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TEMPERATURE CONTROL APPARATUS

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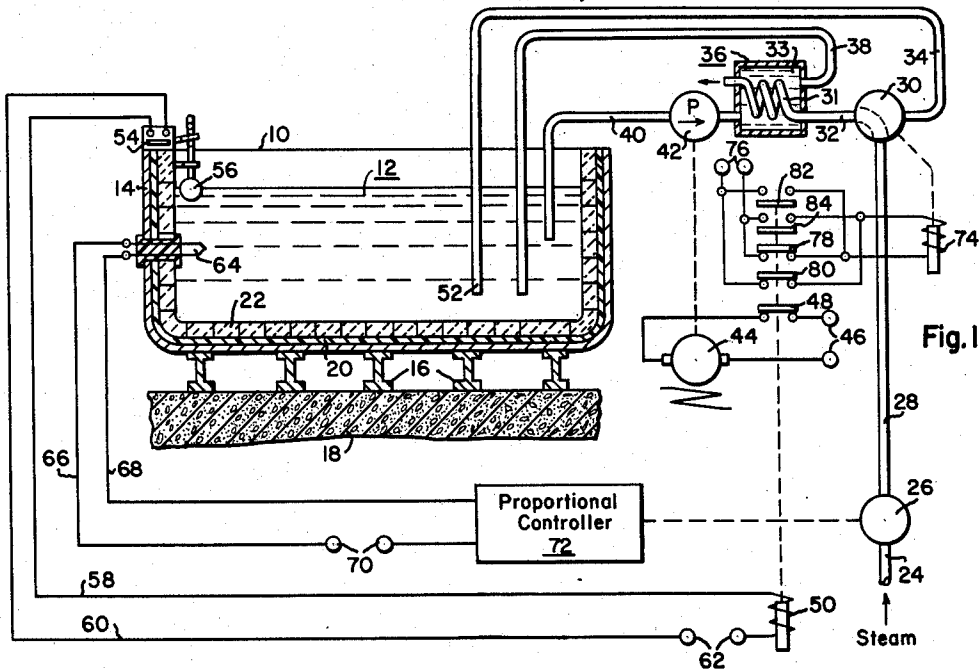


Fig. 1

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This invention relates to apparatus for regulating the temperature of an acid bath used for pickling metal products and the like and, more particularly, to apparatus of the type described which maintains the liquid level of the pickle bath constant during the heating operation.

As is well known, pickling is the term given the process by which oxides or defects formed on the surface of metal sheets, for example, are removed by chemical action. The removal of these oxides or defects by pickling may be performed in order to prepare the surface of the product for inspection or to prepare it for its ultimate end use. In its simplest form, pickling consists of immersing the metal product in a dilute acid bath, which is held at a predetermined temperature, and permitting it to remain stationary until the pickling action is completed. Pickling may also be done by passing the metal product through the acid bath continuously. In addition to maintaining the temperature of the pickle bath constant, means are usually provided for keeping the bath in motion or agitation.

Previous to this invention, the temperature of the pickle bath was usually maintained at a predetermined temperature by either direct injection of steam or by the use of submerged combustion apparatus. Although the direct steam injection method is simple and a fairly efficient heating arrangement and also provides some agitation which aids in accelerating the pickling action, it has a tendency to dilute the pickle bath since the volume of the steam condensate is usually greater than what is required to compensate for loss of liquid through evaporation. This excess steam condensate causes dilution of the acid strength, overflowing of the liquid from the tank, and a consequent loss of unspent acid. If, on the other hand, heating is done by submerged combustion, water must be added to the bath in order to compensate for the loss by evaporation. Thus, the simple and efficient steam injection method causes dilution of the pickle bath; whereas, the use of submerged combustion requires the addition of water to the bath periodically.

It is a primary object of this invention to provide apparatus for automatically maintaining both the temperature and liquid level of a pickle bath constant to prevent dilution and overflow of the same.

A still further object of the invention is to provide a temperature and liquid level control system for an acid pickle bath which is simple and economical in construction and operation.

In accordance with one embodiment of the invention hereinafter described, the pickle bath is heated by a combination of direct steam injection and indirect steam heating through a heat exchanger. Steam is applied to either the heat exchanger or to the direct steam injection nozzle, the quantity of steam being governed by the temperature desired. The allocation of the steam between the direct injection nozzle and the heat exchanger, however, is governed by the liquid level of the acid in the tank. If the level falls, steam is diverted to the direct injection nozzle, whereby the steam condensate adds to the liquid in the tank and raises the level. On the other hand, if the level is at its maximum height, the steam is diverted to the heat exchanger so that additional liquid is not added to the bath. In this manner, the liquid level of the tank remains constant, and

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no dilution or overflow occurs and results in weakening of the acid strength and a loss of unspent acid.

The above and other objects and features of the invention will become apparent from the following detailed description taken in connection with the accompanying drawing which forms a part of this specification and in which:

FIGURE 1 is a schematic diagram of one embodiment of the invention.

Referring to FIG. 1, there is shown a pickling tank 10 containing a quantity of pickling acid 12. In most cases, the acid used in pickling is sulphuric, nitric, or a mixture of nitric and hydrofluoric. The pickle tank 10 consists of an outer rectangular shell 14 of welded steel which rests on a series of I-beams 16. These beams, in turn, are supported on a concrete base 18. The inner surface of shell 14 is coated with rubber or neoprene 20 to protect the steel from the acid. Inside the rubber lining a layer of acid-proof brick 22 is placed completely covering the sidewalls and bottom of the tank. This brick lining is usually joined to the neoprene with a sulfur-base cement, while acid-resisting cement is used in the brick joints.

Steam in pipe 24 passes through regulating valve 26 and pipe 28 to a valve 30 where it may be diverted to either pipe 32 or pipe 34. If the steam in pipe 28 is diverted to pipe 32 as shown, it flows to a heat exchanger 36 where it raises the temperature of the pickle acid forced through pipes 38 and 40 by pump 42. As will be understood, the heat exchanger 36 includes a heating element 31 through which steam from pipe 32 passes and a heated element 33 through which the acid from bath 12 flows. Pump 42 is, in turn, driven by an electric motor 44 which is supplied with power from a voltage source connected to terminals 46. As shown, the voltage source may be selectively disconnected from motor 44 by opening contacts 48 of relay 50. If, on the other hand, the steam from line 28 is diverted to pipe 34, it is forced into tank 10 by direct injection through nozzle 52.

On the left hand side of tank 10 is a limit switch 54 which is actuated by a float 56 riding on the surface of the pickle bath 12. Although the float 56 is shown in the present embodiment for illustrative purposes, it should be understood that other types of level control measurement apparatus may be used in its place. This switch controls operation of relay 50 and is connected to the relay through leads 58, 60 and terminals 62 which are adapted for connection to a voltage source, not shown. The arrangement is such that when the level of the pickle bath 12 falls, switch 54 is closed to connect the voltage source at terminals 62 to the relay. In this process, the relay is energized and reverses the positions of its contacts shown in FIG. 1. Also included in tank 10 is a thermocouple 64 which is connected through leads 66, 68 and voltage terminals 70 to a proportional control device 72, the control device being connected through a mechanical linkage to valve 26. Proportional controllers of this type are well known in the art and serve to convert an electrical signal, of magnitude proportional to the temperature of the bath, into a mechanical movement which opens and closes valve 26. With this arrangement, thermocouple 64 will cause device 72 to open valve 26 further as the bath temperature falls, whereby a greater amount of steam is injected into the heat exchanger 36 or nozzle 52, as the case may be. On the other hand, when the temperature rises, the thermocouple will actuate device 72 to proportionately close valve 26, whereby the amount of steam passing to the heat exchanger or nozzle is decreased. Although the control device 72 is not shown in detail, it will be readily apparent that any of the well-

known electrical control devices may be used which will produce a mechanical motion proportional to the magnitude of an electrical control signal. As an alternative, an off-on controller could be used in place of device 72 to open and close valve 26 in accordance with the temperature of bath 12.

The valve 30 is controlled by a solenoid 74 which is supplied with current from terminals 76 which are adapted for connection to a direct current voltage source, not shown. The voltage source may be connected to solenoid 74 through normally closed contacts 78 and 80 of relay 50 or through the normally open contacts 82 and 84 of the same relay. As will be understood, when contacts 78 and 80 are closed as shown in the drawings, current will flow through solenoid 74 to position valve 30 so that pipes 28 and 32 are interconnected. When relay 50 is energized, contacts 82 and 84 close while contacts 78 and 80 open. The direction of current through solenoid 74 is now reversed, whereby valve 30 is positioned to connect pipe 28 to pipe 34.

In operation, as long as the liquid level in tank 10 is maintained within a set range, the float 56 will maintain switch 54 open so that relay 50 will be de-energized. During this time, contacts 48, 78 and 80 of the relay 50 are closed, whereby pump 42 forces the pickle acid through pipes 38 and 40 and valve 30 interconnects pipes 32 and 28. Heating of the pickle bath is now accomplished through the heat exchanger 36 while the direct injection nozzle 52 is not used. If the temperature of the bath should rise or fall during this time, thermocouple 64 will actuate device 72 and valve 26 to regulate the amount of steam flowing to heat exchanger 36. If the temperature should rise, for example, the amount of steam supplied to the heat exchanger will be decreased; whereas, if the temperature should fall, the amount of steam supplied to the heat exchanger will increase.

If the liquid level in tank 10 falls below the aforesaid range, float 56 will close switch 54 to energize relay 50, thereby opening contacts 48, 78 and 80 and closing contacts 82 and 84. Now voltage source 46 is no longer connected to motor 44, so that pump 42 is inactive. If desired, the contacts 48 on relay 50 may be eliminated. In addition, solenoid 74 will reverse valve 30 to connect line 28 to line 34. In this manner, steam from line 24 is injected directly into the tank 10 to heat the acid pickle bath 12. Obviously, the steam condensate will be absorbed by the acid bath and thereby raise the liquid level. During this time, the amount of steam supplied to nozzle 52 will, of course, be controlled by thermocouple 64 and device 72. This action will continue until the liquid level again rises to force float 56 to open switch 54 and thereby de-energize the relay 50. It can thus be seen that indirect heating through the heat exchanger and direct heating through nozzle 52 are used alternately, depending upon the level of liquid in the tank 10.

Although an external heat exchanger 36 is employed in the embodiment of FIG. 1, indirect heating could also be achieved by placing the heating element 31 (immersion type heat exchanger) in the bath itself, whereby the heat is transferred directly to the acid solution.

Although the invention has been shown in connection with certain specific embodiments, it will be readily apparent to those skilled in the art that various changes in form and arrangement of parts may be made to suit requirements without departing from the spirit and scope of the invention.

We claim as our invention:

1. Apparatus for maintaining the liquid level constant in a tank containing a heated acid bath comprising, in combination, a device for measuring the liquid level of said bath, first means actuated by said measuring device for indirectly heating said bath when the liquid level is at or above a predetermined point, and second means

actuated by said measuring device for heating said bath by direct injection of steam when the liquid level of said bath falls below said predetermined point.

2. Apparatus for maintaining the temperature and liquid level constant in a tank containing a heated acid bath comprising, in combination, a device for measuring the liquid level of said bath, means responsive to said liquid level measuring device for indirectly heating said bath when its liquid level is at or above a predetermined point, further means responsive to said liquid level measuring device for heating said bath by direct injection of steam when the liquid level of said bath falls below said predetermined point whereby the steam condensate adds liquid to said bath, a device for measuring the temperature of said bath, and means responsive to said temperature measuring device for controlling the degree of heating effected by said direct or indirect heating means.

3. Apparatus for maintaining the liquid level constant in a tank containing a heated acid bath comprising, in combination, means for indirectly heating said bath, means for alternately heating the bath by direct injection of steam, a device for measuring the liquid level of said bath, means operated by said measuring device for actuating said indirect heating means while disabling said direct heating means when the liquid level of said bath is at or above a predetermined point and actuating said direct heating means while disabling said indirect heating means when the level of said bath falls below said predetermined point.

4. In an apparatus for maintaining the temperature and liquid level of an acid bath constant, the combination, comprising a direct injection steam nozzle immersed in said bath, a heat exchanger having a heating element adapted to receive steam and a heated element through which acid from said bath may flow, first conduit means connecting said heated element with said bath and adapted to supply liquid from said bath to said heated means and to return liquid from said heated means to said bath, second conduit means connecting said heating element and said steam nozzle to a source of steam, a valve in said second conduit means adapted to alternately connect said steam source to said heating element and to said steam nozzle, said valve being normally positioned to connect said steam source to said heating element, a liquid level responsive device for actuating said valve to connect said steam source to said steam nozzle when the acid bath falls below a predetermined level, and a temperature responsive device for regulating the amount of steam from said steam source to maintain said bath at constant temperature.

5. In an apparatus for maintaining the temperature and liquid level of an acid bath constant, the combination, comprising a direct injection steam nozzle immersed in said bath, a heat exchanger having a heating element adapted to receive steam and a heated element through which acid from said bath may flow, conduit means connecting said heated element with said bath and adapted to supply liquid from said bath to said heated means and to return liquid from said heated means to said bath, a source of steam, an electrical switch, means for opening said switch when the level of said acid bath is at or above a predetermined level and for closing said switch when the level of said bath falls below said predetermined level, means controlled by said switch for connecting said source of steam to said heating element when the switch is open, said last-mentioned means being adapted to connect the source of steam to said nozzle when the switch is closed, and means responsive to the temperature of said bath for varying the degree of heating effected by steam from said steam source.

6. In an apparatus for maintaining the liquid level of an acid bath constant, the combination, comprising a direct injection steam nozzle immersed in said bath, a heat exchanger having a heating element adapted to

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receive steam and a heated element through which acid from said bath may flow, first conduit means connecting said heated element with said bath and adapted to supply liquid from said bath to said heated means and to return liquid from said heated means to said bath, a pump for forcing liquid through said first conduit means and said heated element, a prime mover for driving said pump, second conduit means connecting said heating element and said steam nozzle to a source of steam, valve means within said second conduit means normally connecting said steam source to said heating element, means for measuring the liquid level of said acid bath, and means actuated by said measuring means when the liquid level of said bath falls below a predetermined level for disabling said prime mover and for actuating said valve means to connect said steam source to said steam nozzle while disconnecting said steam source from said heating element.

7. In a liquid-containing tank, means to measure the level of liquid in the tank, first and second alternative heating means responsive to liquid level changes as de-

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tected by said liquid level measuring means to maintain the level of said liquid in said tank substantially constant, said first heating means comprising heat exchanger means to heat said liquid indirectly and said second heating means comprising injection means to heat said liquid directly, said first heating means being actuated when the liquid level is within a set range and said second heating means being actuated when the liquid level falls below said set range.

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