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(54) METHOD AND APPARATUS FOR FORMING LONGITUDINALLY SPACED AND LONGITUDINALLY EXTENDING SLOTS IN STRIP MATERIAL

(71) We, COMALCO (J. & S.) PTY LIMITED, an Australian Company incorporated in the State of Victoria, 95 Collins Street, Melbourne, State of Victoria, 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 method and apparatus for forming longitudinally spaced and longitudinally extending slots in strip material and is applicable to but not limited to, the slotting of a metal section between flanges prior to the drawing of those flanges apart to form a truss, mesh panel or other metal member of expanded metal.

In prior art means and methods for the preparation by shearing of sheet or strip material for the forming of expanded metal panels, the shear lines have been single shear lines and have ended in sharp edges which cause stress concentration zones at the ends of the slits as the metal is stretched. Thus the metal is useful as a non-loadbearing panel, but is not useful as a loadbearing panel.

The main object of this invention is to provide a method and apparatus for shearing longitudinally spaced and longitudinally extending slots in strip material.

The present invention is stated as a method of forming longitudinally and longitudinally extending slots in strip material having a constant cross-sectional shape, comprising: driving the strip in the direction of its longitudinal axis and at right angles to the axis of a slot-shearing roll assembly comprising a series of spaced slot-shearing rollers and through a shearing zone existing between the roll assembly and strip back-up means, each of said slot-shearing rollers having at least one radial projection of arcuate form to define a slot-shearing formation, and simultaneously driving the

slot-shearing rollers rotationally, thereby causing the radial projections on the rollers to shear slugs clear from the strip material and thereby form said slots.

The present invention is also stated as apparatus for performing the method described above, comprising a frame, a pair of aligned bearings carried by the frame and supporting a slot-shearing roll assembly comprising a series of spaced slot-shearing rollers each having at least one radial projection of arcuate form to define a slot-shearing formation; back-up means spaced from the rollers but being adjacent thereto so as to define with the rollers a shearing zone, means for driving strip material to be slotted in the longitudinal direction of the strip and drive means coupled to the rollers for rotational driving thereof, the apparatus being so constructed and arranged that the strip material, in being driven through the apparatus, has formed therein longitudinally spaced and longitudinally extending slots and the slugs sheared from the strip material move clear of the strip material.

An embodiment of the invention is described hereunder with reference to the accompanying drawings in which:—

Fig. 1 is a diagrammatic representation illustrating apparatus for the slotting of strip material.

Fig. 2 is an enlarged and more detailed view in cross-section of the apparatus illustrated in Fig. 1.

Fig. 3 is a fragmentary plan,

Fig. 4 is an exploded perspective view which illustrates three elements of a series of slot-shearing rollers.

Fig. 5 is a longitudinal section through a series of slot-shearing rollers carried on a shaft to form slot-shearing roll assembly and arranged to be supported between a pair of spindles.

Fig. 6 is an enlarged section showing the slot-shearing zone and the relationship

between the slot-shearing rollers and a back-up roll.

Fig. 7 is an enlarged side elevation of a slot-shearing roller.

Fig. 8 is a half section taken on line 8-8 of Fig. 7.

Fig. 9 is a longitudinal section through a back-up roll.

Fig. 10 is a partly diagrammatic view of a hold down roller (when used).

Fig. 11 is a perspective view of an auxiliary table (when used), and

Fig. 12 is a diagrammatic representation showing the control means for the apparatus.

The apparatus 20 has an in-feed roll case 21 and an out-feed roll case 22. Each roll case 21 and 22 is adjustable for height by means of jacks 23 (Fig. 2), each jack 23 having a threaded member 24 which threadably engages a component of a frame 25. Only the adjacent ends of the roll cases 21 and 22 are adjustable for height, since the amount of adjustment required is relatively small. The other ends are provided with hinge supports (not shown).

The in-feed roll case 21 is provided with a plurality of pairs of rollers 28 each carried on a respective shaft 29, the shafts being journaled in bearings 30. The rollers of a pair are spaced on their shaft 29, and between the rollers of the pair there is positioned a transport chain 31 having dogs 32 thereon. The arrangement is such that a dog 32 engages against an end of a strip workpiece 33 as shown in Fig. 2 for driving the workpiece 33 through a shearing zone designated 34 and which exists between a back-up roll 35 and a series of slot-shearing rollers 36. On the output side of the cutting zone 34 the out-feed roll case 22 is like case 21 except that a transport chain is not required and a hold down roller 37, which assists in reducing distortion of the workpiece after it has been cut, is provided.

The configuration of the rollers 36 is best seen from the drawings of Figs. 4, 5, 6, 7 and 8. Each roller 36 is provided with a central opening 41 which engages over a shaft 42 and is keyed thereto by means of a key 43. Each roller is also provided with six bolt holes 44 which contain bolts 45, and by this means it is possible to build up a stack of slotting rollers 36. Each slotting roller 36 is provided with a pair of radial projections 46 of arcuate form to define a slot-shearing formation. The projections 46 are spaced by recessed portions designated 47. There need be only one radial projection 46, the number being determined by the length and pitch of the slots required in the workpiece strip 33.

Between adjacent rollers 36 are positioned respective spacers 49, and surrounding each spacer 49 is a stripper

plate 50, the function of the stripper plate 50 being to assist in avoiding distortion of the workpiece as it is cut, the stripper plates 50 lightly bearing against the upper surfaces of the respective beads on the strip material workpiece 33, which beads are designated 51 in Fig. 9. Further to assist in avoiding distortion, the outer peripheries of the radial projections 46 are knurled as shown in Fig. 4. This latter feature is an optional feature which in some cases is not used.

The bolts 45 bear against the end plates 53 (Fig. 5), and the end plates themselves are contained between annular packers 54 which surround the shaft 42 and at one end bear against a shoulder 55 and at the other end are retained by means of a spindle nut 56, the ends of the shaft 42 containing respective tapered recesses 58 and 59. The recess 59 is intersected by a transverse slot 60. In this manner a slot-shearing roll assembly comprising shaft 42, rollers 36, spacers 49, and stripper plates 50 is formed and may be supported between a driven spindle at one end and an idling spindle at the other so that a quick change over of tooling can be made if the slot configuration is to be varied. In this respect the tooling is attached to the machine in much the same way as a milling cutter is attached to a milling machine. (The shaft may have projections, and the spindles may be provided with recesses).

Fig. 6 shows the detail of operation of the rollers 36 in conjunction with the back-up roll 35. It will be noted that the axis 66 of the back-up roll 35 is displaced upstream relative to the axis of rollers 36. The axis 66 forms the centre of the shearing zone 34, that is that zone of the web which is undergoing a shearing action upon rotation of the rollers 36. The pitch shearing speed of each roller is the lineal speed of that portion of the roller 36 which is tangential to the mid-plane of the workpiece.

As shown in Figs. 7 and 8, the radial projections 46 terminate, in the arcuate direction, in radially extending curved surfaces 67, and the side faces of the projections 46 are undercut to provide a rake or cutting clearance 68 as shown in Fig. 8. This reduces drag on the edges of the metal as shearing takes place in the workpiece.

In order to accommodate different slot-shearing roller diameters, or different heights of beads 51 in different workpieces, it is necessary to be able to adjust the position of the back-up roll 35 in a fore and aft direction, and to this end the back-up roll 35 is carried in bearings (not shown) disposed in bearing blocks 70, and for the same reason the bearings (not shown) in which the shaft 42 is journaled are adjustable vertically, being carried in

bearing blocks which are guided for vertical movement by the slides 71. Respective screw members 72 and 73 effect the adjustments.

Fig. 9 illustrates the cross-sectional shape of the back-up roll 35. The back-up roll 35 comprises a plurality of roller members 75 and spacers 75a carried on a shaft 76, the shaft 76 being of similar configuration to the shaft 42, again being provided with a shoulder 77 at one end, a spindle nut 78 at the other, and respective recesses 79 and 80, the recess 79 being intersected by a transverse slot 81. With this arrangement then the roll assembly which includes the slot-shearing rollers 36 and a roll assembly which includes the members 75 and spacers 75a can be manufactured or repaired, and retained as a pair of matched tools.

Not only is it necessary to change the rollers 36 and the back-up roll when a work-piece of different cross-section configuration is to be slotted, but in many instances it is also necessary to reposition the hold down roller 37. This can be effected in any known way, and Fig. 10 illustrates one simple mechanism wherein an air cylinder 84 is coupled to an arm 85 which is pivoted to a standard 86 upstanding from the frame 25, the coupling being effected by means of a bell crank shaped lever 87 and a coupling link 88. The standard 86 is provided with slots 89 which support a block 90 which in turn rotationally supports a shaft 91, the shaft 91 having secured to it the bell crank lever 87. Thus the block 90 may be positioned in an upper position for high flanges or beads. Similarly the slots 93 provide adjustment means for the pin 94 about which the arm 85 pivots.

If it is desired to slot a thin strip work-piece which may be damaged by utilising the back-up roll 35, the workpiece is conveniently positioned on a table designated 96 in Fig. 11, the table 96 having a number of upstanding parallel spaced flanges 97 to support the workpiece between it and the rollers 36. The lower or underface of the table is provided with a chain 98 secured thereto and arranged to function as a rack, the chain 98 being identical in size and shape to the transport chain 31. Thus a sprocket 99, Fig. 12, which drives the chain 31 when the back-up roll is used, can be used to drive the chain 98 and move the table 96 beneath the rollers 36. The workpiece is retained by means of a stop bar 100 secured to the upper surface of the table 96.

Fig. 12 illustrates diagrammatically the drive means, wherein an electric motor 105 drives a pump 106 which draws oil from a reservoir 107, and drives the oil at pressure through a control valve 108, in turn driving

an hydraulic motor 109 which effects drive to the shaft 42 by means of a drive chain 110. The shaft 42 is coupled through a variable ratio drive designated 112 to one of a pair of tacho-generators 113, the tacho-generators controlling a direct current motor 114 through a direct current feed back control module 115 which controls speed of the motor 114 which has the second tacho-generator 113 coupled thereto. The motor 114 drives the back-up roll 35 through a chain drive 116, and drives the sprocket 99 of the transport chain 31 (or chain 98) through an electric clutch designated 117 in Fig. 12.

In use the apparatus is operated by first inserting a matched pair of tools, namely an assembly including a series of slot-shearing rollers 36 arranged on a shaft 42, and a corresponding series of roller members 75 arranged on a shaft 76 to form a back-up roll, or a table 96. These are arranged to be driven respectively by the motors 109 and 114.

The control 115 is adjusted so that the speed of the transport chain 31 (or alternatively of the chain 98 and table 96) is the same as the pitch shearing speed of the rollers 36, or slightly greater. The degree of difference is adjustable by the control 115, and the operator exercises his skill in adjusting the difference (if any). Slot length and quality of cut can be controlled by varying the speed of the motor 114.

A workpiece is either secured to the table 96 (if this is to be used) or alternatively is positioned over the chain 31 so that its end will be engaged by a dog 32. An impulse is received from a separate sensing means, and this impulse energises the electric clutch 117, the electric clutch 117 being arranged to remain energised until the strip workpiece has completed its traverse through the cutting zone 34.

In this embodiment the sensing means is a magnet coupled to the shaft 42 and a switch operated thereby. This is not illustrated, and alternative sensing means may be used in lieu thereof. However where the magnet/switch means the sensing is used the switch is adjustable to provide means for compensating for starting inertia which varies with workpieces having different weights.

The instant of energising the clutch 117 determines the relationship between the slots and the end of the workpiece. The mechanism for achieving this interlock is in accordance with prior art and forms no part of this invention. As a workpiece passes through the apparatus slugs are sheared clear from it to form longitudinally spaced and longitudinally extending slots. After the workpiece has traversed through the machine, the slugs are removed from the

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5 machine and the workpiece is removed from the out-feed roll case 22. The workpiece may be subsequently expanded by stretching of the metal between the slots which have been formed.

10 The cross-sectional configuration of the workpiece can vary considerably from that which is shown in Fig. 9. The beads 51, especially in conjunction with the upstream location of roll 35 (when used), allow the sheared slugs to fall clear of the workpiece and hence female dies to accept the slugs are not required.

15 The above description has been with reference to a machine wherein the slot-shearing rollers are positioned above the workpiece. However the arrangement can be inverted, to have the back-up roll above the workpiece and the slot-shearing rollers beneath it. This arrangement results in ejection of the slugs onto the workpiece, and may thereby assist in slug disposal.

20 In the embodiment above described using a back-up roll, the transport chain 31 and the roll both imparted drive to the workpiece. However, it is not always necessary to utilise both these drives, and either one may be used in instances wherein the workpiece does not impart heavy cutting loads on the slot-shearing rollers. However in all cases, drive is imparted to both the workpiece and to the slot-shearing rollers.

WHAT WE CLAIM IS:—

35 1. A method of forming longitudinally spaced and longitudinally extending slots in strip material having a constant cross-sectional shape, comprising: driving the strip in the direction of its longitudinal axis and at right angles to the axis of a slot-shearing roll assembly comprising a series of spaced slot-shearing rollers and through a shearing zone existing between the roll assembly and strip-back-up means, each of said slot-shearing rollers having at least one radial projection of arcuate form to define a slot-shearing formation, and simultaneously driving the slot-shearing rollers rotationally, thereby causing the radial projections on the rollers to shear slugs clear from the strip material and thereby form said slots.

50 2. A method according to claim 1 wherein the rollers are driven to have their pitch shearing speed the same as the driven speed of the strip.

55 3. A method according to claim 1 wherein the rollers are driven to have their pitch shearing speed less than the driven speed of the strip.

60 4. A method according to any preceding claim wherein the back-up means is a roll and said driving of the strip is effected by engaging one end of the strip with a dog on a transport chain, and driving the transport chain.

5. A method according to any one of claims 1 to 3 wherein the back-up means is a table and said driving of the strip is effected by securing the strip to the table and driving the table.

6. A method according to either claim 4 or claim 5 wherein the driving of the strip is by a variable speed direct current motor, and the method comprising controlling the speed of said motor by means of a tachogenerator coupled for drive to the slot-shearing rollers and electrically coupled to said electric motor through a circuit which includes direct current feedback control means.

7. Apparatus for performing the method of claim 1, comprising a frame, a pair of aligned bearings carried by the frame and supporting a slot-shearing roll assembly comprising a series of spaced slot-shearing rollers each having at least one radial projection of arcuate form to define a slot-shearing formation; back-up means spaced from the rollers but being adjacent thereto so as to define with the rollers a shearing zone, means for driving strip material to be slotted in the longitudinal direction of the strip and drive means coupled to the rollers for rotational driving thereof, the apparatus being so constructed and arranged that the strip material, in being driven through the apparatus, has formed therein longitudinally spaced and longitudinally extending slots and the slugs sheared from the strip material move clear of the strip material.

8. Apparatus as claimed in claim 7 in which said frame includes two pairs of upstanding slides and the aligned bearings are guided for movement between the slides, and in which threaded members, interconnecting the bearings and frame to constitute adjustment means for effecting adjustment of height of the bearings, are provided.

9. Apparatus as claimed in claim 7 or 8 in which the back-up means comprise a back-up roll journaled in support bearings secured to the frame.

10. Apparatus as claimed in claim 9 when appendant to claim 8 comprising further threaded members coupling the back-up roll support bearings and the frame and constituting position adjustment means for the back-up roll for adjusting the position of the back-up roll in the direction of the drive of the strip material.

11. Apparatus according to either claim 9 or claim 10 in which the back-up roll and the slot-shearing roll assembly each comprises a shaft, a shoulder at one end of the shaft, a series of rollers surrounding the shaft, clamping means clamping the rollers against the shoulder, and a tapered recess in the end of the shafts.

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machine and the workpiece is removed from the out-feed roll case 22. The workpiece may be subsequently expanded by stretching of the metal between the slots which have been formed.

The cross-sectional configuration of the workpiece can vary considerably from that which is shown in Fig. 9. The beads 51, especially in conjunction with the upstream location of roll 35 (when used), allow the sheared slugs to fall clear of the workpiece and hence female dies to accept the slugs are not required.

The above description has been with reference to a machine wherein the slot-shearing rollers are positioned above the workpiece. However the arrangement can be inverted, to have the back-up roll above the workpiece and the slot-shearing rollers beneath it. This arrangement results in ejection of the slugs onto the workpiece, and may thereby assist in slug disposal.

In the embodiment above described using a back-up roll, the transport chain 31 and the roll both imparted drive to the workpiece. However, it is not always necessary to utilise both these drives, and either one may be used in instances wherein the workpiece does not impart heavy cutting loads on the slot-shearing rollers. However in all cases, drive is imparted to both the workpiece and to the slot-shearing rollers.

WHAT WE CLAIM IS:—

1. A method of forming longitudinally spaced and longitudinally extending slots in strip material having a constant cross-sectional shape, comprising: driving the strip in the direction of its longitudinal axis and at right angles to the axis of a slot-shearing roll assembly comprising a series of spaced slot-shearing rollers and through a shearing zone existing between the roll assembly and strip back-up means, each of said slot-shearing rollers having at least one radial projection of arcuate form to define a slot-shearing formation, and simultaneously driving the slot-shearing rollers rotationally, thereby causing the radial projections on the rollers to shear slugs clear from the strip material and thereby form said slots.

2. A method according to claim 1 wherein the rollers are driven to have their pitch shearing speed the same as the driven speed of the strip.

3. A method according to claim 1 wherein the rollers are driven to have their pitch shearing speed less than the driven speed of the strip.

4. A method according to any preceding claim wherein the back-up means is a roll and said driving of the strip is effected by engaging one end of the strip with a dog on a transport chain, and driving the transport chain.

5. A method according to any one of claims 1 to 3 wherein the back-up means is a table and said driving of the strip is effected by securing the strip to the table and driving the table.

6. A method according to either claim 4 or claim 5 wherein the driving of the strip is by a variable speed direct current motor, and the method comprising controlling the speed of said motor by means of a tachogenerator coupled for drive to the slot-shearing rollers and electrically coupled to said electric motor through a circuit which includes direct current feedback control means.

7. Apparatus for performing the method of claim 1, comprising a frame, a pair of aligned bearings carried by the frame and supporting a slot-shearing roll assembly comprising a series of spaced slot-shearing rollers each having at least one radial projection of arcuate form to define a slot-shearing formation; back-up means spaced from the rollers but being adjacent thereto so as to define with the rollers a shearing zone, means for driving strip material to be slotted in the longitudinal direction of the strip and drive means coupled to the rollers for rotational driving thereof, the apparatus being so constructed and arranged that the strip material, in being driven through the apparatus, has formed therein longitudinally spaced and longitudinally extending slots and the slugs sheared from the strip material move clear of the strip material.

8. Apparatus as claimed in claim 7 in which said frame includes two pairs of upstanding slides and the aligned bearings are guided for movement between the slides, and in which threaded members, interconnecting the bearings and frame to constitute adjustment means for effecting adjustment of height of the bearings, are provided.

9. Apparatus as claimed in claim 7 or 8 in which the back-up means comprise a back-up roll journaled in support bearings secured to the frame.

10. Apparatus as claimed in claim 9 when appendant to claim 8 comprising further threaded members coupling the back-up roll support bearings and the frame and constituting position adjustment means for the back-up roll for adjusting the position of the back-up roll in the direction of the drive of the strip material.

11. Apparatus according to either claim 9 or claim 10 in which the back-up roll and the slot-shearing roll assembly each comprises a shaft, a shoulder at one end of the shaft, a series of rollers surrounding the shaft, clamping means clamping the rollers against the shoulder, and a tapered recess in the end of the shafts.



12. Apparatus according to any one of claims 7 to 11 having an in-feed roll case carried by the frame and extending in one direction from the shearing zone, and an out-feed roll case extending in the opposite direction from the shearing zone.

13. Apparatus as claimed in claim 12 comprising height adjustment means between each roll case and the apparatus frame.

14. Apparatus as claimed in any one of claims 7 to 13 in which the slotting roller's radial projections terminate in the arcuate direction in a curved surface which extends in the radial direction.

15. Apparatus as claimed in any one of claims 7 to 14 in which the side faces of the radial projections are undercut so that the projections decrease progressively in thickness radially inwardly from the periphery thereof to form a cutting clearance.

16. Apparatus as claimed in any one of claims 7 to 15 further comprising stripper plates between adjacent slotting rollers, said stripper plates being positioned to bear against a surface of said strip material as said slots are formed therein.

17. Apparatus as claimed in either claim 12 or claim 13 further comprising a hold-down roller positioned above the out-feed roll case and adapted to bear

against the upper surface of the workpiece at the out-feed side of the shearing zone.

18. Apparatus as claimed in any one of claims 7 to 17 wherein the drive means coupled to the slot-shearing rollers comprise an hydraulic motor, a tachogenerator coupled to the rollers, a direct current electric motor coupled to the means for driving the strip material, and an electrical circuit interconnecting the tachogenerator and the direct electric current motor to provide direct current feedback control to that motor.

19. A method of forming longitudinally spaced and longitudinally extending slots in strip material having a constant cross-sectional shape, substantially as hereinbefore described with reference to the accompanying drawings.

20. Means for forming longitudinally spaced and longitudinally extending slots in strip material having a constant cross-sectional shape, substantially as hereinbefore described with reference to the accompanying drawings.

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