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(71) Applicant:
VAI Industries (UK) Limited
Sheffield S9 4EX (GB)

(72) Inventors:
- **Glasby, Ian**
  Hood Green, Barnsley S75 3EY (GB)
- **Grocock, Peter**
  Walkeringham, Nr. Doncaster DN10 4LF (GB)

(74) Representative:
Harman, Michael Godfrey
Hillgate Patent Services,
No. 6 Aztec Row,
Berners Road
Islington, London N1 0PW (GB)

(54) Roll position control in cluster mills

(57) A dynamic position control means for a cluster mill which has a two-part pre-stressed housing in which the two parts are joined by hydraulic cylinders and associated columns. It comprises an actuating means located between the housings of the mill, so as to vary the relative separation or the relative orientation or both of the two halves of the housing during rolling. The actuating means includes at least one hydraulic lifting ram disposed substantially between the two halves of the housing, and ideally four hydraulic lifting rams each ram disposed at the corner position of a rectangular housing. The hydraulic lifting rams are of the doughnut type, encompassing each of the hydraulic cylinder's columns. The dynamic position control means includes position monitoring means, in particular, four position transducers mounted between the four respective corners of the housings. Control means then adjust the actuating means in response to the position monitoring means or other measured data.

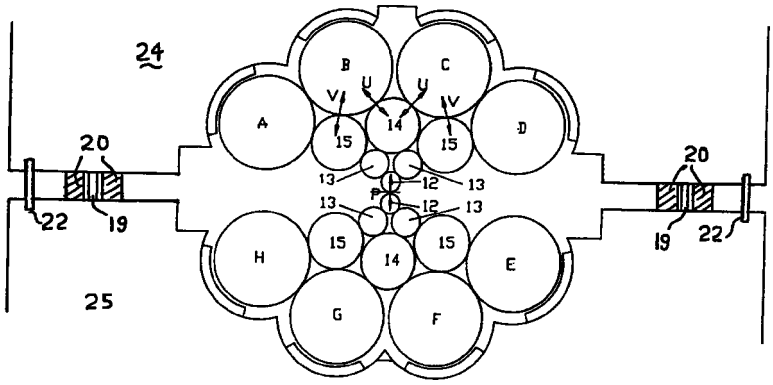

Fig. 2

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Description

[0001] The present invention relates to cluster mills, in particular, the controlling of the position of the rolls presented to the strip.

[0002] The type of cluster mill commonly known as a "Sendzimir" mill or "Z" mill comprises a housing containing two sets of opposing rolls in a 1-2-3-4 arrangement. (EP 0 693 327 A1 describes such a mill, and references earlier US patents to such mills.) More specifically, in such a mill a pair of work rolls is typically supported by two pairs of first intermediate rolls, in turn supported by three pairs of second intermediate rolls, these being finally supported by four pairs of roller bearing assemblies. The housing includes an entrance and exit by which metal strips to be rolled can gain access to the work rolls and leave the mill. Means are provided for adjusting the positions of the backing rolls so as to adjust the gap between the work rolls.

[0003] In the original type of cluster mill, the housing is a single piece in which all rolls are mounted, this housing being known as a monobloc housing. In an alternative type, the housing is a two-part housing, the two parts being split horizontally. The two parts of the housing, arranged one on top of the other, are held together by four columns mounted at the corners of the housing, each column running through both halves of the housing and anchored in the lower housing, securing the two halves of the housing together. Four hydraulic cylinders are mounted upon the corners of the upper half of the housing, each cylinder pulls upon a respective column to secure the two halves of the housing whilst the strips are being rolled.

[0004] The relative position between the rolls may be varied to achieve particular transverse profiles and longitudinal sections, or in response to the strip's shape. Conventionally, this is done by varying eccentrics within the backing assemblies. Each backing assembly consists of a plurality of roller bearings mounted upon a shaft. The shaft is mounted upon a series of eccentrics keyed to the shaft, each eccentric being mounted upon a saddle which rests in a partial bore of the mill housing. On the uppermost and the lowermost pair of backing assemblies, the eccentrics include eccentric rings, these rings having teeth which engage with similarly toothed racks. Movement of the racks, by a hydraulic cylinder, turns the eccentrics, and so, via the roll stacks, alters the position of the work rolls.

[0005] In order to vary the work rolls position a small amount, a large movement of the hydraulic cylinder is required. This limits the speed and accuracy of the adjustment of the roll position.

[0006] In one type of split housing mill, the housings, aligned transversely and longitudinally by the columns, have position transducers monitoring their vertical height, which is then regulated by varying the cylinders' pull upon the respective columns.

[0007] In this type of mill, the roll profile and separation may be varied by changing the force with which the hydraulic cylinders pull upon their shafts. The shafts are to some degree elastic, this deformation being known as 'shaft stretch'. This makes it difficult to quickly and accurately vary the roll profile and separation as small oscillations may result after any change.

[0008] In another type of split housing mill, each cylinder pulls upon a respective column to provide a clamping force. This clamping force exerted by the cylinders pre-stresses the system, seeking to emulate the rigidity of the monobloc housing. This mill is thus stiffer than the alternative design of split housing mill, but like the monobloc, the work rolls may only be varied through the backing assemblies.

[0009] The object of the present invention is to provide a means for quickly and accurately altering the position and separation presented by the work rolls while the mill is in operation.

[0010] According to the present invention there is provided a position control means for a cluster mill having a two-part pre-stressed housing in which the two parts are joined by hydraulic cylinders and associated columns, comprising an actuating means located between the housings of the mill, so as to vary or maintain the relative separation or the relative orientation or both of the two halves of the housing during rolling.

[0011] The preferred embodiments provide a means for altering the orientation of the two halves of the housing relative to each other in a rapid and accurate manner. There is also a reduction in any vibration resulting from the resilience of parts of the cluster mill.

[0012] Preferably, four pressure actuators are disposed one at each corner of the housings, when viewed from above, between the two halves of the housing, so that they act as if to force the two halves apart. Used in conjunction, the four actuators enable the two halves of the housing to move relative to each other with three modes of movement: a simple change in the separation of the two halves of the housing; a tilt or rotation of one housing relative to the other in the direction of the path of the metal strip through the mill; and a tilt or rotation of one housing relative to the other in the transverse direction across the width of the metal strip passing through the mill. These three modes of course are able to be combined. Position transducers, arranged close to each of the corners of the housing, enable the pressure actuators to precisely vary the orientation of the housings.

[0013] The relative movement of the two housings in turn causes a relative movement between the two work rolls, increasing or decreasing the separation between them whilst they are parallel, or increasing or decreasing the separation of the rolls at one end relative to the other so as to present a tapered opening between the rolls.

[0014] Since the alteration of the separation and position of the rolls may be achieved quickly and without resultant vibration, improved control along the length of the rolled metal can more easily be achieved.

[0015] A cluster mill position control embodying the invention will now be described, by way of example, with reference to the drawings, in which;

Figure 1 is a simplified perspective view of a conventional split housing cluster mill; and
Figure 2 is a sectional view of a split housing cluster mill and the invention.

[0016] Referring to Figure 1, a conventional split housing cluster mill is rectangular in plan, and four hydraulic cylinders 28 situated on top of the upper half of the housing 24 hold the two halves of the housing 24,25 together under high pressure by means of four columns 19 which run through the entire housing (only two of which have been shown here), and are secured to the lower housing 25 at their lower ends. The cylinders and columns are located approximately at the corners of the rectangular plan of the cluster mill.

[0017] Referring to Figure 2, the cluster mill position control comprises four pressure actuators 20 (of which only two are shown here), and four position transducers 22 (again only two of which are shown), arranged in conjunction with a conventional split housing cluster mill having an upper housing half 24 and a lower housing half 25, and various rolls A to H and 12 to 15, and a control system for monitoring the position transducers and varying the pressure actuators (which is not shown).

[0018] Each pressure actuator includes a doughnut actuator 20, that is, the lifting ram is annular in plan, and its sleeve is of similarly annular plan, so that each actuator may be fitted so as to encompass the column of the corresponding hydraulic cylinder 19. In this way, each hydraulic cylinder is exerting a force pulling the two halves of the housing together, in close conjunction with a pressure actuator exerting a force pushing the two halves apart. The forces exerted by both the set of hydraulic cylinders and the set of pressure actuators will of course vary depending upon the particular mill and the type of strip, but typically could be in the order of 1000 to 1200 tonnes.

[0019] Each pressure actuator is controlled by a servo mechanism located close to it, so that the volume of fluid in the system is kept to a minimum, so as to reduce the compressibility of the system.

[0020] A position and/or pressure transducer 22 is located close to each actuator, so that the independent effects of each actuator may be accurately measured.

[0021] A control mechanism for operating the actuators, which may take many conventional forms, also monitors the transducers, so that the information obtained from the transducers may be used to automatically adjust the operation of the actuators in response to any small unpredictable variations.

[0022] The hydraulic cylinders and pressure actuators, working in opposition, ensure that all the hydraulic fluid in the whole system may be kept at a very high pressure, and therefore less compressible and less prone to vibration.

[0023] By varying the pressure actuators' action, alone or in conjunction with the hydraulic cylinders, the two halves of the housing may be made to lift (so that their opposing surfaces are kept parallel), tilt (so that one housing makes an approximate rotation about its longitudinal axis, that is parallel to the feed direction), and rock (so that one housing makes an approximate rotation about its transverse axis, that is horizontally perpendicular to the feed direction) independently. These independent actions may then be superimposed at great speed to achieve different roll positions.

[0024] Any three of the transducers are sufficient to completely define the relative positions of the two housings in terms of their lift, tilt and rock. The profile presented by the work rolls will be similarly known (if the backing assemblies are also being used, the alteration due to this must also be accounted for). The work rolls are set to the required strip profile (which may vary in time) by adjustment of the actuators. When the position transducers show that the actual strip profile is deviating from the desired profile, the actuators are caused to oppose this deviation, so that the profile is returned to its desired dimensions.

[0025] The simplest method of regulating the work roll profile is as follows. When a transducer finds that the separation of the housings at the point of that transducer is becoming narrower than the desired housing separation (this corresponding to the desired work roll profile), the associated actuator is caused to exert an extra amount of force proportional to the separation deviation. Similarly, when the separation is increased, the actuator lessens the force that it applies.

[0026] Ideally a some form of controller, such as a PID controller, should be present in the processing means, so that as the time that the deviation has been apparent increases, the actuators are caused, using some integral component of the deviation, to oppose the deviation in an increasing fashion. Shapemeters and the like could also be introduced in order to monitor the strip as it enters and/or leaves the mill, the signals from such measuring devices being weighted and added to those of the housing's position transducers. Data from the strip entering the mill could be used to synchronise the exertion of the actuators with the strip variation. Data from the strip leaving the mill could be used as feedback to improve the accuracy of the actuators effect.

[0027] The control means may be used in conjunction with other means of varying the roll position, in particular by varying the roll eccentrics. The control means may then allocate a proportion of the necessary variation to the different means. The division could be in fixed proportion, or one means could be implemented in preference to the second means which would only be added over a particular pressure, or some other strategy. By varying the eccentrics, small changes at many points along the rolls may be achieved. A uniform change

across the strip's width, a wedge shape profile for example, is more easily tackled by varying the tilt of the rolls by using the actuators between the housing as herein described. The control means may then allocate small-scale changes to be controlled by the roll eccentrics, whilst large-scale changes are dealt with by the actuators between the housings.

[0028] Many variations are possible. For instance, it is sufficient, if not desirable, to have only three actuators arranged non-collinearly between the two halves of the housing, to achieve the same range of movement. Similarly, the relative positions of the two halves of the housing could be monitored by three position transducers arranged non-collinearly. It may be more convenient to have a plurality of cylindrical lifting rams arranged circularly beneath an annular disc encompassing each cylinder column or a lifting ram adjacent to each column rather than a doughnut arrangement. If only one or two degrees of freedom of movement are required for the system, the number of actuators could be reduced to only one or two, especially if both the actuators and the hydraulic cylinders are to be varied. Alternatively, additional actuators could be provided to augment the action of the four principal actuators. Obviously also the present techniques can be applied to cluster mills containing varying numbers of backing rolls.

Claims

1. A dynamic position control means for a cluster mill having a two-part pre-stressed housing in which the two parts are joined by hydraulic cylinders and associated columns, comprising an actuating means located between the housings of the mill, so as to vary the relative separation or the relative orientation or both of the two halves of the housing during rolling.

2. A dynamic position control means according to claim 1 wherein the actuating means includes at least one hydraulic lifting ram disposed substantially between the two halves of the housing.

3. A dynamic position control means according to claim 2 where the actuating means comprises four hydraulic lifting rams, each ram disposed at the corner position of a rectangular housing.

4. A dynamic position control means according to either of claims 2 and 3 wherein the hydraulic lifting rams are of the doughnut type, and encompass each of the hydraulic cylinder's columns.

5. A dynamic position control means according to any previous claim including position monitoring means.

6. A dynamic position control means according to claim 5 where the position monitoring means are four position transducers mounted between the four respective corners of the housings.

7. A dynamic position control means according to claim 6 including control means for adjusting the actuating means in response to the position monitoring means or other measured data.

8. A dynamic position control means substantially as herein described.

9. Any novel and inventive feature or combination of features specifically disclosed herein within the meaning of Article 4H of the International Convention (Paris Convention).

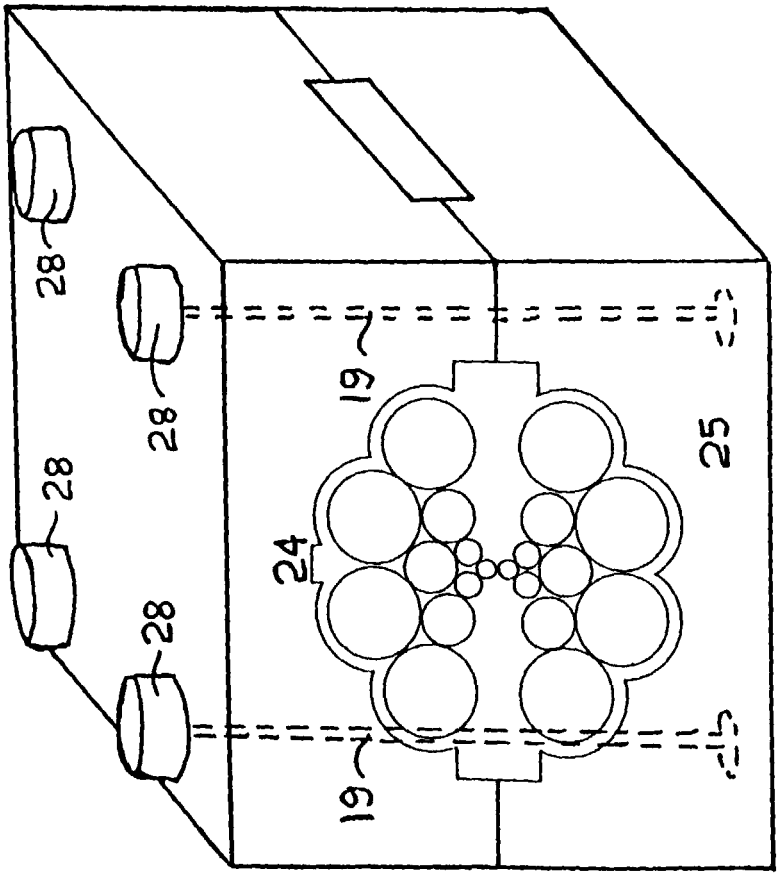

Fig. 1

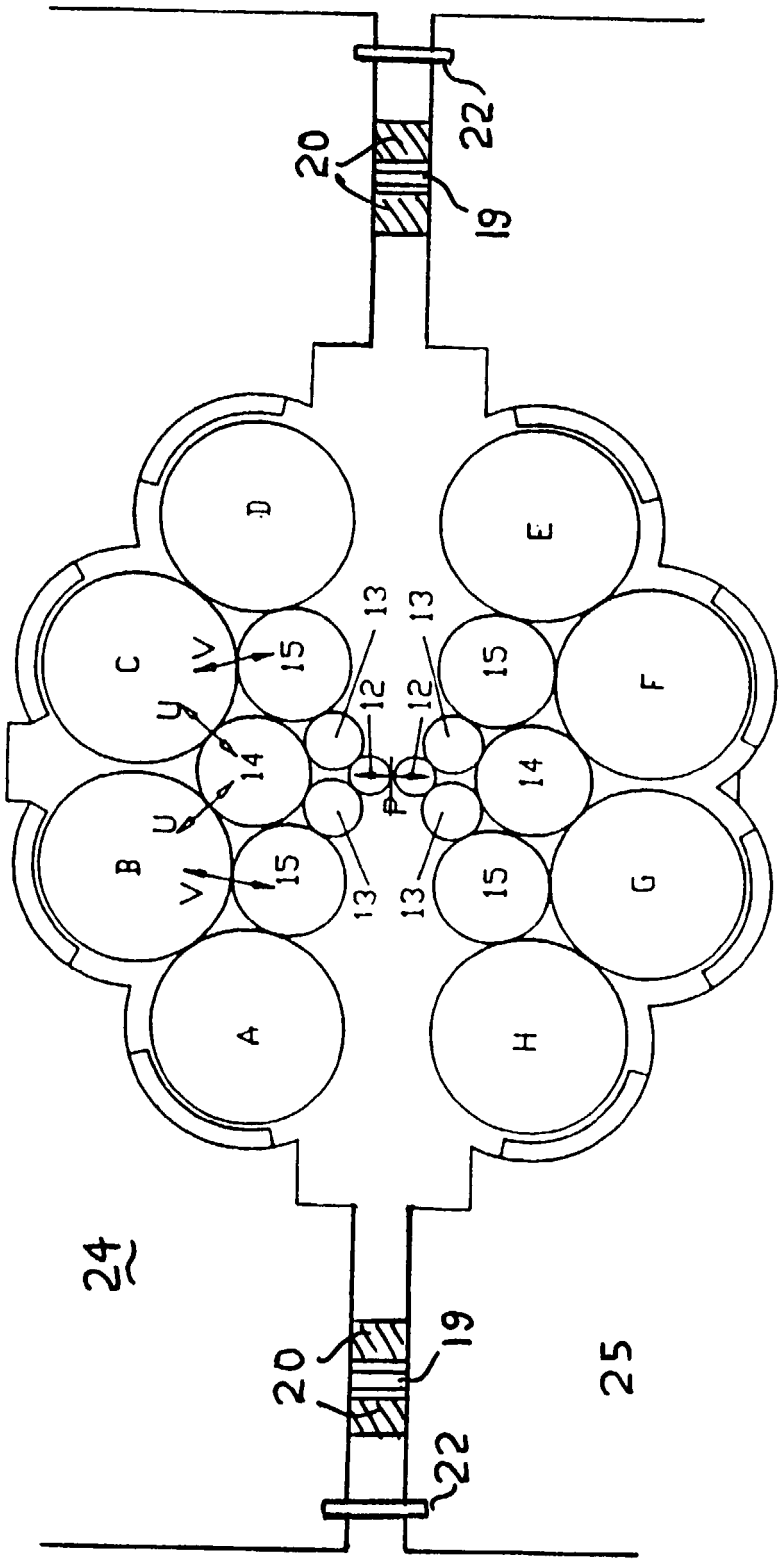
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Fig. 2