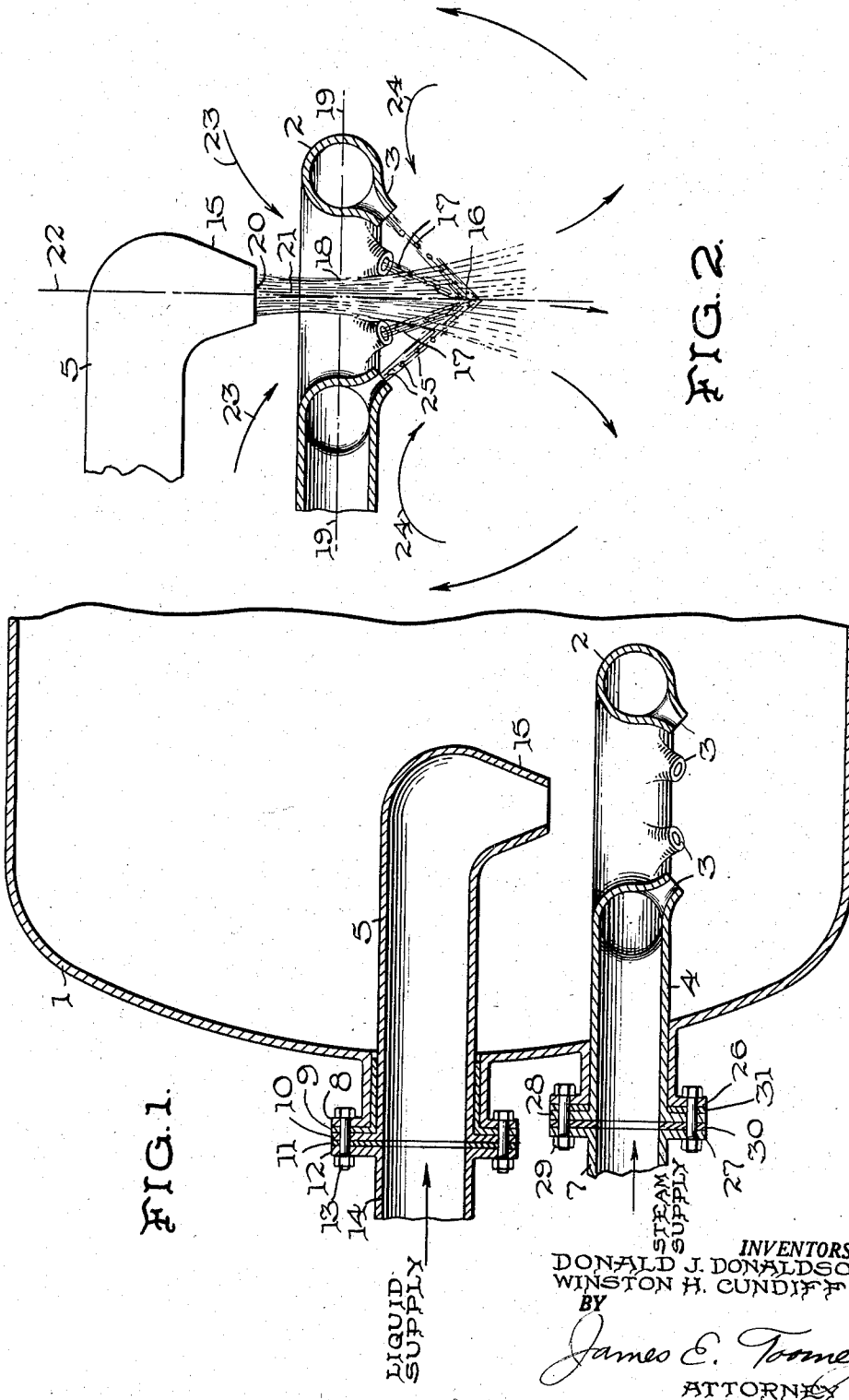


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HEATING APPARATUS AND METHOD

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1

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HEATING APPARATUS AND METHOD

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The present invention relates to a method for heating liquids and/or slurries by the injection of steam or other high temperature gaseous media therein. The invention also relates to apparatus which may be employed for heating liquids and/or slurries for the injection of steam therein.

Attendant with the heating of liquids and slurries by the direct injection of steam there are many unsolved problems and difficulties. In the methods and apparatus of the known types employed for heating liquids and slurries by the direct injection of steam the serious problem of "steam" or "water" hammer occurs. Generally, steam or water hammer is caused by the rapid collapse of the steam and is aggravated by high temperature differentials between the steam and the liquid to be heated. When high temperature differentials are present very serious ramifications due to the vibrations occur some of which frequently result in damage to the surrounding vessel and associated apparatus. If excessive steam hammer is evidenced in a steam injection system it can usually be reduced by decreasing the necessary temperature rise within the heating vessel, such as by reducing the amount of steam consumed per unit of liquid being heated. Another method for decreasing the temperature is to recycle the heated liquid such that the temperature of the liquid feed is increased with respect to the steam. This method also serves to reduce the difference between the liquid vapor pressure and the steam pressure, a relationship which materially affects the present or absence of steam hammer. Manifestly, there is a demand for a method of employing the direct injection of live steam which will accomplish the heat transfer from the steam to the liquid or slurry over a wide range of varying operating conditions without the occurrence of the dangerous vibrations caused by the collapse or rapid condensation of the steam during the process of heating.

According to the process of the invention herein described these vibrations can be substantially minimized and in many cases eliminated. The process is particularly adaptable to use in continuous steam injection systems where a liquid or slurry is continuously fed to and discharged from a pressure vessel. It has been found that transfer of heat can be made to proceed effectively by feeding the cold liquid to be heated to the vessel in a manner such as to present an unconfined cold liquid stream thereof which is surrounded by previously heated liquid. The cold stream of liquid or slurry is surrounded by a plurality of steam jets which initially discharge in the warm liquid and finally condense at a point downstream from the discharge point thereof in the cold liquid. The directional feature of the steam insertion combined with the initial contact of the steam with warm liquid prior to contacting the unconfined cold liquid contribute to effective and smooth heat transfer substantially without the dangerous vibrations over wide ranges of operation.

The invention is particularly applicable to systems wherein immediate heating of the cold liquid feed in a

2

vessel is desired. The process is particularly applicable to Bayer alumina ore refining operations wherein live steam heating of the slurries in the digesters is desired. Therein, it is undesirable to have liquid currents of lower temperature since the results of the digestion period are closely keyed to the time of treatment at the particular temperature. Furthermore, the vessels are large making the probability of cold currents high unless immediate heating of the feed liquor steam is accomplished.

According to the invention a steam annulus is employed which has a plurality of steam nozzles so situated in the annulus as to cause the steam emerging therefrom to merge at a point on the axis of the annulus yet relatively removed from the plane thereof. On the opposite side of the steam nozzles, the liquid to be heated is fed along the axis of the steam annulus preferably through a reducing nozzle so as to increase the velocity thereof as it issues from the feed pipe. This combination of injecting the liquid to be heated with the means for inserting steam into the liquid within a pressure vessel has been found to greatly facilitate the live steam addition into liquids confined in the pressure vessel so as to substantially overcome the water hammer accompanying other known types of steam injection methods. In general, it may be stated that the aspirating effect of the steam insertion in combination with the aspirating effect of the liquid feed means combined to produce the advantageous result by drawing preheated liquid into the heating zone thereby reducing the temperature differential between the steam inserted and the liquid contacted thereby initially in the heating zone.

Accordingly, it is an object of the present invention to provide an apparatus for heating a liquid or slurry.

Another object of the invention is to provide a method for heating a liquid or slurry which minimizes the occurrence of steam or water hammer.

A further object of the invention is to produce a simple and economical apparatus useful in treating a liquid by the direct injection of live steam therein.

Figure 1 is a schematic side elevation of an apparatus utilizing the principles of the herein described invention.

Figure 2 is a schematic presentation showing the relative disposition of the steam annulus with respect to the discharge point of the liquid feed pipe and in general describing concept of the invention.

With particular reference to Figure 1, there is shown a portion of the pressure vessel 1 having a flange portion 8. The liquid feed pipe 5 having flange portion 10 and reducer nozzle 15, is generally disposed within pressure vessel 1. Liquid supply pipe 14 having flange portion 12 is disposed without said vessel and connects with flange portions 10 and 8 of said liquid feed pipe 5 and pressure vessel 1, respectively, by means of bolts 13. Suitable gaskets or seals 11 and 9 are appropriately placed between flange portions 12 and 10, and 10 and 8, respectively, to provide a liquid seal under the particular pressure conditions. Steam annulus 2, having a plurality of steam nozzles 3, is disposed within pressure vessel 1 so that the axis of the annulus 2 and the axis of the reducer nozzle 15 are substantially coincidental. The steam annulus 2 is supported by steam feed pipe 4. Steam feed pipe 4 is connected through its flange portion 28 to another flange portion 26 of the vessel and to flange portion 27 of steam supply pipe 7 by means of bolts 29. Suitable gaskets or seals, 30 and 31, are disposed between flange portions 29 and 28, and 28 and 26, respectively.

With particular reference to Figure 2, there is shown schematically the relative position of the annulus 2 with respect of the liquid discharge point at the reducing nozzle 15 of liquid feed pipe 5. The liquid discharge point 20 is so positioned as to discharge the liquid to be heated at 21 along the axis 22 of annulus 2 at a point relatively

3

removed from the plane 19 thereof and on the opposite side of the steam injection nozzles 3. It has been found preferable to employ a reducing type nozzle such as shown at 15 to accomplish an accelerated discharge of the liquid from the feed pipe 5. Thus, an unconfined cold liquid stream 21 issues which aspirates previously heated liquid around same as shown by arrows 23. In this regard, positioning of the discharge point with respect to the annulus should be such as to accomplish the greatest velocity at the plane 19 of the steam annulus. Thus, the throat 18 of the venturi should be positioned as close as possible to the plane 19 of annulus 2 to accomplish the result most effectively according to the preferred embodiment. This accomplishes a much desired aspirating effect which causes previously heated liquid to be drawn into the heating zone as, for example, that indicated by arrows 23.

As shown in Figure 2, the steam nozzles 3 are positioned on the opposite side of the annulus from the liquid feed discharge point 20 and further positioned to discharge the steam so as to merge at merge point 16 relatively removed from the plane 19 of the steam annulus 2. As shown, the jets 17 of steam issuing from the plurality of nozzles 3 in annulus 2 have an additional aspirating effect which augments the aspiration accomplished by the high velocity of the feed liquid, the previously heated liquid coming forth as shown by arrows 23 and by arrows 24 in the heating zone; this first contacts the issuing steam and thereby minimizes the temperature differentials which normally cause rapid collapse of the steam. Furthermore, the jets of steam cause previously heated liquid to mix with the cold incoming liquid after the initial contact of the steam with the heated liquid so as to appreciably decrease the difference between the temperature of the liquid undergoing final contact with the steam and the steam temperature as, for example, at merge point 16. It has been found that this combination is exceedingly effective in minimizing steam or water hammer and permits a wide range of operation as regards both the quantity of liquid heated and the temperature rise accomplished by the steam injection.

Although the embodiment of the invention depicted in Figures 1 and 2 shows placement of the steam ring or annulus 2 in a horizontal position with respect to a vertical discharge of the liquid to be heated, it is to be understood that the invention is not thus limited. Thus, the directional feature set forth in the embodiment is not critical. The respective placements of the annulus and the discharge point of the liquid may be positioned such as to accomplish a stream issuing and being heated in any direction depending on the particular adaptation and end use. Similarly, although the preferred embodiment is such as to call for a high velocity discharge of the cold liquid by means of a constricted nozzle such as a reducer nozzle, it is apparent that the invention is not thus limited since the main objective of the reducer nozzle is to produce an unconfined cold liquid stream which aspirates or draws previously heated liquid along the outside of the discharge stream. In the sense that the high velocity discharge of the cold liquid feed presents a cold liquid core which is surrounded by previously heated liquid as the liquid is carried into the heating zone, the cold stream issuing from the feed pipe may be characterized as an "unconfined cold liquid stream." The unconfined cold liquid stream, because of its high velocity, is encompassed by a preheated quantity of liquid which rapidly moves in the direction of the heating zone found in the area subjected to the issuing steam.

The steam as it originally issues from the steam nozzles strikes previously heated liquid encompassing the unconfined cold liquid stream, thereby minimizing the rapid collapse of the steam which would be encountered where the situation presents a colder liquid thereto. Thus, in Figure 2 the steam issuing from nozzle 3 first strikes preheated liquid as, for example, at 25 which has been

4

drawn into the zone through the combined aspirating action of the cold liquid stream and the steam jet. After giving up a portion of the latent heat to the preheated liquid in zone 25, the temperature differential between the steam and the liquid is materially decreased so that, in the zones about the merge point 16, there is a definite minimization of the tendency to rapidly collapse because of the high temperature differentials. Furthermore, the jetting action of the directed steam nozzles causes previously heated liquid to mix with the cold liquid stream at the merge point 16 thereby further decreasing the temperature differential at this point by its mixing action.

Although the invention description heretofore set forth calls for directional nozzles which merge at a point relatively down stream and removed from the plane annulus, it will be apparent that minor variations in the down stream direction of one or more of the steam nozzles may be accomplished without departing from the spirit and scope of the invention. Similarly, although the invention is described with respect to a donut shaped annular steam annulus other configurations may be employed with equal facility.

What is claimed is:

1. A method of internally heating a confined body of liquid in a pressure vessel to a vapor pressure that is near its static pressure by direct injection of steam within the body without severe water hammer, comprising feeding a liquid of lower temperature into said body of liquid having a higher temperature to form an unconfined lower temperature liquid stream flowing through a steam injection zone within said body, the flow of said stream causing convergent circulation of the higher temperature liquid from all sides around the outer periphery of said stream in said steam injection zone, introducing jets of steam into said steam injection zone at a plurality of points surrounding said unconfined liquid stream, whereby said jets of steam first contact the circulating higher temperature liquid causing said higher temperature liquid to mix with said lower temperature liquid in said stream thereby appreciably decreasing the difference between the temperature of the said lower temperature liquid and the steam temperature, said steam being directed from said plurality of steam introducing points to merge in said stream at a point relatively downstream from said steam introducing points.

2. Apparatus for internally heating a body of liquid in a vessel by direct injection of steam within the body without severe water hammer, comprising a steam annulus located within said body of liquid and connected to a steam supply, said annulus having a plurality of nozzles, a feed pipe having a diameter smaller than said annulus positioned within the body of liquid having a higher temperature for discharging an unconfined stream of lower temperature liquid axially through said annulus, the flow of said stream causing convergent circulation of said higher temperature liquid from all sides around the outer periphery of said stream in the immediate area of said annulus said plurality of nozzles of said annulus being angularly disposed with respect to the plane of said annulus to direct jets of steam through said higher temperature liquid toward said unconfined lower temperature liquid stream at a point relatively downstream from the plane of said annulus.

3. Apparatus for internally heating a body of liquid in a pressure vessel by direct injection of steam within the body without severe water hammer, comprising in combination with a pressure vessel, a steam annulus located within said body of liquid and connected to a steam supply, said annulus having a plurality of steam nozzles, a feed pipe having a diameter smaller than said annulus extending into said vessel containing the body of liquid at a higher temperature and positioned therein to discharge an unconfined stream of lower temperature liquid axially through said annulus, the flow of

5

said stream causing convergent circulation of said higher temperature liquid from all sides around the outer periphery of said stream in the immediate area of said annulus said plurality of steam nozzles being so disposed on said annulus as to direct the jets of steam therefrom through said higher temperature liquid toward said unconfined lower temperature liquid stream at a point on the axis of said annulus relatively downstream from the plane thereof.

5

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