary cutter knives at a slotting station and piercing said slots with said rotary cutter knife blades to displace slugs from said webs, into said slug clearance spaces and carrying said slugs away from said slotting station on said work-piece.

One of the difficulties which has been

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encountered heretofore has been the disposal of slugs which are removed from the work-piece, and it is important in a production setup that the slugs are quickly and efficiently cleared in a production setup that the slugs are quickly and efficiently cleared from the tool set as the work-piece passes through, so as to avoid the need for hand clearing. There is also possibility of damage to the tool if a slug is carried around by the tool and interferes with a subsequent cut.

In an embodiment of this invention the anvil roller is provided with peripheral annular work-piece support surfaces which are engageable by the work-piece beads to support the work-piece during formation of the slots, and the roller surfaces between the work-piece support surfaces define with the work-piece beads clearance spaces which exceed one and one half times the web thickness, that is, the slug thickness, so that the slug is displaced and freely removed from the work-piece and also from the anvil roller and is carried away by the work-piece with a minimum of danger of the slug interfering with the cutter knives or the anvil roller.

The second difficulty which is encountered is the tendency for the cutting knife blade to drag on its side edges as a work-piece progresses through the cutting tool assembly, and in an embodiment of this invention, each cutting knife blade is provided with side walls which converge in a radially inwards direction so as to provide positive rake which will reduce the amount of drag between the cutting knife blade and the work-piece.

One of the problems encountered found to be very difficult to overcome has been the tendency for the ends of the slots to be "picked up" or burred by the ends of the radially extending portions of the cutting knife, and in an embodiment of this invention the ends of the part-circular peripheral portions of the cutting knife blades are curved, each curve end being parallel to and spaced from an adjacent curved end of a similar, (and adjacent blade). By having the ends generally parallel, there is less tendency for the uncut portion of the work-piece to be wedged between the end surfaces, a difficulty which is encountered if the end surfaces of the cutting knives extend in a radial direction.

However this precaution in itself is not sufficient to completely ensure there is no "picking up" or burring of the ends of the slots, and to avoid excessive interference of the end of the knife blade with the slot as it is formed, in an embodiment of the invention the anvil roller is driven with a peripheral speed of its support surfaces exceeding the pitch speed of the cutter knife blades by between 5% and 10%. This tends

to move the work-piece at a higher speed than the speed it would otherwise be driven by the cutter knives and minimises interference between the slot end in the work-piece and the emerging parallel end of the cutter knife blade.

Another surprising effect which has been found has been the tendency for the work-piece to be roller rather than cut between the cutting knives and the anvil roller, and it has been found that the greater the diameter of the cutter knives the greater this tendency for rolling of the work-piece instead of cutting the work-piece, probably due to the increased area of contact between the cutter knife and the work-piece and the increased length of cut required if the cutter knife blade is of excessive diameter. We have found by a series of experiments that it is desirable that the cutter knives do not exceed 250 mm diameter, otherwise the difficulty of rolling becomes excessive, particularly with metal which is very ductile.

In order to divide a neat cleanly finished final product, it is necessary to avoid the cutter knife blade deforming the web which is cut in a lateral direction, since such deformation is found to provide a very sharp edge. In an embodiment of this invention, this difficulty is avoided by arranging the thickness of the cutter knife across its cutting periphery to be at least equal to the width of the web to be cut thereby. This then provides a clean shear plane for the work-piece bead.

An embodiment of the invention is described hereunder in some further detail with reference to and as illustrated in the accompanying drawings in which:-

Figure 1 is a side elevation of a portion of a work-piece slotting rotary tool, illustrating the tool head arrangement,

Figure 2 is a view similar to *Figure 1* which illustrates the manner in which the bearings are located with respect to one another for adjustment purposes,

Figure 3 is a partly sectioned end elevation, showing a work-piece being slotted by the tool,

Figure 4 is a fragmentary perspective illustrating a bank of rotary cutter knives and the stripper plates interposed between them,

Figure 5 is a section through an anvil roller according to a further embodiment,

Figure 6 is a section showing a rotary cutter knife,

Figure 7 is a side elevation of a stripper plate, and

Figure 8 is a fragmentary perspective view of the work-piece shown in *Figure 1* illustrating the slugs which are removed therefrom when the rows of spaced staggered slots are formed in the work-piece web.

The object of the tool described herein is

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to quickly and efficiently form a plurality of spaced staggered slots 10 in the webs 11 of a work-piece 12, the work-piece 12 being of otherwise constant cross-sectional shape and having transversely spaced relatively thick beads 13 spaced apart by relatively thin webs 11, the slots 10 being formed by removal of slugs 14. In the embodiment illustrated, the work-piece is provided with five only beads 13 for simplicity of description, but in practice there could be a larger number than this, usually between 10 and 20. The work-piece is formed by an extrusion process, extruding an aluminium alloy having sufficient ductility for bending and stretching and sufficient hardness for clean cutting by the tool.

Referring now to Figures 1, 2 and 3 the machine tool is generally designated 18 and is provided with a frame 19 which supports a first set of bearings 20 carried in a bearing housing 21 which is adjustable for height by means of packers which are not shown, the bearing housing 21 also being secured to the frame by studs 22 and bolts 23, the studs 22 passing through vertically extending slots 24. The bearings 20 have journaled in them an anvil roller shaft 25 driven by an electric motor 26 through a chain drive 27, and as seen in figure 2, the chain drive 27 provides means whereby height adjustment for the anvil roller shaft 25 can be achieved. This facilitates use of different diameter rollers, cutter knives and different depths of web 13 in work-pieces.

However it is desirable not only to have a vertical adjustment to accommodate such differences, but also a horizontal adjustment since the cutter knife blades will penetrate the web at a point which is not vertically above the cutter knives but displaced in advance thereof. Thus it is desirable that the anvil roller should be located in advance of the cutter knives, and the degree of advance will require adjustment to suit the thickness of web being cut and the depth of beads. This is achieved by having the cutter knife shaft 30 journaled in bearings 31 carried in a bearing housing 32 which is adjustable in a longitudinal direction, the bearing housing 32 having slots 33 through which the bolts 23 pass. Fine adjustment is achieved by means of the adjusting screws 34 carried on the frame 19. The shaft 30 which carries on it the cutter knives is direct coupled to a motor 35, and the motor 35 therefore moves together with the bearing housing 32 when adjustment takes place. It might be noted that the use of two motors in this manner enables a simple construction to be effective, and maintains a constant ratio of rotational velocity between the two shafts 25 and 30, which will vary only by the variation of speed of the motor.

Reference is now made to the drawings of

Figures 3, 4, 5, 6 and 7, and it will be seen that the anvil roller 38 (not shown in Figures 6 & 7) carried on the anvil shaft 25 is provided with a plurality of axially spaced flanges 39 and between which there are grooves 40. As seen best in Figure 3, the outer surfaces designated 41 of the flanges 39 engage the upper surfaces of the beads 13 of the work-piece 12 and constitute work-piece support surfaces which give the required reaction against the forces imparted by the cutter knife blades as the slots 10 are formed in the work-piece 12. It will also be seen that the slugs 14 are accommodated in a series of slug clearance spaces between the webs 11 of the workpiece 12 and the bases of the grooves 40. It is found from a practical point of view that it is necessary for these spaces to exceed one and one half times the web thickness, since the slugs 14 are not planar in shape (as illustrated in Figure 8) but in fact are frequently twisted or bent.

However the slugs 14 are displaced upwardly from the webs 11, and most if not all of the slugs are then carried away from the slotting station by the work-piece. This greatly facilitates disposal of the slugs and reduces danger of the slugs being carried around by the anvil roller or by the cutting knives, which can have disastrous results on the cutting knives if they become located between the cutting knives and the work-piece prior to a cut taking place.

Figure 6 illustrates a section through the cutter knife shaft 30, and shows a four-bladed cutter knife 44. The cutter knife 44 is supported by a boss 45 keyed to the shaft 30, by boss 45 also functioning to space the cutter knives 44 at the correct spacing from one another. The assembly is held together as a stack by a series of bolts 46. The ends 47 of each cutter knife blade are generally parallel to the respective ends of adjacent cutter knife blades as illustrated in Figure 6, the ends not extending in a radial direction which would otherwise form a wedge-shaped slot between adjacent blades into which the work-piece would be firmly jammed as it is cut. However, by having the adjacent ends 47 of adjacent knife blades parallel to one another, this jamming is substantially avoided. The drawing of Figure 5 illustrates a slightly different arrangement, wherein the blades of the cutter knives 44 cut through a work-piece designated 50 which has deep flanges 51 accommodated in recesses 52 in the anvil roller 38. However in all instances the cutter knife blades are provided with side faces designated 53 which converge radially inwardly so that the outer peripheries of the cutter knives are provided with rake edges, this reducing the drag. It will be appreciated that considerable friction occurs between the opposite side edges of the cutter knife

blades and the workpiece, tending to cause a continuous curve in the work-piece downwardly in a downstream direction from the cutter knives, but this is compensated for by the advanced position of the anvil roller 38 which tends to curve the work-piece in the opposite direction.

As said above, it is essential that no slugs become engaged between the cutter knives and the work-piece, and it is also necessary to support the work-piece on the downstream side of the cutting station, and this is achieved by a series of stripper blades 56 one of which is illustrated in Figure 7. Each stripper blade 56 is interposed between two cutter knives 44, and supports the work-piece after it passes the cutting station. There is a considerable friction between the work-piece and the stripper blades 56, and this friction tends to rotate the stripper blade 56 in a clockwise direction as seen in Figure 7. For this reason the leading edge 57 of the stripper blade 56 lies on a radius R1 which is less than the radius R 2 where the blade is engaged by the work-piece, so that the friction will not cause the stripper blade 56 to rotate to a position where it jams on the underside of the work-piece.

Because of the friction which exists between the stripper blades 56 and the bosses 45 which rotate within the central apertures 58 of the stripper blades 56, some lubrication is found to be highly desirable and this is achieved in this embodiment by having lubricant 60 contained in a container 61. The lubricant 60 has a secondary effect of lubricating the cutter knives 44, improving the cutting ability of the knife blades and reducing wear thereon.

In use, as noted above, the anvil speed is greater than the pitch speed of the cutter knife blades between 5% & 10%, and this reduces the tendency for the ends of the slots to be burred. It has been found that when the slots are long, their length can be adjusted within a narrow range by adjusting the relative speeds of the anvil roller and cutter knives. The existence of flanges on the anvil roller can provide a suitably large clearance space for the slugs, and in some instances (as in Figure 5) can also be arranged to accommodate relatively weak beads on the work-piece. By utilising separate drives, a simple construction can be achieved, and by maintaining a relatively small diameter of cutter knife, the tendency for the ductile metal to be rolled instead of cut is substantially reduced. A cleaner cut is achieved when the side faces of the cutter knives are made to converge radially inwardly, and the use of parallel ends of the knives avoids the wedging effect which can otherwise take place. When those portions of the webs which remain between the slots are relatively in length (that is shorter than

the slots) the cutter knives are found to firmly grip the work-piece and provide an indexing effect which provides in turn a regular slot length, so that it is relatively simple to stretch the work-piece subsequently and maintain a constant pattern throughout its area. By using a cutter knife which is equal to or even slightly greater than the width of the web, the development of sharp or ragged edges on the final product is substantially avoided.

In general, it has been found that a work-piece slotting rotary tool in accordance with this invention is effective in providing higher production rates and low cost work-pieces for subsequent stretching.

WHAT WE CLAIM IS:

1. A work-piece slotting rotary tool for the forming of rows of spaced staggered slots in relatively thin webs between relatively thick beads of a work-piece having a constant cross-sectional shape, comprising: a frame, a first set of bearings in the frame, an anvil roller shaft journaled for rotation in the first bearings, an anvil roller carried on its said shaft,

a second set of bearings in the frame, a rotary cutter shaft journaled for rotation in the second bearings and parallel to but spaced from the anvil roller shaft, a plurality of rotary cutter knives on the rotary cutter shaft, each cutter knife having at least one radially outstanding blade staggered with respect to the blade or blades of adjacent said cutter knives,

power means coupled to both said shafts for rotationally driving the shafts in opposite directions, and

support means on the frame for supporting said work-piece between the anvil roller and the rotary cutter knives,

characterised in that the anvil roller comprises a plurality of axially spaced radially outstanding flanges the peripheral annular surfaces of which constitute work-piece support surfaces which are engageable by the work-piece beads to support the work-piece during the formation of said slots therein, and that the roller surfaces between the work-piece support surfaces define with respective work-piece webs, slug clearance spaces which exceed one and one half times the web thickness.

2. A work-piece slotting rotary tool according to claim 1 further characterised in that the power means is arranged to drive the anvil roller with a peripheral speed of its support surfaces exceeding the pitch speed of the blades of the rotary cutter knives by between 5% and 10%.

3. A work-piece slotting rotary tool according to claim 1 or 2 further characterised in that the anvil roller is in advance of the rotary cutter shaft.

4. A work-piece slotting rotary tool

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5 blades and the workpiece, tending to cause a continuous curve in the work-piece downwardly in a downstream direction from the cutter knives, but this is compensated for by the advanced position of the anvil roller 38 which tends to curve the work-piece in the opposite direction.

10 As said above, it is essential that no slugs become engaged between the cutter knives and the work-piece, and it is also necessary to support the work-piece on the downstream side of the cutting station, and this is achieved by a series of stripper blades 56 one of which is illustrated in Figure 7. Each
15 stripper blade 56 is interposed between two cutter knives 44, and supports the work-piece after it passes the cutting station. There is a considerable friction between the work-piece and the stripper blades 56, and
20 this friction tends to rotate the stripper blade 56 in a clockwise direction as seen in Figure 7. For this reason the leading edge 57 of the stripper blade 56 lies on a radius R1 which is less than the radius R 2 where the
25 blade is engaged by the work-piece, so that the friction will not cause the stripper blade 56 to rotate to a position where it jams on the underside of the work-piece.

30 Because of the friction which exists between the stripper blades 56 and the bosses 45 which rotate within the central apertures 58 of the stripper blades 56, some lubrication is found to be highly desirable and this is achieved in this embodiment by having
35 lubricant 60 contained in a container 61. The lubricant 60 has a secondary effect of lubricating the cutter knives 44, improving the cutting ability of the knife blades and reducing wear thereon.

40 In use, as noted above, the anvil speed is greater than the pitch speed of the cutter knife blades between 5% & 10%, and this reduces the tendency for the ends of the slots to be burred. It has been found that
45 when the slots are long, their length can be adjusted within a narrow range by adjusting the relative speeds of the anvil roller and cutter knives. The existence of flanges on the anvil roller can provide a suitably large
50 clearance space for the slugs, and in some instances (as in Figure 5) can also be arranged to accommodate relatively weak beads on the work-piece. By utilising separate drives, a simple construction can be
55 achieved, and by maintaining a relatively small diameter of cutter knife, the tendency for the ductile metal to be rolled instead of cut is substantially reduced. A cleaner cut is achieved when the side faces of the cutter
60 knives are made to converge radially inwardly, and the use of parallel ends of the knives avoids the wedging effect which can otherwise take place. When those portions of the webs which remain between the slots
65 are relatively in length (that is shorter than

the slots) the cutter knives are found to firmly grip the work-piece and provide an indexing effect which provides in turn a regular slot length, so that it is relatively simple to stretch the work-piece subsequently and maintain a constant pattern throughout its area. By using a cutter knife which is equal to or even slightly greater than the width of the web, the development of sharp or ragged edges on the final product is substantially avoided.

In general, it has been found that a work-piece slotting rotary tool in accordance with this invention is effective in providing higher production rates and low cost work-pieces for subsequent stretching.

WHAT WE CLAIM IS:

1. A work-piece slotting rotary tool for the forming of rows of spaced staggered slots in relatively thin webs between relatively thick beads of a work-piece having a constant cross-sectional shape, comprising:

a frame, a first set of bearings in the frame, an anvil roller shaft journaled for rotation in the first bearings, an anvil roller carried on its said shaft,

a second set of bearings in the frame, a rotary cutter shaft journaled for rotation in the second bearings and parallel to but spaced from the anvil roller shaft, a plurality of rotary cutter knives on the rotary cutter shaft, each cutter knife having at least one radially outstanding blade staggered with respect to the blade or blades of adjacent said cutter knives.

power means coupled to both said shafts for rotationally driving the shafts in opposite directions, and

support means on the frame for supporting said work-piece between the anvil roller and the rotary cutter knives,

characterised in that the anvil roller comprises a plurality of axially spaced radially outstanding flanges the peripheral annular surfaces of which constitute work-piece support surfaces which are engageable by the work-piece beads to support the work-piece during the formation of said slots therein, and that the roller surfaces between the work-piece support surfaces define with respective work-piece webs, slug clearance spaces which exceed one and one half times the web thickness.

2. A work-piece slotting rotary tool according to claim 1 further characterised in that the power means is arranged to drive the anvil roller with a peripheral speed of its support surfaces exceeding the pitch speed of the blades of the rotary cutter knives by between 5% and 10%.

3. A work-piece slotting rotary tool according to claim 1 or 2 further characterised in that the anvil roller is in advance of the rotary cutter shaft.

4. A work-piece slotting rotary tool

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according to any preceding claim further characterised in that said support means comprise a plurality of stripper plates are positioned between respective pairs of adjacent said rotary cutter knives and, each stripper plate has a support edge lying on a radius which increases from its leading edge towards its trailing edge.

5 5. A work-piece slotting rotary tool according to any preceding claim further characterised in that each rotary cutter knife blade is a part-circular peripheral portion terminating in curved ends, each curved end being generally parallel to and spaced from an adjacent curved end of a similar part-circular peripheral portion, and each blade having side walls which converge in a radially inwards direction.

10 6. A work-piece slotting rotary tool according to any preceding claim further characterised in that the outer diameters of the rotary cutter knives do not exceed 250mm

15 7. A work-piece slotting rotary tool according to any preceding claim further characterised in that the thickness of each cutter knife across its cutting periphery is at least equal to the width of the web to be cut thereby.

20 8. A method of forming rows of spaced staggered slots in relatively thin webs between relatively thick beds of a work-piece

having a constant cross-sectional shape with a slotting tool according to claim 2, characterised by:

35 driving said anvil roller in one direction and said cutter shaft in the reverse direction at speeds such that the peripheral speed of said annular work-piece support surfaces exceeds the pitch speed of the rotary cutter knives by between 5% and 10%,

40 feeding said work-piece between said anvil roller and said rotary cutter knives at a slotting station and piercing said slots with said rotary cutter knife blades to displace slugs from said webs, into said slug clearance spaces, and carrying said slugs away from said slotting station on said work-piece.

45 9. A method of forming rows of spaced staggered slots according to claim 9 wherein said anvil roller is positioned above said rotary cutter knives and in advance thereof, further characterised by:

50 displacing said slugs upwardly from the work-piece and disposing of some at least of said slugs by carrying them on the slotted portion of the work-piece to a discharge locality.

55
60 BAILEY, WALSH & CO.,
9 Park Place,
Leeds LS1 2SD.
Agents for the Applicants.