This invention relates to an electrically heated evaporator. More specifically, it relates to a film evaporator for vaporizing caustic alkali solutions.

It is known to dehydrate or concentrate caustic alkali solutions by means of film evaporators. The use of such apparatus offers several advantages. Owing to the continuous operation, operating costs are low. Moreover, the temperature of the liquid to be heated is not too high so that the material is not easily attacked. The good thermal efficiency of film evaporators is another notable feature.

Film evaporators of the type mentioned may consist of a vertical or substantially vertical tube preferably made of nickel. The solution to be dehydrated flows down the inner surface of the tube as a coherent film. If at the same time the tube is heated, and the amount of heat supplied and the solution fed in bear a certain relation to each other, it may be expected that the tube will be vaporized for the most part and that a substantially anhydrous melt will be discharged at the lower end of the tube.

If the said relationship is changed, then either only a portion of the water evaporates, so that the solution of caustic soda is for example concentrated from 50% to 70%, or an anhydrous melt may be obtained which may be superheated.

While the first variant of the process may be used industrially, overheating of the melt is avoided so that the corrosion of the tube may be kept within permissible limits. For example, a dehydrated caustic soda melt at temperature below 400°C has a negligible attack on nickel, and cannot be detected in the melt. If the temperature of the melt is raised above 400°C, then at about 450°C, attack on the nickel becomes more marked and the melt produced has a yellow-green color. At temperatures above 500°C, a black melt is discharged and the nickel tube is strongly attacked.

The use of a film evaporator therefore requires an accurate regulation of the heat supplied and of the amount of caustic alkali solution fed in. It has been found to be advantageous to use the tube of a film evaporator electrically. One prior art heating means comprises electrical heating elements arranged concentrically along the length of the evaporator tube.

This arrangement however has great disadvantages. The heat is transmitted from the heating elements via a heat-resistant protective layer to an inner tube of a nickel-chromium-cobalt alloy which in turn heats the evaporator tube by radiation. Owing to the high heat resistance between heating element, protective layer, inner tube and evaporator tube, it is only after about four hours that the thermal equilibrium is set up, because it is only after this period that the heating element has reached its end temperature.

Moreover, the specific loading of the heating surface of the evaporator tube is low, a tube having an external diameter of 125 mm. and a length of 3.96 m. handling only 72 kg./h. of 50% caustic alkali solution. An evaporation capacity of 19 kg./h. of water per square meter of surface of the evaporator tube may be varied from these values.

Another disadvantage of this arrangement is that it is impossible to shut off the plant within a short time because the high temperature of the heating element must be taken into account and cooling off of the same awaiting before the feed of liquid to the tube can be discontinued.

It is an object of this invention to provide an electrically heated film evaporator whose heating-up can be quickly and easily controlled. Another object of the invention is to provide a film evaporator which can be heated within a short period. Yet another object of the invention is to produce different amounts of heat along the length of the evaporator tube according to the heat required in the tube.

These and other objects and advantages of the invention are achieved by the electrically heated film evaporator according to this invention having a preferably vertically arranged evaporator tube. It is characterized by the following features: (a) the evaporator tube is arranged as an electrical resistor in the circuit; (b) a feed line is provided at or near the upper end of the tube for the supply of the material to be heated to the inner wall of the evaporator tube; and (c) the evaporator tube is provided at or near each end with a contact plate for the supply of electric current.

Beneath the feed line for the material to be dehydrated, the evaporator tube may be tapped for uniform distribution of the liquid fed in.

Over the length between the two contact plates, it is advantageous to make the wall of the evaporator tube of different thicknesses according to the heat required.

In order that the usual electric voltages may be used without loss, a plurality of evaporator tubes may be provided, preferably connected in series.

The use of the evaporator tube as an electric conductor generating the heat within the wall of the tube is the most favorable solution because the tube has alternating current flowing either through its whole length or through only a portion thereof so that the tube is heated according to requirements. The heat may be varied within wide limits by regulation of the current and voltage. The evaporator tube may be enveloped in insulating material, for example mineral wool, to keep heat loss low.

The caustic alkali solution is supplied at or near the top of the evaporator tube, flows down on the inner wall of the tube and leaves at the bottom of the tube dehydrated to a greater or lesser degree, depending on the temperature to which it has been exposed. Then it is collected. The evaporated water flows in the opposite direction, passes through the upper end of the tube as vapor mixed with a small amount of air, and is passed to a condenser which condenses the water vapor. The remaining air is blown into the atmosphere by the action of a fan. The output of the fan is controlled so that the amount of air sucked in is just sufficient to prevent water vapor issuing from the lower end of the evaporator tube.

We have found that when working in this way, in contrast to the prior art methods, no expensive distribution of the caustic alkali solution on the evaporator tube is necessary. It is sufficient if the solution is supplied at or near the upper end of the evaporator tube through a feed line which is mounted radially or tangentially on the evaporator tube. The solution is immediately distributed uniformly on the inner surface of the tube and flows down. The only measure recommended is that the inner wall of the tube should be roughened or tamped for a short distance, for example 50 to 100 mm., below the point at which the liquid enters.

Using the evaporator tube as an electric conductor offers the additional advantage that the metal cross-section of the tube may be varied at will by metals welded onto the tube or by the use of tubes having different wall thickness or unequal diameter. This makes it possible to vary the heat supplied to different parts of the tube. For
example it is advantageous if the lower end of the heated portion of the tube, for about 50 cm., has twice the metal cross-section of the remainder of the length of the tube and when starting up from cold is only a few minutes. During operation, the temperature of the tube is not very much higher than the temperature of the solution. Therefore the risk of overheating is very slight. The electric current and the liquid feed may be shut off at the same time without the risk of the evaporator tube becoming overheated and therefore strongly corroded. Furthermore, in this apparatus it is not necessary to produce, at the beginning and end of the evaporation, a melt which is only partly dehydrated.

The invention will now be described with reference to the accompanying drawing which illustrates diagrammatically by way of example a series of three electrically heated evaporator tubes according to the invention. The actual dimensions used will vary according to the evaporation capacity.

Three vertical nickel tubes 1a, 1b and 1c are connected electrically in series by means of the contact plates 2, 3, 2' and 3' which are in elastic connection with each nickel tube, and an alternating current is supplied to the electrically connected tubes. Each nickel tube is 7 m. in length and 70 mm. in internal diameter and has a wall thickness of 2.5 mm. in the upper portion and an increased wall thickness of 5 mm. in the bottom portion extending about 50 cm. axially upwardly from the bottom of the heated portion of the tube. Each tube as shown thus serves as an electrical conductor for about 6 m. of its length.

Since all three tubes are substantially identical in structure and operation, the following description with reference to one of these tubes 1a applies also to the remaining tubes 1b and 1c except as otherwise noted. Reference numerals are the same for the structure in each tube. The caustic soda solution is introduced through a feed line 4c to the upper end of the nickel tube 1a and above the contact plate 2 (plate 2' in tubes 1b and 1c), is distributed along the heated portion 4c of the inner wall 6c of the tube, flows down the inside of the tube as a uniform film and leaves the tube as a dehydrated melt at the lower end 7a thereof and can be collected there. The roughened portion 5b of the inner wall 6b of tube 1b is likewise shown as a tapped thread, while this roughened portion 5c on the inner wall 6c of tube 1c is in the form of a cross-notched area. In each case the roughened portion is about 100 mm. long in the axial direction and is located immediately downstream from the feed line.

Water vapor and sucked-in air are drawn away by fan 15 through the upper ends 6a, 6b and 6c of the tubes and passed through the manifold 10 and a condenser 11 in which the heat exchange fluid is introduced at 12 and removed at 13. The condensed liquid is withdrawn, through line 14 and gases are ventilated by the fan 15. Each evaporator tube is heat insulated with mineral wool 9a, 9b and 9c.

If the tube 1a is loaded with a current of 5000 amp., a voltage drop of about 12 volts is produced in the heated condition. At the same time about 100 kg./h. of a 50% caustic soda solution is metered in through the feed line 4a. The solution is dehydrated in contact with the inner wall 6a. When the melt leaves the tube at 7a, it still contains about 0.5% of 1% of water. Its temperature is 380° to 400° C.

Each square meter of the inner surface of the tube 1a therefore evaporates 38 kg. of water per hour. This value is not however the maximum value. Loading of the tube wall with electric current is limited by the velocity of the vapor at the upper end and this should advantageously not exceed 10 in. Each of the tubes 1b and 1c can be operated in the same manner under the same conditions so as to handle a total feed to all three tubes of 300 kg./h. of the 50% caustic soda solution. While only three tubes are illustrated in the drawing, it is advantageous in an industrial plant to bank together six or more tubes of appropriate length since this will give a satisfactory voltage drop when connected electrically in series.

The evaporator described is also suitable for dehydrating caustic alkali solutions having higher contents of caustic alkali, for example 71% caustic soda solution, which is to be regarded as a melt because it solidifies at room temperature. It is advantageous to heat up the caustic alkali solutions by cheaper sources of energy than electrical energy to a temperature at or near the boiling points prior to evaporation and only then to supply the solutions to the film evaporator. For example 50% caustic soda solution may with advantage first be concentrated to 71% by means of conventional multipass evaporators and then dehydrated in the electrically heated film evaporator.

We claim:
1. An electrically heated film evaporator for dehydrating caustic alkali solutions comprising: a substantially vertical evaporator tube, the evaporator tube being connected in an electrical circuit as an electrical resistance; means to uniformly distribute the solution to be dehydrated on the inner wall surface of said tube including (A) a feed line for supplying the solution at an angle to the axis of said tube to impinge on the inner wall of said tube in the neighborhood of the upper end of said tube and (B) a roughened portion on the inner wall of said tube extending over a short axial distance within said tube beneath and immediately downstream from said feed line; and means for supplying electric current to said evaporator tube.

2. An evaporator as claimed in claim 1 wherein the thickness of the wall of said evaporator tube varies inversely with local heat requirements.

3. An evaporator as claimed in claim 1 comprising a plurality of said evaporator tubes connected electrically in series.

4. An evaporator as claimed in claim 1 wherein a fan is connected in gaseous communication with the upper end of said evaporator tube for withdrawal of water vapor and air through said upper end.

5. An evaporator as claimed in claim 1 wherein said roughened portion on the inner wall of said tube comprises a tapped thread extending up to about 100 mm. below said feed line.

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