This invention relates to spray drying methods and apparatus and more particularly relates to a method and apparatus for avoiding unwanted deposits which necessitate frequent equipment shut down for cleaning.

In the spray drying of liquids utilizing conventional centrifugal spray drying apparatus wherein a rotating spray disc extends into a drying or desiccating chamber, undesirable deposits of dry material gradually build up between the stationary and moving parts of the apparatus so that eventually the moving parts rub against the fixed parts to slow the speed, load the motor, and necessitate a shut down for cleaning. These deposits also tend to clog the orifices in the disc. In addition to causing frequent shut downs for cleaning, these deposits tend to become burned by the high temperature of the spray drying apparatus and, where such deposits fall into the dry product, contamination occurs and a large amount of the product may be rendered unsuitable for human consumption.

While numerous attempts have been made to solve these problems, such as the use of a current of cold air, high pressure nozzles, or two substance nozzles, no completely effective remedy has been found and all equipment of this type must be periodically shut down for cleaning.

It is accordingly a primary object of the present invention to provide a method and apparatus for spray drying wherein the accumulation of undesirable deposits of the substance to be extracted is prevented and substantially continuous operation of the equipment is possible.

It is another object of the invention to provide a novel method and centrifugal atomizer apparatus wherein unwanted deposits are prevented from forming between the fixed and moving parts of the apparatus.

It is another object of the invention to provide an improved method and apparatus for spray drying liquids on a continuous basis without necessity of shut down for cleaning deposits from the apparatus.

It is another object of the invention to provide a method and apparatus for spray drying a substance carried by a liquid by spraying the liquid into a drying atmosphere which tends to cause deposits of the substance to form on certain surfaces of the spray drying apparatus, while preventing the formation of such deposits by projecting onto the deposit prone surfaces a wet gas.

Further objects and advantages of this invention will become apparent upon reference to the following description and claims and appended drawings wherein:

Figure 1 is a vertical section of a spray drying apparatus constructed according to one embodiment of the invention;

Figure 2 is a vertical cross section through a spray drying apparatus constructed according to another embodiment of the invention; and

Figure 3 is a vertical section through a spray drying apparatus constructed according to still another embodiment of the invention.

Referring to Figure 1 there is shown a disc atomizer apparatus which consists of a shaft 10 which is preferably vertical, as illustrated, and which carries an atomizing head or disc 12 attached to the lower end thereof by a nut 14. The shaft 10 passes concentrically through the housing 16 and is journaled therein by means of a bearing 18 carried by supports 20 and 22 which are fixed to the housing 16 by means of the wall 24. The housing 16 is inserted into the dryer container, shown partially at 26, which forms the atomizing chamber. Container 26 includes an aperture 27 for delivering a drying gas to the container.

The oil for lubrication of bearing 18 may be delivered to the bearing from above and is hence conveyed past the splash ring 28 to the oil catching bowl 30 located in bearing support 22. From here the oil is removed by means of a suitable conduit, not shown. A labyrinth seal 32 is mounted on the bearing support 22 to prevent the oil from running down along the shaft 10 into the drying chamber.

The liquid to be evaporated is carried through a pipe not shown, to ring duct 34 in bearing support 22 and from here is delivered through liquid supply tubes 36 into the cavity 38 in the atomizer disc 12. The ring duct 34 is otherwise closed by means of a cover plate 40 which is received on a shoulder 42 in the housing 16 and the housing extends down below the cover plate to form a peripheral skirt 44 which terminates in close proximity to the disc 12. The liquid supply tubes 36 are carried by the cover plate 40. The atomizer disc 12 is dish shaped and is provided with an upwardly extending rim 46 having radial nozzles 48 therein. The upper portion of the rim 46 carries an inwardly extending flange 50 which serves as a means for mounting a covering ring 52.

The liquid entering the annular cavity 38 in the atomizer disc is projected towards the rim under the influence of centrifugal force and is sprayed through radial nozzles 48 into the drying chamber, where it is emitted as a haze in the surrounding drying gas. As the liquid leaves the supply tubes 36 and impinges upon the rapidly revolving disc, it is partially dispersed and a considerable number of drops thereof enter the space 54 between the covering ring 52 on the atomizing disc and the cover plate 40 in the housing 16. These drops adhere to the cover plate 40 and covering ring 52 as well as the supply tubes 36 and tend to dry in the drying gas atmosphere which permeates this space. This action results in the formation of a constantly growing deposit which eventually leads to a rubbing contact between the deposit on the covering ring 52 and the deposit on the cover plate 40. This slows the rotation of the atomizing disc, overloads the driving motor, and eventually necessitates a shut down of the apparatus for cleaning.

In addition to the foregoing deposits, the atomizing disc tends to become heated to the temperature of the hot drying gas normally utilized and the fluid itself frequently enters the apparatus at a high temperature. Under these conditions, and even under conditions where the fluid enters at room temperature, the fluid leaving the supply tubes 36 and spreading across the bottom of the cavity 38 is immediately heated, so that a certain amount of evaporation occurs inside the disc. This leads to the accumulation of deposits in the vicinity of the supply tubes 36 and the shaft 10 and these deposits grow until they contact the tubes 36 to cause eventual slowing of the disc, loading of the motor and shut down for cleaning. Further, the high temperature of the disc causes a burning of the deposits so that if any of the deposited material falls into the dryer, as is frequently the case, the dried material is contaminated.

According to the present invention these undesirable
deposits, shut downs and contamination are avoided by means of a wet gas cushion which preferably contains a vapor of the same liquid as carries the substance to be extracted. This vapor is preferably present in an amount sufficient to create a partial pressure of the vapor in the gaseous mixture equal to or higher than the saturation pressure of the particular liquid which carries the substance to be extracted. By this means carrier liquid evaporation on the surface of the spray- ing apparatus is eliminated and there is consequently no formation of deposits.

As an example, where milk is to be spray dried, water is material being evaporated and hot air at a temperature of approximately 160°C is used as the drying gas. Under the influence of this air and the inflowing liquid the atomizer disc attains a temperature of approximately 50°C, which is immediately communicated to the milk on the disc. In order to prevent evaporation the gas cushion should consist of air at a temperature of approximately 50°C, containing a quantity of water vapor or steam at a temperature of at least 50°C and in an amount sufficient to create a partial pressure equal to the saturated vapor pressure of water at 50°C.

In the apparatus shown in Figure 1 the proper mixture of cushion gas is obtained in an annular chamber 56 into which air is admitted by means of conduit 58 and steam is admitted by means of conduits 60 and 62 having outlets 64. The steam or water vapor may be produced in any suitable manner, such as in a boiler, and then introduced into conduits 60 and 62. Where the desired temperature of the water vapor is relatively low, as in the foregoing example, it is obvious that some reduction in the temperature of the steam is necessary, with the partial pressure of the vapor being controlled by the amount of water vapor introduced into the cushion gas. Capsules 66 are provided in the cover plate 40 and these admit the cushion gas into the space 54 between the cover plate 40 and the covering ring 52. Since the cushion gas is preferably supplied at a pressure slightly in excess of the pressure of the drying air in the drying chamber it expels the drying air from the space 54 and effectively eliminates evaporation of liquid and build up of deposits in this area. The small clearance between the peripheral skirt 44 and disc 12 facilitates this action and prevents any inflow of drying gas.

The continuous flow of cushion gas and the centrifugal effect of the rapidly rotating disc 12 causes the gas to flow radially outward over the rim 46 of the disc. In addition to maintaining a saturated atmosphere in the space 54 this flow tends to reduce the tendency of drying gas present at the nozzles 48 and produces an annular zone around the nozzles having at least a greatly reduced drying potential. This reduces the formation of deposits at the nozzles and permits long operation without shut down for cleaning. This effect may be further enhanced by utilizing a housing 16 of larger diameter than that shown in Figure 1 whereby the peripheral skirt 44 extends downwardly to surround the upper portion of the rim 46. With such a construction the radially escaping cushion gas is brought into the immediate vicinity of the nozzles to almost completely eliminate the presence of drying gas at this point.

In order to limit the centrifugal dispersing action of the rapidly spinning disc 12 on the cushion gas, the underside of cover plate 40 is provided with radial vanes 68, two of which are shown in cross section in Figure 1, which tend to limit the rotational movement of the gas. In addition, the clearance between the lower edge 44 of the housing 16 and the upper surface of the rim 46 of the disc 12 is preferably kept at a minimum. It will be appreciated that in the spray driers heretofore utilized small clearances of this type have been impractical, since the rapid accumulation of deposits at these points caused shut down of the apparatus after only a short period of operation.

While the apparatus shown in Figure 1 illustrates one type of spray drier incorporating the invention, the principle of the invention may be applied to a wide variety of spray driers and a second embodiment of apparatus is shown in Figure 2. In the apparatus shown in Figure 2 the shaft 70 passes through a labyrinth seal 72 carried by the cover plate 74 which closes the lower end of the housing 76. A dish shaped spray disc 78 having an upright peripheral rim 80 is attached to the shaft 70 by means of a nut 82. The upper opening in the spray disc is closed by means of a covering ring 84 which engages the shaft 70 and prevents the escape of the cushion gas from this area. The plate 74 is fastened to the shaft 70 by bolts 75, 79 and the plate 74 is merely a cover plate without any indication of the delivery of cushion gas from it.

A further embodiment of apparatus is shown in Figure 3. The plate 74 is connected to the shaft 70 by a knurled ring 86. The fluid to be spray dried flows into the cavity 88 in the spray disc through fluid supply tubes 90 which pass through the cover plate 74. A centrally located circular skirt 92 depends from the underside of cover plate 74 into close proximity to the central opening 94 in the cover plate 94. The covering ring is provided with a shoulder 94 at this position and the shoulder defines passageways 96 for a purpose presently to become apparent.

Cushion gas of the proper temperature and liquid content is conducted by pipe 98 into an annular duct 100 surrounding the shaft 70. From here the cushion gas escapes into the space 102 enclosed by the skirt 92 past the supply tubes 90 into the cavity 88 in the spray disc 78. The labyrinth seal 72 precludes the cushion gas from rising along the shaft 70 into the lubricating elements.

An additional supply of cushion gas is provided by means of pipe 106 which supplies gas through cover plate 74 into the space 108 between the cover plate 74 and covering ring 84. The supply of cushion gas down through the space 102 within skirt 92 and into the spray disc prevents the formation of deposits in the vicinity of the supply tubes 90 and in the cavity 88 in general. The cushion gas from pipe 106 prevents the formation of deposits within the space 106 while the small clearance between skirt 92 and collar 94 prevents liquid from escaping into the space 108. Any droplets which do tend to escape are delivered back into the cavity 88 within the spray disc 78 by centrifugal action through the passageways 96. It will be appreciated that the small clearance between the skirt 92 and collar 94 is possible only because a positive pressure of cushion gas exists within the spray disc and prevents the formation of deposits which would soon fill this small space.

Cushioning gas may be supplied to the vicinity of the nozzles 48 by means of a passage 110 in the shaft 70 which communicates with an annular duct 112 having radial passages 114 connected thereto and terminating at the nozzles 86.

In addition to being applicable to rotating disc type sprayers, the principle of the invention may also be applied to fixed spray nozzles and an illustration of such an arrangement is shown in Figure 5. Liquid to be evaporated is introduced into the drying vessel 116 by means of a conduit 118 which is connected to nozzle assembly 120 having a nozzle orifice member 122. The nozzle assembly 120 is surrounded by a jacket 124 which is sealed to the nozzle at 126 by any suitable packing means. The lower end of the jacket 124 adjacent the nozzle orifice member 122 is open as shown at 128, and cushion gas is supplied to the jacket through a conduit 130 in the upper end thereof. The nozzle orifice member 122 and the opening 128 in the jacket are so arranged that the jacket does not interfere with the dispersion process but prevents the liquid which gathers around the nozzle orifice from drying out.

While the cushion gas has been described as consisting of a mixture of a gas, such as air, and a liquid which is the same as the liquid carrying the substance to be extracted, it is also possible to increase the percentage of
the liquid phase of this mixture to the extent that it comprises the entire cushion gas. That is to say, during a spray drying process where water is the liquid to be evaporated, the cushion gas may consist of pure steam. In such a situation a very small quantity of cushion gas is effective to achieve the desired purpose, although it is necessary to take care lest the temperature of the spray disc be raised an undesirable amount.

It will be apparent from the foregoing that there has been provided a method and apparatus for spray drying liquids whereby the accumulation of dry deposits of such substance on the moving and stationary parts of the apparatus is eliminated so as to permit a truly continuous operation. This effect is achieved by blanket- ing the areas likely to accumulate deposits with a cushion gas which includes an amount of the liquid bearing the substance to be extracted sufficient to give a partial pressure equal to the saturation pressure of that liquid.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiment is therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by United States Letters Patent is:

1. A method of spray drying a substance carried by a liquid comprising the steps of spraying said liquid into a drying atmosphere which tends to cause deposits of said substance to form on certain surfaces of said spraying apparatus, and preventing the formation of such deposits by projecting onto the deposit prone surfaces a gas containing vapor chemically similar to the vapor of said liquid in sufficient quantity to produce at said surfaces a mixture having a partial vapor pressure of said chemically similar vapor substantially no less than the saturated vapor pressure of said liquid at the temperature of said mixture.

2. A method of spray drying a substance carried by a liquid comprising the steps of spraying said liquid into a drying atmosphere which tends to cause deposits of said substance to form on certain surfaces of the spraying apparatus, and preventing the formation of such deposits by projecting onto the deposit prone surfaces a gas containing vapor chemically similar to the vapor of said liquid being at least equal to the saturation vapor pressure of the liquid carrying said substance.

3. A method of spray drying a substance carried by a liquid comprising the steps of spraying said liquid into a drying atmosphere which tends to cause deposits of said substance to form on certain surfaces of the spraying apparatus, and preventing the formation of such deposits by projecting onto the deposit prone surfaces a gas containing a vapor of the same liquid as the liquid carrying said substance, the partial pressure of said vapor being at least equal to the saturation vapor pressure of the liquid carrying said substance.

4. A method as set out in claim 3 wherein said gas is air and said vapor carried by said gas is water vapor.

5. A method of spray drying a substance carried by a liquid comprising the steps of spraying said liquid in a spray drying apparatus in a drying atmosphere which tends to cause deposits of said substance to form on certain surfaces of the spray drying apparatus, and preventing the formation of such deposits by projecting onto the deposit prone surfaces a gas containing a vapor of said liquid to form at said surfaces a mixture, the partial pressure of said vapor being at least substantially equal to the saturated vapor pressure of the liquid carrying said substance at the temperature of said mixture.

6. A spray drying apparatus for drying a substance carried by a liquid comprising a spraying means, a contain- 6
er enclosing said spraying means, means for delivering to said container a drying gas which tends to cause the formation of deposits of the substances to be dried on surfaces of said spraying means, means for providing a gas containing vapor chemically similar to the vapor of said liquid and means for delivering said gas containing vapor to said surfaces, means for providing a gas containing vapor providing said gas and vapor in such proportions that a mixture is produced at said surfaces having a partial vapor pressure of said chemically similar vapor substantially no less than the saturated vapor pressure of said liquid at the temperature of said mixture.

7. An apparatus as set out in claim 6 wherein said spraying means has fixed and rotatable portions adjacent one another, said rotatable portion comprising a dish-shaped disc having a turned up rim with nozzles therein, a ring plate covering said disc, a cover plate on said fixed portion parallel to said ring plate, means for delivering said liquid past said cover plate and ring plate into said disc near the axis thereof, and conduit means in said cover plate for delivering said gas containing vapor into the space between said cover plate and said ring plate.

8. An apparatus as set out in claim 7 wherein said fixed portion includes therein a mixing chamber for mixing said gas and vapor, and further conduit means connecting said mixing chamber to said conduit means.

9. An apparatus as set out in claim 6 wherein said spraying means includes fixed and rotatable portions adjacent one another, said rotatable portion comprising a dish-shaped disc having a turned up rim with nozzles therein, a ring plate covering said disc, a cover plate on said fixed portion parallel to said ring plate, means for delivering said liquid extending through said cover plate past said ring plate into said disc near the axis thereof and conduit means in said cover plate for delivering said gas containing vapor into the space between said cover plate and said ring plate, said fixed portion including a lower peripheral edge which extends down towards and into close proximity with said disc below said cover plate to thereby form a small slit which maintains said gas in said space and prevents surrounding gas from entering.

10. An apparatus as set out in claim 9 including radial vanes affixed to the underside of said cover plate.

11. A spray drying apparatus for drying a substance carried by a liquid comprising a spray apparatus having fixed and rotatable portions adjacent one another, said rotatable portion having a cavity therein communicating with nozzles, first conduit means in said fixed portion for delivering said liquid to said cavity in said rotatable portion, a mixing chamber in said fixed portion, second conduit means in said fixed portion connected to said mixing chamber for delivering a gas thereto, third conduit means in said fixed portion for delivering a liquid to said mixing chamber, and fourth conduit means in said fixed portion for delivering a mixture of said gas and second named liquid to surfaces of said rotatable portion.

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