FLUID CUSHION TURNING ROLL FOR MOVING WEB

5 Claims, 4 Drawing Figs.

ABSTRACT: A fluid cushion turning roll for supporting a longitudinally moving web around an arcuate turn, comprising a pair of radial side plates at the opposite ends of the turn, an array of arcuate-edged baffle members extending between the side plates, and a base member closing off the bottoms of the baffle members to define a plurality of narrow arcuate pressure chambers across the inside of the turn. A constant-pressure fluid supply supplies air or other gas to all of the pressure chambers, through limiting orifices in the base member, affording a fluid cushion supporting the web out of engagement with the solid elements of the turning roll.
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CROSS REFERENCE TO RELATED APPLICATION
This invention is an improvement upon and utilizes some of the operational features of the fluid cushion turning roll described and claimed in the copending application of Lloyd W. Johnson, Ser. No. 673,504, filed Oct. 6, 1967, now U.S. Pat. No. 3,498,515.

BACKGROUND OF THE INVENTION
In numerous industrial applications, a web of paper, cloth, plastic, metal, or other material is subject to continuous processing as it moves along a given path. It is often necessary or desirable to alter the direction of the web path, particularly to conserve the space required for processing equipment. Thus, in a treating oven or other continuous process apparatus, it may be necessary to change the direction of web movement through angles of 90° or 180° one or more times to retain a practical size for the processing apparatus.

If the web surface has been coated or otherwise processed so that it has a relatively sensitive surface, it may be damaged by contact with conventional turning rolls or other parts of the apparatus. Conversely, surface material from the web may tend to deposit on conveyor rolls or other solid surfaces with which it comes in contact and the buildup of such deposits may ultimately require shut-down and cleaning of the process equipment. Webs having soft surfaces that may be readily scratched during processing also present substantial difficulties when conveyed through conventional processing equipment. Furthermore, it may be difficult to match the speed of a turning roller to the longitudinal speed of the web, particularly in those instances in which web velocity is subject to substantial variation in operation of the processing equipment.

It has previously been proposed to support and guide a longitudinally moving web, for accurate movement, on a substantially continuous cushion of air, gas, or other fluid. One example of an air or liquid cushion structure of this kind that has been suggested by the British Iron and Steel Research Association is a "hover bearing" apparatus which is described in substantial detail in Carlisle et al. U.S. Pat. No. 3,097,971. Other examples of air turning rolls are disclosed in Bricke et al. U.S. Pat. No. 3,216,638 and Freuler U.S. Pat. No. 3,279,091.

Previously known fluid cushion turning roll structures frequently encounter difficulty from the Bernoulli effect produced by the flow of the cushion fluid along the web path from the point at which the fluid is introduced toward the area from which it is exhausted. Fluid leaving the cushion area between the turning roll apparatus and the web, in conventional apparatus, ordinarily passes through a relatively restricted area. The relatively high velocity of the fluid flow in the restricted area produces a pressure drop which tends to pull the web into contact with the apparatus, particularly if there is any surface of substantial extent bordering the high velocity flow. This effect tends to defeat the primary purpose of the fluid cushion device, since the web may be damaged or may deposit materials at the point of contact with the apparatus.

Another problem presented with respect to most fluid cushion turning rolls relates to the width of the web in comparison with the air cushion apparatus. If the web is significantly narrower than the turning roll, the edges of the web tend to be unsupported and hence may be easily damaged. Moreover, an excessive flow of fluid may be required, since the presence of the web is ordinarily the only limit to the flow of fluid from the turning roll apparatus. Accordingly, conventional turning roll structures are usually limited to use with a web of given width, and any changes in processing requirements or variations in web width may render the turning roll equipment obsolete.

SUMMARY OF THE INVENTION
It is a particular object of the present invention, therefore, to provide a new and improved fluid cushion turning roll for supporting and guiding a longitudinally moving web along a turning path, in which the Bernoulli effect tending to draw the web into contact with the solid parts of the turning roll apparatus is effectively minimized or essentially eliminated.

Another object of the invention is to provide a new and improved fluid cushion turning roll which will accept a wide range of web widths without imposing excessive fluid flow requirements or requiring particular adjustment of the apparatus to accommodate web width changes.

A related object of the invention is to provide a fluid cushion turning roll which produces relatively high pressures in areas where the web comes closer to the solid parts of the turning roll apparatus and lower pressure where the web is further away from the apparatus.

Another object of the invention is to provide a new and improved fluid cushion turning roll that is relatively simple in construction and economical of manufacture.

Accordingly, the present invention relates to a fluid cushion turning roll for supporting and guiding a web of given width, moving longitudinally along a path, around an arcuate turn in the path. The turning roll comprises a pair of side plates extending transversely of the path at the opposite ends of the turn and projecting radially inwardly of the path, each of these side plates is at least as wide as the web and preferably somewhat wider and each has a straight thin outer edge parallel to the axis of the turn. An array of baffle members is mounted between the side plates in mutually spaced relation to each other, each baffle member having a thin arcuate outer edge conforming approximately to the desired configuration for the turn. The inner edges of the baffle members are closed off by a base member, defining a plurality of narrow arcuate pressure chambers extending across the inside of the turn in the web path. Fluid supply means are provided for supplying a compressible fluid, under substantially constant pressure, to all of the pressure chambers, through the base member, affording a fluid cushion that supports the web out of engagement with the solid elements of the turning roll.

Other and further objects of the present invention will be apparent from the following description and claims and are illustrated in the accompanying drawings, which, by way of illustration, show a preferred embodiment of the present invention and the principles thereof and what is now considered to be the best mode contemplated for applying these principles. Other embodiments of the invention embodying the same or equivalent principles may be made as desired by those skilled in the art without departing from the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS
FIG. 1 is a sectional elevation view of a fluid cushion turning roll, constructed in accordance with one embodiment of the invention, for turning a continuously moving web through an angle of approximately 90°.
FIG. 2 is a partially sectional elevation view taken approximately as indicated by line 2-2 in FIG. 1.
FIG. 3 is an enlarged detail sectional view of a portion of the apparatus as indicated by the broken line circle 3 in FIG. 1; and
FIG. 4 is a sectional elevation view, similar to FIG. 1, of an air turning roll constructed in accordance with the invention and effective to turn a moving web through an angle of 180°.

DESCRIPTION OF THE PREFERRED EMBODIMENTS
FIGS. 1 and 2 illustrate a fluid cushion turning roll 10 constructed in accordance with one embodiment of the present invention. The fluid cushion turning roll 10 supports and guides a continuous web 11 along a path around an arcuate turn, the turn extending through an angle of 90° around roll 10. Web 11 is continuously moving as generally indicated by
arrow A in FIG. 1. The axis of the turn around which web 11 moves, with support and guidance from roll 10, is indicated by reference numeral 12.

Turning roll 10 comprises a pair of side plates 14 and 15. Each of the side plates 14 and 15 extends radially outwardly with respect to axis 12; that is, the position of the side plates is such that they project radially inwardly at the arcuate path followed by web 11. Side plates 14 and 15 are mounted upon a supply plenum 16 which, in the illustrated embodiment, comprises a relatively large pipe concentric with turn axis 12. A plurality of bolts or other appropriate fastening means 17 may be utilized to mount the side plates on the supply plenum 16.

An array of arcuate baffle members 18 is included in the turning roll 10. Baffle members 18 are mounted between side plates 14 and 15 in spaced relation to each other. The baffle members are preferably formed from relatively thin sheet metal stock and, in any event, have thin arcuate outer edges that conform approximately to the configuration of the turn through which web 11 moves as it passes around turning roll 10. The side plates 14 and 15 and the baffle members 18, together with an arcuate segment 19 of pipe 16, commonly define a plurality of narrow arcuate pressure chambers 21 extending across the inside of the turn followed by web 11. That is, the arcuate segment 19 of pipe 16 affords a base member that closes off the inner portion of each of the pressure chambers 21. The interior of the supply plenum, pipe 16, is in communication with each of pressure chambers 21 through a series of orifices 22, 23, 24 and 25. The orifices 22, which are most closely adjacent side plate 14, are preferably somewhat larger than the intermediate orifices 23 and 24 near the center of the arc.

Moreover, the end openings 25 are also preferably somewhat larger than the intermediate openings 23 and 24. This size differential is utilized to assure an adequate air cushion adjacent the edges of side plates 14 and 15.

As noted above, the edges of the arcuate baffles 18 are relatively thin. Furthermore, the edge portions of side plates 14 and 15 should be quite narrow, in the direction of web travel. A preferred construction is shown in FIG. 3, in which it is seen that the side plate 15 has a beveled edge portion leading to a thin edge 26 that extends linearly across the web path. The thin-edge construction adopted for baffles 18 and side plates 14 and 15 avoids the presentation of any substantial surface areas in the part of the turning roll immediately adjacent web 11 and materially reduces the possibility of attraction of web 11 into engagement with the solid elements of the turning roll apparatus.

In operation, air or other compressible fluid is fed under pressure in the supply plenum 12. The fluid pressure supply means employed preferably comprises a fan or blower of a type which is effective to maintain the same pressure, within the supply plenum, despite substantial variations in the total gas flow. Commercially available blowers of the kind used for supplying combustion air to gas fired furnaces or ovens are suitable for this purpose. Fans of the so-called "backward curved" type, and other known blowers, can also be utilized to obtain the requisite relatively constant pressure despite flow variations.

In operation, air or other compressible gas from plenum 16 fills the individual pressure chambers 21 and supports web 11 on a substantially continuous air cushion at a short distance from the edges of side plates 14 and 15 and baffles 18. If web 11 moves away from the air turning roll, the impedance to the flow of air outwardly of pressure chambers 21 is materially reduced. If web 11 moves toward baffles 18, the impedance increases and the flow is reduced. The pressure variation within chambers 21 is inversely related to the flow of air. Thus, as the web 11 moves toward the turn roll the pressure in chambers 21 increases toward a maximum determined by the pressure within plenum 16 and the increase in pressure tends to force the web back outwardly toward its original path. If the web moves away from the air turning roll, due to velocity changes or other external forces, the reduction of pressure

within the adjacent chambers 21 permits the web to move back toward the air turning roll. Thus, both the pressure and the fluid flow for each pressure chamber 21 varies whenever the spacing between web 11 and turning roll 10 changes in the area immediately adjacent the pressure chamber.

All of the openings 22—25 between plenum 16 and pressure chambers 21 are quite small in relation to the surface area of the plenum behind each of the pressure chambers. In fact, openings 22—25 are deliberately constructed as limiting orifices. Consequently, turn roll 10 can accommodate webs of varying width. If one or more of the pressure chambers 21 is completely uncovered by web 11 (see chamber 21A in FIG. 2), there is no excessive loss of fluid because the restricting orifices impose a substantial limitation on the flow of the fluid outwardly of the plenum.

The edge of the web 11 may be substantially unsupported, to the extent that it is located between the baffles 18. Consequently, the width of the individual pressure chambers 21, particularly near the edge of the apparatus, should be maintained quite narrow to prevent the edge of the web from coming into contact with the turn roll. For stiff webs, or webs that are edge-trimmed in subsequent processing, the widths of the individual pressure chambers can be increased somewhat.

One specific embodiment of the invention for carrying a 24-inch-wide web has given satisfactory service with 32 individual pressure compartments 21 each having a width, parallel to axis 12, of 1 inch. In that particular device, plenum 16 was constructed from a 4-inch-diameter pipe and air was supplied to the air turning roll by a combustion air blower rated at 50 cubic feet per minute at 12 ounces pressure. The orifices employed were ½ inch diameter for intermediate openings 23 and 24 and 3/16 inch diameter for end openings 22 and 25.

The exact number and size of orifices 22—25 may vary for different applications. However, it is necessary to have a substantial flow of fluid close to and parallel to each of the two side plates 14 and 15, since much of the cushion fluid escapes over the edges of these side plates in a direction parallel to the path of movement of the web, as shown in FIG. 3. The use of somewhat larger openings 22 and 25 immediately adjacent the side plates helps to overcome the Bernoulli effect which would tend to pull the web into contact with the edges of the side plates.

FIG. 4 illustrates an air turning roll 110 that is similar in construction to turning roll 10 but that guides and supports a web 1111 through an arcuate turn of 180°. As in the previous embodiment, the turning roll comprises a central plenum 1116. In this instance, plenum 1116 is of hexagonal configuration instead of the circular cross-sectional configuration of the plenum in the previously described embodiment. Two side plates 1114 and 1115 are mounted upon the duct or plenum 1116 at the opposite ends of the turn described by web 1111. Side plates 1114 and 1115 are radially aligned with the central axis 112 of the turn.

A plurality of individual baffle members 1118 extend between side plates 1114 and 1115, only one of the baffle members 1118 being illustrated in FIG. 4. As in the previously described construction, the baffle members 1118, the side plates 1114 and 1115, and the portion 119 of the supply duct that closes off the inside ends of the baffle plates conjointly define a plurality of narrow arcuate pressure chambers that extend across the inside of the turn in the web path. Air or other gas is supplied to these pressure chambers through a plurality of individual restricting orifices 124—131. As before, the two orifices 125 and 131 immediately adjacent side plates 1114 and 1115 are preferably made somewhat larger than the intermediate openings 125—130 into the pressure chambers, in order to assure an adequate flow of air parallel to and over the edges of side plates 1114 and 1115.

In both embodiments of the invention described above, as expressly described in connection with the embodiment of FIGS. 1—3, the pressure and fluid flow for each pressure chamber varies as a function of the spacing between the web and the turning roll. If the web seals off a given pressure
chamber, the pressure drop across the orifices leading into that chamber drops to zero and the chamber pressure becomes the same as the plenum pressure. In the extreme case of a chamber completely uncovered by the web the entire difference in pressure between the plenum and ambient appears across the orifices. Thus, the orifices play an important role in determining how far the web will space itself from the baffles, in addition to limiting the loss of fluid from the pressure chambers.

I claim:

1. A fluid cushion turning roll for supporting and guiding a web of given width, moving longitudinally along a path, around an arcuate turn in the path, comprising:
   a pair of side plates extending transversely of said path at the opposite ends of the turn, and projecting inwardly of said path;
   an array of baffle members, extending between said side plates in mutually spaced relation to each other, each baffle member having an arcuate outer edge conforming approximately to the configuration of said turn;
   a base member closing off the inner portion of said array of baffle members;
   said side plates, said baffle members and said base member conjointly defining a plurality of narrow arcuate pressure chambers across the inside of said turn, said base member having at least one opening therethrough leading into each pressure chamber; and
   fluid supply means for supplying a compressible fluid, under substantially constant pressure, to all of said pressure chambers, through said base member openings, to afford a fluid cushion supporting said web out of engagement with the solid elements of the turning roll.

2. A fluid cushion turning roll according to claim 1, in which said base member includes a plurality of individual openings into each of said pressure chambers.

3. A fluid cushion turning roll according to claim 2, in which the openings into each pressure chamber include an end opening adjacent each side plate and at least one intermediate opening spaced a substantial distance from both side plates, and in which said end openings are substantially larger than said intermediate openings.

4. A fluid cushion turning roll according to claim 2 in which each of said openings is a limiting orifice much smaller in cross-sectional area than the area of said base member covered by each pressure chamber.

5. A fluid cushion turning roll according to claim 1 in which each of said side plates has a thin, straight, beveled outer edge extending parallel to the axis of the turn.