CONTACTING ELONGATED FLEXIBLE MATERIAL WITH LIQUID

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The present invention relates to contacting elongated flexible material with liquid, and more particularly to methods and apparatus for maintaining a uniform liquid level in a tank through which such material passes lengthwise in contact with the liquid.

In many industrial operations it is necessary to pass continuous webs of flexible material through tanks containing liquid in order to treat the material with the liquid. It is often desirable to pass such material through the tank in a single straight run without reeling it in a plurality of runs about rolls. When the material thus passes through the tank in a single run, then the length of the tank will be largely determined by the speed of the material and the desired treatment time. In the processing of rapidly moving material such as continuous strip steel, which may travel at speeds up to about 2000 feet per minute, it often happens that the tanks containing pickling or other solutions with which the strip is contacted tend to be quite long.

Strips moving rapidly through such long tanks tend to move the liquid downstream in the tank. If the tank is long and narrow, then the ratio of the wetted area of the strip to the volume of the liquid becomes quite high and the tendency of the liquid to be driven to the downstream end of the tank becomes quite marked and the liquid level at the downstream end of the tank tends to be substantially higher than the liquid level at the upstream end of the tank. As a result, the strip at the upstream end of the tank may not be entirely in contact with liquid; while at the downstream end of the tank spillage and foam accumulation may occur.

Although many attempts have been made to equalize the liquid levels at both ends of such tanks, none, as far as is known, has been entirely successful when practiced industrially on a commercial scale.

Accordingly, it is an object of the present invention to provide methods and apparatus for equalizing the liquid level at opposite ends of an elongated tank despite the movement of material through the tank.

Another object of the present invention is the provision of methods and apparatus for regulating liquid level in a tank without the need for mechanically handling large quantities of liquid.

Still another object of the present invention is the provision of methods and apparatus for regulating liquid level in a tank which involves a minimum power expenditure.

Finally, it is an object of the present invention to provide such methods that will be easy and reliable to practice with a minimum of supervision, and to provide such apparatus that will be relatively easy and inexpensive to manufacture and install, maintain and operate, and rugged and durable in use.

Other objects and advantages of the present invention will become apparent from a consideration of the following description, taken in connection with the accompanying drawings, in which:

FIGURE 1 is a plan view, with a central portion broken away, of apparatus according to the present invention;

FIGURE 2 is a cross-sectional elevational view of the structure of FIGURE 1; and

FIGURE 3 is an enlarged fragmentary view with parts broken away of a portion of FIGURE 1.

Referring now to the drawings in greater detail, there is shown an elongated tank 1 through which passes a running length of strip 3. In the illustrated embodiment, the strip 3 is thin steel strip, while tank 1 is a cleaning or pickling tank for the strip. It is to be understood, however, that the invention is applicable to a wide variety of other environments.

A guide roll 5 disposed adjacent the upstream end of the tank regulates the position of strip 3 entering the tank, while a pair of pinch rolls 7 adjacent the downstream or exit end of the tank regulates the position of the strip as it leaves the tank and serves to remove excess liquid from the strip. In the tank itself, the strip passes under a driven roll 9 adjacent the upstream end of the tank and a driven roll 11 adjacent the downstream end of the tank. Rolls 9 and 11 serve to position the strip accurately while the strip is in the tank. Pinch rolls 7 and driven rolls 9 and 11 are driven by motors 13 to aid in advancing the strip through the tank and to overcome what would otherwise be the tendency of the strip due to the inertia of these rolls. Other rolls as well may be driven throughout the processing line in order to aid in feeding the strip.

The tank is partly filled with a treatment liquid 15 which may be a pickling solution or rinse water or other aqueous or organic or inorganic liquid. The upper surface of the liquid is represented by a liquid level 17 in FIGURE 2. As is shown in FIGURE 2, a strip 3 is in motion to the right as seen in that figure and drags liquid along with it toward the downstream end of the tank. Liquid level 17 accordingly is not horizontal but inclines upward in a downstream direction from a lowest level adjacent the upstream end of the tank to a highest level adjacent the downstream end of the tank.

As a result, the point at which both sides of strip 3 are completely in contact with liquid tends to be displaced downstream in the tank and foam tends to form and be swept downstream and collect at the downstream end of the tank. Also, the excess of liquid at the downstream end of the tank tends to spill.

Accordingly, there is provided the structure peculiar to the present invention in the form of a surge return conduit 19 which communicates with the downstream end of the tank at an upstream end 21 of conduit 19 and which communicates at its downstream end 23 with the upstream end of tank 1. In its broadest aspect, surge return conduit 19 returns liquid from the downstream end of tank 1 to the upstream end of tank 1 thereby to equalize the liquid level at both ends of the tank.

More specifically, surge return conduit 19 has an inlet 25 that is in line with the lengthwise extent of the tank. Inlet 25 is of a height no greater than the desired depth of liquid in the tank, that is, the depth of liquid when liquid level 17 is horizontal from end to end of the tank. However, inlet 25 is of a width substantially greater than its height. Inlet 25 communicates with a first transverse portion 27 of surge return conduit 19, which in turn also communicates with a return portion 29 of conduit 19. Return portion 29 is straight and extends at least a major portion of the length of and parallel to tank 1. Preferably, as in the illustrated embodiment, return portion 29 extends substantially full length of tank 1. Return portion 29 terminates in a second transverse portion 31 which in turn communicates with an outlet portion 33 of return conduit 19. Outlet portion 33 is in alignment with the lengthwise extent of tank 1 and lies on the longitudinal midline of that tank as seen in FIGURE 1.

Surge return conduit 19 is horizontal from end to end thereof. Outlet portion 33 extends from the level of the bottom of tank 1 to a height which is preferably no
greater than the desired height of the liquid at the upstream end of tank 1, that is, the height of liquid level 17 when liquid level 17 is horizontal. Preferably, the bottom of conduit 19 is unplanar from end to end thereof and coplanar with the bottom of tank 1.

An upstream jet conduit 35 communicates at its upstream end with inlet 25 of surge return conduit 19 and at its downstream end with a pair of pumps 37 in parallel. Each pump 37 has a solid impeller (not shown) therein that contacts liquid flowing downstream through conduit 35 to pump 37 and impels it in the usual manner of a pump. Any of a variety of conventional pumps is suitable for use as pumps 37. Pumps 37 are in parallel so that one may serve as a standby pump for the other. Pumps 37 have the usual speed controls.

The pump outlets communicate with the upstream end of a downstream jet conduit 39. Conduit 39 is the downstream jet conduit relative to the pump, and the upstream end of conduit 39 communicates with the pump outlet. Conduits 35 and 39 thus serve as intake and outlet conduits, respectively, for pumps 37.

The downstream end of conduit 39 extends through surge return conduit 19 adjacent the turn between portions 27 and 29 thereof and terminates inside conduit 19 in a jet discharge nozzle 41 which is sealed down at its discharge end. Nozzle 41 is in alignment with the center line of surge return conduit 19 as seen both in elevation and in plan. Nozzle 41 is thus disposed adjacent the upstream end of surge return conduit 19, at the upstream end of return portion 29, and substantially nearer the downstream end of tank 1 than the upstream end thereof. Similarly, pumps 37 are disposed adjacent the downstream end of tank 1. Nozzle 41, however, is disposed downstream from the intake of upstream jet conduit 35. Jet conduits 35 and 39 and nozzle 41 are all substantially smaller in cross-sectional area than is surge return conduit 19. Liquid travels through conduits 35 and 39 and nozzle 41 under the influence of pump 37 at a velocity substantially greater than the velocity of the liquid through conduit 19. On the other hand, the quantity of liquid traveling through conduit 19 apart from conduits 35 and 39 is substantially greater than that which travels through conduits 35 and 39.

In operation, strip 3 moves through the liquid in the tank from left to right as seen in FIGURE 2, and the liquid that surges toward the downstream end of the tank flows through surge return conduit 19 back to the upstream end thereof. In the absence of conduits 35 and 39 and pump 37, the flow of liquid through conduit 19 would be largely circular in the tank. Accordingly, pump 37 is continuously operated to withdraw a relatively small proportion of liquid from adjacent the downstream end of the tank and to propel it at greatly increased velocity through nozzle 41 and into the liquid flowing in surge return conduit 19.

A number of advantages follow from this use of a jet of the liquid from the tank to propel the remainder of the liquid in conduit 19. In the first place, the fact that conduit 19 is of substantially greater cross-sectional area than conduits 35 or 39 or nozzle 41 means that only a relatively small portion of the liquid need be handled through pump 37 in order to have a beneficial effect with regard to a relatively large volume of liquid. A substantial variation in the operation of pumps 37, therefore, produces only a relatively smaller variation in the flow of liquid through conduit 19. In turn, this means that the flow of liquid through conduit 19 may be very sensitively controlled without controlling the operation of pumps 37 with corresponding sensitivity.

Another advantage of this arrangement is that the jet action of the liquid introduced through nozzle 41 is used to greater advantage than if conduits 19 and 35 were of the same size. This is because nozzle 41 is disposed centrally of surge return conduit 19 and the jet of liquid emerging from the nozzle 41 thus is spaced a substantial distance from any side wall of conduit 19 and exerts the maximum venturi or ejector influence on liquid traveling in conduit 19.

The provision of nozzle 41 closer to the upstream end than to the downstream end of conduit 19 is also advantageous for several reasons. In the first place, the jet emerging from nozzle 41 is most effective when it acts against a wall of water of greatest thickness in front of it. The length of return portion 29 is utilized to provide in effect a wall of liquid in front of nozzle 41 of great depth, that is, of great thickness, in fact, of a thickness equal to at least a major portion of the length of tank 1. As a result, the propulsive influence of nozzle 41 is much greater than if it were positioned so as to point toward a near bend of conduit 19. In the second place, the positioning of nozzle 41 adjacent the downstream end of the tank is further advantageous in that surge return conduit 19 does not tend to be entirely full of liquid toward its discharge end. When the liquid level in the upstream end of tank 1 is below the top of outlet portion 33 of conduit 19, an air space tends to form at the top of conduit 19 that extends from outlet portion 33 thereof upstream toward the jet nozzle 41 and terminates at a substantial distance from the inlet 25 of conduit 19. Nozzle 41 operates with maximum efficiency when it is spaced as far upstream as possible from this air space; and indeed, the efficiency of nozzle 41 falls off markedly in the presence of an air space above it even though the nozzle itself may still be submerged. The positioning of pumps 37 adjacent the downstream end of tank 1 assures that liquid moving through jet conduits 35 and 39 need not traverse an excessively long course through these relatively small conduits. Also, due to the resistance of relatively small conduits to the flow of liquid therethrough is thus kept at a minimum.

Finally, the provision of a relatively large surge return conduit 19 of minimum length in combination with separate jet conduits that communicate with the pump assures that most of the liquid will follow a path of least length and least resistance through conduit 19 over an entirely horizontal course, while only a minor proportion of the liquid need be diverted on a more circuitous path of varying altitude through pumps 37. As a result, the power consumption necessary to move a desired quantity of liquid from the downstream to the upstream end of tank 1 is kept at a minimum.

From a consideration of the foregoing disclosure, it will be obvious that all of the initially recited objects of the present invention have been achieved.

Although the present invention has been described and illustrated in connection with a preferred embodiment, it is to be understood that modifications and variations may be resorted to without departing from the spirit of the invention, as those skilled in this art will readily understand. For example, although upstream jet conduit 35 is seen to have its inlet in the inlet 25 of surge return conduit 19, it will be understood that it is necessary only that jet conduit 35 take liquid from adjacent the downstream end of the tank. Thus, conduit 35 could have an inlet in line with the lengthwise extent of the tank and communicating directly with the tank or indirectly with the tank through inlet 25 of conduit 19; or the inlet of conduit 35 could extend from a side of the downstream end of tank 1. Also, although outlet portion 33 of conduit 19 is shown as returning liquid in line with the general direction of movement of material through tank 1, it will be understood that it could open into a side of the upstream end of the tank. This latter arrangement, however, is less preferred, as the lateral currents thus introduced into the tank tend to deflect strip 3 from its predetermined configuration in the tank. These and other modifications and variations
are considered to be within the purview and scope of the present invention as defined by the appended claims.

What is claimed is:

1. A method of contacting elongated flexible material with a liquid, comprising moving the material lengthwise through an elongated tank from a material entry end portion of the tank to a material exit end portion of the tank in contact with liquid in the tank, returning a first stream of liquid from the material exit end portion of the tank to the material entry end portion of the tank along a horizontal path, withdrawing from adjacent the material exit end portion of the tank a second stream of liquid, contacting the second stream with a solid impeller to move the second stream at a higher velocity than the first stream, and introducing the second stream into the first stream downstream of its point of withdrawal but substantially closer to the upstream than to the downstream end of the first stream and in a downstream direction.

2. A method as claimed in claim 1, said second stream having a cross-sectional area substantially less than the cross-sectional area of said first stream.

3. A method as claimed in claim 1, the first stream having a straight portion extending most of the length of the tank, the point of introduction of the second stream into the first stream being disposed adjacent the upstream end of said straight portion and the direction of introduction of the second stream into the first stream being in line with said straight portion and in a downstream direction.

4. Apparatus for contacting elongated flexible material with a liquid, comprising an elongated tank for liquid, means for moving the flexible material lengthwise through the tank from a material entry end portion of the tank to a material exit end portion of the tank in contact with liquid in the tank, a substantially horizontal surge return conduit communicating between the material exit end portion of the tank and the material entry end portion of the tank for returning to the material entry end portion of the tank excessive liquid urged to the material exit end portion of the tank by the moving material, and pump means having an intake conduit communicating with the liquid adjacent the material exit end portion of the tank and an outlet conduit communicating with means discharging in a downstream direction into the surge return conduit substantially closer to the upstream than to the downstream end of the surge return conduit.

5. Apparatus as claimed in claim 4, the intake and outlet conduits being substantially smaller in cross-sectional area than the surge return conduit.

6. Apparatus as claimed in claim 4, said pump means being disposed adjacent the material exit end portion of the tank.

7. Apparatus as claimed in claim 4, the surge return conduit having a straight portion extending most of the length of the tank, said outlet conduit communicating with the surge return conduit adjacent the upstream end of said straight portion and discharging into the surge return conduit in a downstream direction in line with said straight portion.

References Cited in the file of this patent

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<th>Inventor(s)</th>
<th>Date</th>
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