RESTRAINING DEVICE FOR ROLLS OPERATING IN PAIRS

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The present invention relates generally to the manufacture of processing machinery of the type in which a pair of spaced substantially parallel rolls cooperate to compact, crush and/or densify material passing therebetween. More particularly, the present invention relates to an improved arrangement of the several parts and members of such machines whereby the cooperating pair of rolls are maintained in a relative fixed spatial relationship to each other irrespective of the material passing therebetween and the load imparted to the rolls thereby.

The maintenance of a fixed relationship between the cooperating rolls is important to this type of machine regardless of the particular application for which it is used. For example, when used as a flaking mill in the preparation of the popular breakfast foods, uniform spacing is exceedingly important because without uniformity of spacing between the rolls, uniformity of product is substantially impossible. And of the favorite breakfast cereal is the result of toasting irregular flakes, it will be quite impalatable for many of the flakes will be burned while others will be incompletely toasted and some will even be raw.

In other applications it is equally important that a uniform spacing be maintained along the entire length of the rolls. For example, when the cooperating rolls are used to densify material, irregular spacing will provide a product having dissimilar densities in its various portions. This is intolerable in industries such as for example the chemical and the pharmaceutical industry where uniform specific gravities and densities of the products produced are of paramount importance.

Still another important reason for maintaining uniform spacing between the cooperating rolls along their entire length is the tendency of the rolls, particularly when one or the other has gone askew, to collide and/or rub together causing spalling, scratching and otherwise marring and spoiling the surface. When this occurs, the quality of the product being formed by the rolls is greatly impaired and the rolls will ultimately have to be either repaired or replaced, both operations which result in costs in both direct labor, materials and in shutdown time.

As is readily apparent from the foregoing discussion, it is important that accurate as well as reliable control of the spacing between the cooperating rolls be incorporated into these machines.

Two of the principal causes of roll disalignment in machines of the type discussed are: (1) the cyclic loading and unloading of the rolls by the passage of material therebetween which causes fatigue and ultimately fatigue failure in the members supporting the rolls and (2) the play of the roll journals relative to the bearings in which the roll journals are mounted.

The first of these problems is substantially eliminated by the present invention in a manner to be clearly developed by the following description while the second of these problems is substantially eliminated by my joint invention with Ray C. Edwards described in copending application Serial No. 726,485, filed April 4, 1958.

The prior art heretofore has attempted to solve the first problem enumerated above by applying a static load to the rolls generally in opposition to the dynamic load encountered thereby in the course of its normal operation. This approach to reduce fatigue and fatigue failures is generally characterized by the imposition of a pressure or load upon the bearing block into which the roll is journaled. The load, or "preload" as I shall call it hereinafter, is transmitted by the bearing block through the roll journal to the nip of the rolls where it reacts against the load imparted to the rolls by the material passing therebetween to effect a substantial load balance thereupon. By balancing the dynamic load upon the rolls by a static preload, the movement of the rolls in response to the dynamic load imparted thereto is reduced thereby reducing the fatigue failures normally incident thereto. Such systems of pre-loading are not the complete answer, however, for they still possess serious disadvantages. One disadvantage results from the dependency of the resistance to dynamic loading upon the elasticity of the roll housing frame. Consequently, the resistance to the dynamic loading, i.e., the static preload, is a variable or floating pressure and fluctuates with the variable conditions of the material passing between the nip of the rolls. Thus cyclic loading is still present, the costly shutdowns and repairs resulting from fatigue failures are not overcome, and great disparity between various portions of the product formed still exists.

Another prior art attempt to solve the problem comprises pre-loading both of the roll bearing blocks with a load, the static preload, in excess of and in opposition to the dynamic operating load of the mill, and another load in opposition to the static preload for maintaining the nip of the rolls at a preset distance apart. The latter load is provided by the insertion between the bearing blocks of a rigid block or its equivalent having either a definite or an adjustable thickness.

Both of the aforementioned prior art attempts suffer from the same disadvantage, viz., they both preload the cooperating rolls through the bearing blocks into which the rolls are journaled thereby loading or biasing these blocks to a relatively fixed position relative to the housing of the machine. Thus, if the alignment of the bearing blocks is lost, as occurs from the passage of foreign matter, etc., between the rolls, the bearings are incapable of being properly realigned without ceasing the operation of and frequently dismantling the machine.

The present invention substantially eliminates the cyclic loading of the rolls in a machine of the type described thereby greatly reducing fatigue failure and enhancing life properties while maintaining fixed the spaced relationship between the rolls to insure a uniform product passing therefrom in a manner which further enables the bearing blocks to have complete freedom of movement for self-alignment. The present invention effects these beneficial results by prestressing the machine with a static preload in excess of the dynamic load, which is encountered between the nip of the rolls when the machine is in operation, applied solely upon the components of the yoke or harness of the machine. No static preload whatsoever is applied to the bearing housing thus permitting the free movement of the bearing housing required for self-alignment while the machine is in operation. This approach to applying a static preload to machines of this type is believed to be completely new in this art.

Accordingly, one of the prime objects of the present invention is to provide a machine of the type described in which a novel arrangement of its several parts and elements effects a static preload upon the rolls thereof without inhibiting the free movement for self-alignment of the bearing blocks into which the cooperating rolls are journaled.

Another object of the present invention is to provide a machine of the type described in which a pair of cooperating rolls are restrained by novel means avoiding the use of massive structural elements.
Another object of the present invention is to provide a machine of the type described including means for supporting cooperating rolls in which the effective clearance at the nip of the rolls maintained uniform, despite varying thicknesses of material being fed therethrough.

Another object of the present invention is to provide a machine of the type described in which prestressed yoke components maintain a pair of cooperating rolls in fixed spatial relationship to each other.

A further object of the present invention is to provide a machine of the type described in which a pair of cooperating rolls are preloaded with a static load in excess of their dynamic operating load and are rotationally mounted in self-aligning free moving bearings.

With these and other objects in view, as will hereinafter appear, I have devised a restraining device for rolls operating in pairs having certain novel features of construction, combination and arrangement of parts and portions as will hereinafter be described in detail and particularly set forth in the appended claims, reference being had to the accompanying drawing and to the characters of reference thereon which form a part of this application and in which:

FIG. 1 is a vertical sectional end view of a roll mill embodying the present invention; and

FIG. 2 is a plan view partially in section of the device of FIG. 1 (rotated 90° clockwise for ease of placement).

Like characters of reference refer to similar parts and portions throughout the several views in the drawing.

Although my present invention for a restraining device for rolls operating in pairs is applicable to many industries and may be used in connection with many different machines, the description, as well as the illustrations of the present embodiment of my invention, will be confined to a roll mill.

Referring now to the drawing, an exemplary embodiment of the present invention is shown in conjunction with a roll mill 11 having a pair of cooperating rolls 12, 13 rotatably mounted therein.

Rolls 12, 13 are respectively provided with journals 14, 15 which are, respectively, supported for rotation by bearings 16, 17 which in turn are supported by a lower tie rod bar or frame member 18 having receiving means 19 defined therein for receiving a tie rod 20. Bearings 16, 17 are caged by tie rod bar 23 having receiving means 24 defined therein for receiving a second tie rod 25. Bearings 16, 17 may be of a suitable type such, for example, as sleeve bearings, split sleeve bearings, antifriction roller bearings and the like.

Bearings 16, 17 are respectively provided with self-aligning back-up plates 26, 27 which are secured within mill 11 by end plates 28, 29 mounted to frame member 18 and tie rod bar 23 by tie rods 20, 25 which include suitable washers 30 and nuts 31. These plates are provided with mating concave and convex surfaces of slightly different radii to provide for rocking movement of the one member with respect to the other.

Intermediate bearings 16, 17 and disposed in suitable seats 32, 33 respectively defined therein is a positioning means such as springs 34 for biasing rolls 12, 13 a fixed predetermined minimum distance apart to maintain the cooperating surfaces of plates 26, 27 in close contact to keep out foreign matter.

End plate 29 is provided with an annular opening through which defines hydraulic cylinder 36. A hydraulic piston 37 is slidably arranged within cylinder 36 for communication therewith to define an expandable cavity or chamber 38 therebetween having conduit means 39, 40 respectively connected thereto providing for the ingress and egress respectively of hydraulic fluid from a suitable reservoir (not shown) into cylinder 36 to be provided with suitable sealing means such, for example, as packing 41 to prevent the ingress of hydraulic fluids to the rolls.

End plate 29 is provided with a detachable cover plate 42 to permit ready access to piston 37. A pressure block 46 is arranged intermediate piston 37 and a pair of shim packages 47, 48 respectively disposed in intimate contact with shoulders 49, 50 respectively defined on tie rod bar 23 and frame member 18 for transmitting force from piston 37 through shim packages 47, 48 to tie rod bar 23 and frame member 18, respectively.

A material supply hopper 51 is mounted to the upper surface of tie rod bar 23 in supersetted relationship to the nip of cooperating rolls 12, 13 in any suitable manner such, for example, as by welding. Lateral reinforcement may be provided by a pair of angle members 52, 53 extending adjacent the hopper 51 and secured to tie rod bar 23 and its counter part 18 is provided upon which 11 in any suitable fashion. Thus exact dimensional similarity is provided mill 11 by tie rods 20, 25 and angle members 52, 53 extending transversely of tie rods 20, 25.

In this respect, it is of course understood that the roll mill herein chosen to exemplify the present invention has two substantially identical ends so that the description herein of the several cooperating elements and members of one end is equally applicable to the several cooperating elements and members of the other end. Accordingly, only the end shown in FIG. 1 is herein described.

As used herein, the terms "yoke" or "harness" comprise the several elements and members to hold shim packages and bearings for free movement thereof. Specifically, therefore, the yoke 55 of roll mill 11 includes frame member 18, tie rod bar 23, end plates 28, 29 joined to frame member 18 and tie rod bar 23 with tie rods 20, 25, and shim packages 47, 48. Also as used herein, the term "hydraulic means," indicated in FIG. 1 by the general reference number 56, includes fluid piston 37, hydraulic cylinder 36 defined in end plate 29, expandable chamber 38 and conduits 39, 40.

To assemble roll mill 11 in accordance with the present invention, frame member 18, and tie rod bars 20, 25 are respectively disposed in position adjacent bearings 16, 17, 18. When backing plate 26 is in position adjacent bearing 16, and plate 28 is placed in position on the tie rods 20, 25 which are respectively inserted in the receiving means 24 provided in tie rod bar 23 and the receiving means 19 provided in frame member 18. At the other end of the roll mill 11, shim packages 47, 48 are located in adjacent nonbearing relationship to backing plate 27 and pressure block 46 is positioned between the bases 47, 48 stationary relative to tie rod bar 23 and frame member 18. End plate 29 is next placed in position on tie rods 20, 25 and washers 30 and nuts 31 are placed upon the ends of the tie rods 20, 25 to hold all of the aforesaid described members and elements in their respective positions.

Piston 37 having sealing means 41 operably linked therewith is now inserted within hydraulic cylinder 36 and is secured therein by cover plate 42.

In operation, the minimum spacing at the nip of the rolls is established by the cooperation of spring 34 with hydraulic means 56. The admittance of fluid under pressure through conduit 39 into expandable chamber 38 actuates piston 37 against pressure block 46 which bears against shim packages 47, 48 to provide compressive forces upon frame member 18 and tie rod bar 23 while inducing equal resistive thrust forces upon both end plates 28, 29 and end plate 29. In addition, hydraulic means 56 maintains the roll adjacent thereto, i.e., roll 13, in a position to maintain its axes of revolution substantially parallel to the corresponding axis in the cooperating roll. Thus, as shown in FIG. 1, the axes of revolution of roll 13 is maintained substantially parallel to the axis of revolution of roll 12 by hydraulic means 56.

Second hydraulic means 57 similar to hydraulic means 56 is operatively associated with the jacket at the other
end of roll 13, i.e., the end remote from journal 15. Both hydraulic means 56, 57 preferably are synchronously controlled by a single hydraulic system to assure equal pressure distribution upon the pressure blocks at both ends of the roll. Any of the well known hydraulic control systems for effecting synchronous movement in a plurality of hydraulic motors, pumps and the like, may be utilized in the practice of this invention and it is not intended to limit the system to any particular arrangement of pumps, valves, tanks, etc. Suitable control circuits are well known in the hydraulic machine art and therefore need not be discussed further here.

The actuator is embodied in a prestressed condition by drawing up on the tie rods 20, 25 and hydraulic pressure is applied through conduit 39 to chamber 38 to actuate piston 37. Piston 37 transmits the force applied thereto through pressure block 46 and shims 47, 48 to the respective shoulders 49, 50 of tie rod bar 23 and frame member 18 to put these members in compression and the tie rods in tension. Once these members are stressed to a value as high as that required for compacting a given product, no additional elongation takes place and the gap between the rolls and the resulting thickness of the densified product is thus fixed. When a load is applied to the rolls, the shafts will deflect slightly and the bearings will rock slightly in the self-aligning blocks maintaining bearing contact at all times.

To adjust the gap between the rolls, one very simply varies the thickness of the shim package interposed between the pressure block and the tie rod bars. Thus, this adjustment can be readily adjusted to conform to the product thickness desired.

Thus the present invention fulfills all of the aforesaid objects in a manner requiring only relatively light members which have relatively small cross sectional areas. Thus the unique design principles herein described obviate excessive deflections of the fabrication of the machines of the type described and allow the complete freedom for self-aligning of the bearings desired for working high loads.

While one embodiment and its modifications have been herein described, it is of course understood that this is done so only to exemplify the present invention and not to limit it. It is intended to include within the scope of this invention any device of the type described which accomplishes the restraint of cooperating rolls by prestressing the components of the yoke or harness supporting the rolls in a manner embodying the spirit of this invention especially as defined by the appended claims.

What is claimed is:

1. A machine comprising: a yoke; a pair of parallel rolls; roll supporting means mounted in said yoke and defining cylindrical cavities, each of said rolls having cylindrical portions journalled in said cavities of cooperating ones of said roll supporting means; and hydraulic loading means holding said cooperating ones of said supporting means in said yoke in predetermined spaced relationship to each other and engaging said yoke to prestress said yoke about said supporting means while permitting free self-aligning movement of said supporting means within said yoke resulting from dynamically loading said rolls are substantially eliminated.

2. A machine comprising: a yoke; a pair of parallel rolls; roll supporting means mounted in said yoke and having cylindrical cavities defined therein, each of said rolls journalled in a cylindrical portion journalled in one of said cavities and in predetermined spaced relationship to each other; and hydraulic loading means holding said supporting means in said yoke and engaging said yoke to prestress said yoke about said supporting means while permitting free self-aligning movement of said supporting means within said yoke, said means including loading means placing a portion of said yoke in tension and another portion of said yoke in compression whereby cyclic elongations resulting from dynamically loading said rolls are substantially eliminated.

3. A machine comprising: a yoke; a pair of parallel rolls; roll supporting means defining cylindrical cavities, each of said rolls having cylindrical portions journalled each one in each of said cavities of cooperating ones of said roll supporting means; positioning means holding cooperating ones of said supporting means in said yoke in predetermined spaced relationship to each other; and loading means engaging said yoke in noncontacting proximity to said roll supporting means to prestress said yoke without disturbing the free self-aligning movement of said supporting means within said yoke, whereby cyclic elongations resulting from dynamically loading said rolls are substantially eliminated.

4. A machine comprising a pair of identical ends, each of said ends comprising a rectangular yoke including upper and lower tie rod bars closed at their respective ends with a first and a second end plate joined thereto by an upper and lower tie rod respectively passing through said upper and lower tie rod bars; a pair of journal bearings upon said lower tie rod bar in laterally spaced relationship to each other and cabled by said upper tie rod bar; a pair of self-aligning bearing plates operatively associated one with each of said bearings intermediate said bearings and the one of said end plates adjacent thereto; a pair of cooperating rolls operably mounted in said bearings in spaced working relationship to each other; and means for applying a static preload to said yoke while permitting free self-aligning movement of said bearings relative thereto, said means including hydraulic means for providing a static preload and shim means interposed between said hydraulic means and said upper and lower tie rod bars for transmitting said preload to said tie rod bars and placing said tie rod bars in compression and said tie rods in tension.

5. In a machine of the type characterized by having a pair of cooperating rolls operatively mounted therein, means for preloading the machine comprising; means mounting a pair of rolls, each in a pair of self-aligning bearings, a preset distance apart in a yoke; means placing force transmitting means in engagement with said yoke without disturbing the free self-aligning movement of any of said bearings; and means importing a static preload through said force transmitting means to said yoke.

6. A machine comprising a yoke; a pair of journal bearings mounted in and cabled by said yoke in laterally spaced relationship to each other; a pair of self-aligning bearing plates operatively associated one with each of said bearings intermediate said bearings and said yoke; a pair of cooperating rolls operably mounted in said bearings in spaced working relationship to each other; and hydraulic means for applying a static preload to said yoke without engaging said bearings to permit free self-aligning movement of said bearings relative to said yoke.

7. A machine comprising a pair of identical ends, each of said ends comprising a rectangular yoke including upper and lower tie rod bars closed at their respective ends with a first and a second end plate joined thereto by an upper and lower tie rod respectively passing through said upper and lower tie rod bars; a pair of journal bearings upon said lower tie rod bar in laterally spaced relationship to each other and cabled by said upper tie rod bar; a pair of self-aligning bearing plates operatively associated one with each of said bearings intermediate said bearings and the one of said end plates adjacent thereto; a pair of cooperating rolls operably mounted in said bearings in spaced working relationship to each other; and means for applying a static preload to said yoke without engaging said bearings to permit free self-aligning movement of said bearings relative to said yoke, said means including hydraulic loading means creating said static preload and shim means interposed between said loading means and said upper and lower tie rod bars for transmitting said preload to said tie rod bars and placing
said tie rod bars in compression and said tie rods in tension.

8. A machine comprising a yoke having a pair of upper and lower tie rod bars in spaced relationship to each other and closed at their respective ends with a first and a second end plate joined thereto by a pair of upper tie rods passing through said upper tie rod bars and a pair of lower tie rods passing through said lower tie rod bars; a pair of journal bearings mounted upon each of said lower tie rod bars in laterally spaced relationship to each other and capped by the corresponding one of said upper tie rod bars; a self-aligning bearing plate operatively associated with each one of said bearings intermediate said bearing and the one of said end plates adjacent thereto; a pair of cooperating rolls operably mounted in opposed ones of said bearings in spaced working relationship to each other; and means for applying a static preload to said yoke while permitting free self-aligning movement of said bearings relative thereto, said means including hydraulic means for providing a static preload and shim means interposed between said hydraulic means and said upper and lower tie rod bars for transmitting said preload to said tie rod bars and placing said tie rod bars in compression and said tie rods in tension.

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