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(54) Rolling mill for metal powder compaction.

(57) A rolling mill for the roll compaction of metal powder into strip (14) of equal width to the length of the rolls (10,11) is provided with edge restraint devices in the form of cylindrical blocks (15) mounted in the roll gap region with their axes parallel to the roll axes and rotatably driven to cause an end face of each edge restraint block to move in frictional contact with the respective end faces (16,17) of the rolls (10,11).

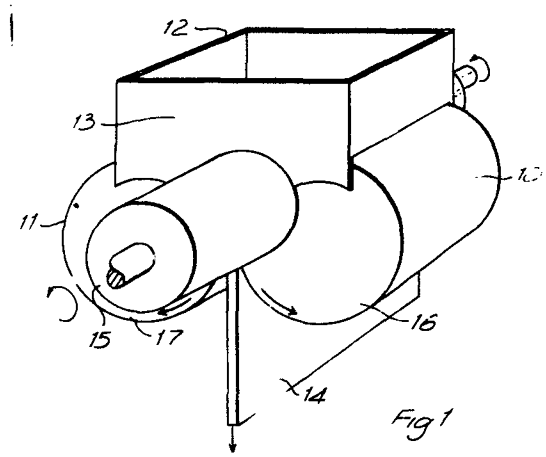

Fig 1

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TITLE MODIFIED
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The present invention relates to the compaction of metallic powder to strip or sheet form by rolling, and is particularly concerned with a rolling mill therefor which is provided with edge restraints for controlling the lateral spread of powder in the roll gap.

Metal powders (which term is used herein to include powders consisting at least in part of one or more metals and/or alloys) can be compacted by feeding them to the intake side of a gap between a pair of rolls. The powder may be compacted at ambient or elevated temperature, and the strip-like product which issues from the exit side of the roll gap may be flat sided, though contoured rolls may be used to provide any desired surface profile on the product.

In all powder rolling applications, a problem is posed by the tendency of powder to spread laterally in the roll gap, i.e. at right angles to the rolling direction. Such a tendency results in the production of strip having weak, low density edges, so that an edge trimming operation becomes necessary. In large scale operations, particularly of the continuous type, it is highly desirable to be able to avoid or to at least to mimimise any edge trimming needed since this is a labour intensive operation and is wasteful because of the large amount of scrap produced. The problem of controlling strip edges is particularly acute where the apparatus is designed to produce a strip extending over the entire length of the roll gap. In such a case the lateral spread of powder results in egress of the powder from the roll gap. It is with the production of such strip, i.e. the width of which is equal to the length of the rolls, that the present invention is particularly concerned.

In the past various methods have been suggested for controlling the edge of a strip produced by powder rolling. One type of edge control involves the use of a stationary restraint member urged against the end-faces of the rolls in the vicinity of the roll gap, thereby acting as a closure for the roll nip area. Alternatively, it has been proposed to provide flange-like constructions which are fixed to one of the rolls or integrally constructed therewith so as to overlap the other roll at the extremity thereof or in a groove provided near the extremity thereof. Further alternatives which have been suggested involve the use of one or more rollers mounted with their axes orthogonal to the roll axes and forced against the end-faces of the rolls, or used to urge a strip of metal or rubber into contact with the roll end-faces. Yet another approach which has been advocated involves feeding an edge-restraint strip into the roll gap at both extremities thereof, with the powder being fed between the strips.

None of the above-mentioned approaches has provided an entirely satisfactory solution to the problem. Typical of their shortcomings are:

I. Whenever the edge-restraint device is a stationary member, a static powder zone results in the roll nip region and the strip produced exhibits edges of low density, or even unconsolidated edges;

II. Many of the designs suggested do not adequately prevent powder egress from the roll gap because they make only a tangential contact with the roll end-faces;

III. Devices which employ a moving surface to restrain the strip edge generally cease to operate effectively when wear of that surface takes place. Such wear is inevitable when contact is made with the end-faces of the rolls since different points on these end-faces move, in operation, with different linear velocities;

IV. In the case of the apparatus employing narrow bands or belts which contact the roll edges or which are fed between the rolls, the edge control bands may be easily damaged, or they may become entrapped in the metal strip produced. Moreover, the use of such bands or belts generally restricts the flexibility of the apparatus for producing strips of different thicknesses.

The applicants have now devised a simple and reliable means of edge restraint which enables metallic strip as wide as the roll length to be produced with sound edges which do not require subsequent trimming.

According to the present invention a rolling mill for the roll compaction of metal powder into strip comprises a pair of cylindrical rolls of equal length rotatably mounted with their longitudinal axes parallel to define a roll gap therebetween, means for feeding a powder to be compacted to an intake side of the roll gap along the entire length of the rolls, each end of the roll gap being closed by an edge restraint member characterised in that each edge restraint member comprises a cylindrical block of smaller diameter than each roll, rotatably mounted about an axis parallel to the roll axes and spaced therefrom, that means are provided for urging each restraint member so that at least a portion of an end face thereof is in frictional contact with the end faces of each of the rolls, and that means are provided for driving each restraint member to impart rotation thereto whereby relative sliding action is produced between the end faces of the rolls and the end faces of the restraint members.

In use, the restraint member is rotatably driven while its end-face is maintained in frictional contact with the roll end-faces. Gradual wear of the restraint member end-face is of course expected to occur, but throughout such wear the end-face of the member will continue to mate with the roll end-faces, against which it is urged by suitable spring biasing, so as to maintain a powder tight seal at the roll nip.

To avoid the damage to the rolls it is preferred to construct the restraint member, or at least that portion which contacts the roll end-faces, of a material which wears in preference to the roll material. Thus for example the restraint member may be made of a steel softer than the steel used for the roll end-faces, or it might be made of materials such as brass or even a brake-lining composite material. Most preferably the restraint member can have a two-piece construction comprising a permanent shank provided with a replaceable wear-tip.

A driving force, other than any force resulting from friction with the rolls, must be provided for rotating the restraint member about its central axis. The driving force can be supplied by a separate motor, or may for convenience be supplied, using suitable mechanical coupling, by the same motor used for driving the rolls.

The restraint member can be positioned in different ways relative to the two roll axes, providing that in all cases the end-face of the restraint member effectively seals off the gap between the rolls at the intake side of the roll gap. Thus the restraint member axis can be anywhere between a pair of planes each containing a roll axis and each perpendicular to the common plane of the roll axes. For example, the restraint member axis can coincide with the line drawn at the roll gap centre parallel to and coplanar with the roll axes, which line shall be referred to for convenience as the "roll gap central axis". Preferably however, the restraint member axis is offset from that roll gap central axis. The offset can comprise a displacement parallel to or normal to the common plane of the roll axes. Such an offset is preferred for two reasons. Firstly it can be used to minimise contact between the restraint member and the edge of a compacted strip, which contact is neither necessary nor beneficial. Furthermore, the offset can be used to ensure that the centre of the restraint member end-face, which is the only location of that end-face constituting a stationary spot, is removed from the vicinity of the roll gap. Preferably the restraint member is so positioned that it overlaps the first and second rolls to different extents. Most preferably the centre of the restraint member end-face lies within the portion of that end-face overlapped by one of the rolls.

Where, as is preferred, the rolls are overlapped to different extents by the restraint member, it is preferable to rotate the member in the same angular direction as the roll with which there is greater overlap. When this is done the direction of movement of the member's end-face will be generally with the powder flow rather than against it.

In order to maximize the flexibility of the rolling mill for coping with different powders and for the production of different strip thicknesses, it is preferable to mount the restraint member in such a manner that its central axis can be selectively moved to various positions spaced from and parallel to the roll gap central axis.

An embodiment of the invention will now be described by way of example only. Although for the sake of simplicity the specific embodiment is a mill employing vertical powder feed, the invention is by no means restricted to such mills and can with equal success be embodied in rolling mills wherein powder is fed horizontally to the roll gap.

In the accompanying drawings:

Figure 1 is a schematic illustration of a perspective view of the rolls and edge restraint member in an embodiment of the invention; and

Figure 2 illustrates the position of the restraint member axis relative to the roll axes in the embodiment of Figure 1.

In Figure 1, a pair of rolls 10 and 11 of equal length and diameter are shown in a horizontally spaced configuration. The rolls have generally flat end-faces and are mounted (by means not illustrated) with their end-faces coplanar with one another. A rechargeable hopper 12 is positioned above the rolls, and has a lower end which is shaped to follow the roll contours so that powder is discharged from a hopper slot above and close to the roll gap. The end-walls 13 of the hopper are shaped and dimensioned so as to overlap the roll edges, and sealing means may be provided to ensure a powder-tight fit between the end walls 13 and the rolls.

Powder fed to the roll gap exits downwards as a compacted strip 14. Edge restraint is provided by a cylindrical block 15 mounted at each axial extremity of the roll gap. The block is urged towards the rolls by means (not illustrated) which may be either automatically or manually adjustable to allow for wear of the block. The urging may be effected by spring-biasing or by means of hydraulic pressure for example. Under the action of the urging means, a frictional contact is maintained between the end-face of the block 15 and the end-faces 16 and 17 of the rolls 10 and 11 respectively. Moreover a powder-tight seal is maintained between the block 15 and the hopper 12 by shaping the end-wall 13 of the hopper so as to conform to the contour of the block 15 and preferably providing seals between the lower edge of the end-wall 13 and the outer cylindrical surface of the block 15.

It is preferable to mount the restraint member 15 so that its position relative to the roll axes is selectively adjustable. To accommodate such variation of the position of the block 15, the end-walls 13 of the hopper should be adaptable to the displacement of the block 15, or movable with the block so that, between them, a powder-tight seal can be established at all times.

A preferred positioning of the restraint member is illustrated in Figure 2. In that diagram the line L M represents the horizontal plane containing the rotational axes A and B respectively of the rolls 10 and 11. The lines P Q and R S represent vertical planes containing the axes A and B respectively. The point C represents the roll gap central axis, and as can be seen from the drawing the preferred configuration involves positioning the restraint member 15 so that its rotational axis D is displaced both vertically and horizontally from the roll gap central axis C. This results in a much greater extent of overlap between the block 15 and the roll 10, than between the block 15 and the roll 11.

The precise position of the block axis D can of course be otherwise than as illustrated. D can, in general, be positioned anywhere between the planes P Q and R S providing the arrangement enables the restraint member to seal off adequately the powder intake side of the roll gap (i.e. the portion of the roll gap above and close to the line L M). However, the arrangement illustrated is preferred for the following reasons:

i. By virtue of the vertical displacement of D from C there is little or no contact of the restraint member with the compacted strip;

ii. The extent of the horizontal displacement of D from C is such that D lies within that portion of the end-face of block 15 which overlaps the end-face of the roll 10. In this way it is possible to avoid even a point contact between the powder and a stationary edge restraint surface; and

iii. With such a horizontal displacement the restraint member surface which contacts the powder can be arranged to move in the same general direction as the powder flow. This is achieved by rotating the block 15 in the same angular direction as the roll which is overlapped by the block to a greater extent, i.e., the block 15 and the roll 10 are both driven anti-clockwise as viewed in the drawing.

Rotating cylindrical blocks of the above-described type provide an effective as well as convenient form of edge restraint. They can be used with a wide range of roll gap settings to produce various strip thicknesses. They can be replaced in a relatively simple manner when a predetermined amount of wear has taken place. It has been found convenient to construct each block 15 in two detachable parts: a first cylindrical portion acting as a permanent shank, and a second cylindrical portion constituting a wear tip. Removal of a restraint member from the rolling mill will only be necessitated when the block, or its tip in the case of two-part construction, has worn to such an extent that inadequate powder sealing results. The time period between necessary replacement can be controlled by suitable choice of the axial dimension of the wear tip. Thus where the material used is one that will wear very slowly, the wear tip may be a relatively short cylinder, i.e., disc-like in shape.

As will be clear, many modifications may be made to the details of this embodiment. For example, the rolls may be vertically superimposed and powder fed horizontally to the roll gap. Alternative hopper designs can be used. Thus instead of the hopper having end walls which overlap the roll edges, the hopper may be shaped to fit between the rolls with its end-walls coplanar with the roll end-faces. In such a case the restraint member may be urged into frictional contact with the hopper end-wall as well as the roll end-faces. Furthermore, the rolls need not be of identical diameter to one another, nor is it essential that their end-faces be entirely flat providing a portion thereof to be contacted by the restraint member is flat.

Claims

1. A rolling mill for the roll compaction of metal powder into strip (14) comprising a pair of cylindrical rolls (10, 11) of equal length rotatably mounted with their longitudinal axes parallel to define a roll gap therebetween, means (12) for feeding a powder to be compacted to an intake side of the roll gap along the entire length of the rolls, each end of the roll gap being closed by an edge restraint member characterised in that each edge restraint member comprises a cylindrical block (15) of smaller diameter than each roll rotatably mounted about an axis parallel to the roll axes and spaced therefrom, that means are provided for urging each restraint member (15) so that at least a portion of an end face thereof is in frictional contact with the end faces (16,17) of each of the rolls (10,11) and that means are provided for driving each restraint member (15) to impart rotation thereto, whereby relative sliding action is produced between the end face of the restraint member (15) and the respective end faces (16,17) of the rolls (10,11).

2. A rolling mill as claimed in claim 1 wherein at least the end face of each edge restraint member (15) is made of a material which is less wear resistant than the end-faces (16,17) of the rolls (10,11).

3. A rolling mill as claimed in claim 1 or 2 wherein the axis of rotation (D) of each restraint member (15) is in a horizontal plane parallel to and spaced from the plane (L M) containing the roll axes.

4. A rolling mill as claimed in any preceding claim wherein the axis of rotation (D) of each restraint member (15) is positioned such that its end face overlaps the end face (16) of a first one of the rolls (10) to a greater extent than it overlaps the end face (17) of the other roll (11).

5. A rolling mill as claimed in claim 4 wherein the portion of the end face of the restraint member (15) which overlaps the end face (16) of the first roll (10) includes

the axis of rotation (D) of the restraint member.

6. A rolling mill as claimed in claim 4 or 5 wherein each restraint member (15) is arranged to be driven, in use, in the same direction as the first roll (10).

7. A rolling mill as claimed in any preceding claim wherein the edge restraint member (15) is adjustably mounted relative to the rolls such that its axis (D) can be selectively displaced in a direction within or parallel to the plane (L M) containing the roll axes.

8. A rolling mill as claimed in claim 7 wherein the mounting is such that the member can be displaced in a direction normal to the plane (L M) containing the roll axes.

9. A rolling mill as claimed in any preceding claim wherein the rolls (10,11) are of equal diameter to one another and are mounted with their axes (A,B) in a horizontal plane (L M), and where each restraint member (15) is mounted with its rotational axis (D) above the horizontal plane (L M) of the roll axes.

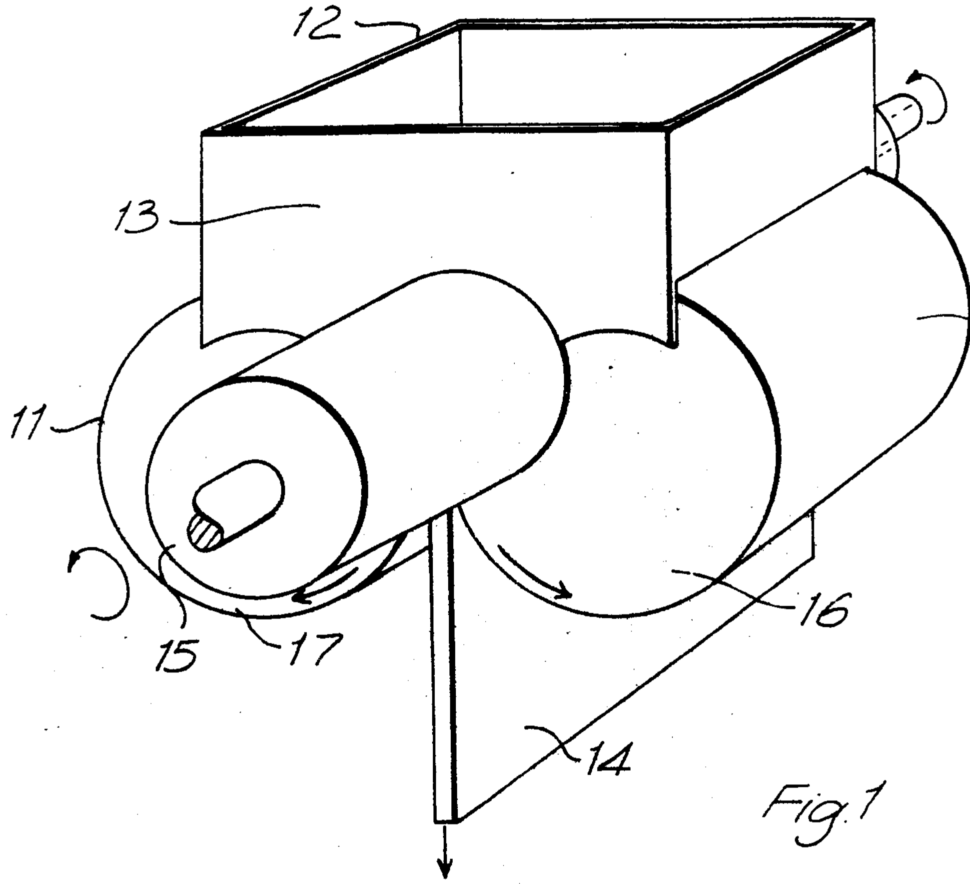

Fig.1

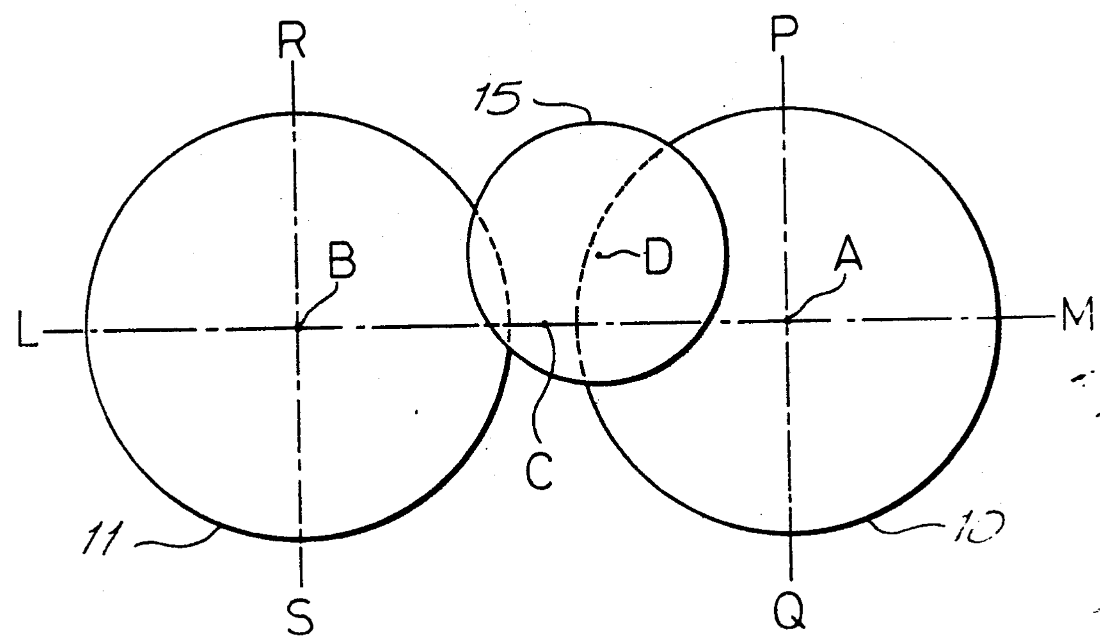

Fig 2

European Patent Office

EUROPEAN SEARCH REPORT

Application number
EP 78 30 0198

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl.²)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
	FR - A - 841 382 (SAHUT, CONREUR & CIE) * Abstracts 1,2; page 1, lines 39-46; figures 1,2 * --	1,3-6	B 22 F 3/18 B 30 B 11/18
A	US - A - 3 124 838 (J.A.H.LUND et al.)		
A	US - A - 3 242 530 (H.H.HIRSCH et al.) ----		

TECHNICAL FIELDS SEARCHED (Int.Cl.²)

B 22 F 3/18
B 30 B 11/18
B 30 B 11/20
B 30 B 15/30

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	23-10-1978	SCHRUERS