"Design And Fabrication of Agitated Thin Film Dryer" - Review

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ABSTRACT

Agitated thin-film dryers (ATFDs) are used to produce dry free-flowing powder from slurry/solution-type feed and widely implemented in pharmaceutical, chemical, food industries and metal industries. The feed passes through the ATFD in several forms such as solution/slurry and successively becomes paste, wet powder, and dry powder. The flow of feed in the ATFD undergoes a helical path (combination of rotational velocity imparted by the agitator/blade and axial velocity of feed) while flowing through the annular part of the dryer. The ATFD is described stage-wise and the parameters such as physical properties, scraped surface heat transfer coefficient, and evaporation rate (drying rate) are derived using stepwise model equations.

Keywords: - *Heat Transfer, ATFD, Fouling & Effluent.*

1. INTRODUCTION.

Evaporators are used in a wide range of processes including Pharmaceuticals, foods and beverages, metal industries, pulp and paper, chemicals, polymers and resins, inorganic salts, acids, bases, and a variety of other materials. There are many types and variations of evaporators and the best for a particular application depends on the product characteristics and desired results. Evaporation is an operation used to concentrate a solution of a nonvolatile solute and a volatile solvent which in many pass is water. A portion of the solvent is vaporized to produce a concentrated solution, slurry or thick & viscous liquid. An evaporator consists of heat exchanger or a heated bath, valves, manifolds, controls, pumps, and condenser.

The most common designs are jacketed pans, tubular heat exchangers, and plate and frame heat exchanger and agitated thin film evaporator. An **AGITATED EVAPORATION MACHINE** is one of the most significant steps towards it. An agitated thin film evaporator is a recent technology used to dry the concentrated solution of essential solids so that moisture is evaporated & dry powder of solid is obtained.

2. A properly designed evaporator.

- **a.** Be designed to effectively transfer the heat at a high rate with minimum surface area to be cost effective for installation, operations and maintenance.
- **b.** Effectively separate the vapors from the liquid concentrate meet the conditions required by the product being processed.
- **c.** Produce a product that needs the required quality.
- **d.** To be energy efficient, where possible making effective use of steam with multiple effect evaporation or vapor recompression.
- **e.** Minimize the fouling of heat transfer surfaces.
- **f.** Be constructed of materials that are adequate to minimize.

3. LITERATURE SURVEY.

3.1 Sanjay B. Pawar , A.S. Mujumdar , B.N. Thorat – Article 2011

The design of agitated thin film dryer (ATFD) is difficult both mechanically and process engineering point of view. The present work describes the basic flow pattern in ATFD in terms of bow wave and its transformation along the dryer height. The effect of flow rate, jacket side heating medium temperature and speed of the rotor has been studied for a pilot scale ATFD. The effect of rotor speed was found less significant for water as a feed material than for sugar and ammonium sulfate solutions over the studied range of speed. The scraped side heat transfer coefficient was obtained using the penetration theory and its value was found in the range of 3000–7000W/m2 ◦C.

3.2 Nicholas P. Cheremisinoff.

We may organize water treatment technologies into three general areas: Physical Methods, Chemical Methods, and Energy Intensive Methods. Physical methods of wastewater treatment represent a body of technologies that we refer largely to as solid-liquid separations techniques, of which filtration plays a dominant role. Filtration technology can be broken into two general categories - conventional and non-conventional. This technology is an integral component of drinking water and wastewater treatment applications. It is, however, but one unit process within a modern water treatment plant scheme, whereby there are a multitude of equipment and technology options to select from depending upon the ultimate goals of treatment. To understand the role of filtration, it is important to make distinctions not only with the other technologies employed in the cleaning and purification of industrial and municipal waters, but also with the objectives of different unit processes.

3.3 Freeze H.L., and Glover W.B.

Agitated thin film evaporators are attractive for the concentration, distillation, stripping or deodorization of liquids in broad variety of chemical-process-industries (CPI) applications where the process streams are temperature sensitive (and must have only brief exposure to heat), viscous, or tend to foul or foam. When this type equipment does seem to be the right choice in a given situation, the common, and sound, approach is to ask an evaporator manufacturer to conduct an evaluation and make an equipment quotation. The quality of such an evaluation will depend on the type and quality of the data that the manufacturer receives from the potential customer’s engineers and perhaps to some extent, on those engineers’ familiarity with the evaluation process itself.

The thin-film process - That familiarity begins with an understanding of what a thin-film evaporator is and how it works. A vertical thin-film evaporator consists of two major assemblies: a heated body and a close-clearance rotor. The process fluid enters the unit tangentially above the heated zone, and is distributed evenly over the inner surface of the body wall by a distribution ring mounted on the rotor. The rotor blades spread the product over the en- tire heated wall, and generate highly turbulent flow conditions in the thin layer of liquid.

The product spirals down the wall, while the turbulent conditions developed by the rotor blades generate optional heat flux, rapidly evaporating volatile components. The resulting vapors flow upward through the unit into a centrifugal separator, which re- turns entrained droplets or froth directly back to the heating zone. Clean vapors pass through the vapor outlet ready for condensing or further processing. Meanwhile, the concentrated liquid stream leaves the evaporator through its bottom conical outlet. Continuous washing by the bow waves generated by the rotor minimizes surface fouling of the thermal wall, where the concentrated liquid or residue is most prevalent.

Thin-film evaporators are commercially available in various basic or standard versions. They can have vertical or horizontal designs, with cylindrical or tapered bodies and rotors. The rotor can employ any of several zero clearance designs, or a rigid fixed clearance design, or an adjustable clearance type. The basics for scale up from the manufacturer’s pilot testing program are the same or similar for all.

3.4 Sulzer Chemtech ltd.

In 20th Century the growth in the Chemical Sector was increased due to World War II and Cold War. Due to Chemical industries increasing there was tremendous increasing in Chemical Waste and sub-product. It was difficult to collect and store these chemicals. It was also harmful to nature and humans. It was necessary to reduce the increasing rate of chemical and dispose it properly by order of chemical of united nation, that why which convert liquid chemical into solid powder. Lateran, some improvement implemented on the evaporator design to make its more efficient and reliable. In India Sulzer Chemtech introduced the agitated thin film evaporator in chemical Industries.

4. Problem Definition.

Technical problems can arise during evaporation, especially when the process is applied to the food industry. Some evaporators are sensitive to differences in viscosity and consistency of the dilute solution. These evaporators could work inefficiently because of a loss of circulation. The pump of an evaporator may need to be changed if the evaporator needs to be used to concentrate a highly viscous solution.

Fouling also occurs when hard deposits form on the surfaces of the heating mediums in the evaporators. In foods, proteins and polysaccharides can create such deposits that reduce the efficiency of heat transfer. Foaming can also create a problem since dealing with the excess foam can be costly in time and efficiency. Antifoam agents are to be used, but only a few can be used when food is being processed.

Corrosion can also occur when acidic solutions such as citrus juices are concentrated. The surface damage caused can shorten the long-life of evaporators. Quality and flavor of food can also suffer during evaporation. Overall, when choosing an evaporator, the qualities of the product solution need to be taken into careful consideration.

5. Objectives.

a. When solids are dried, they obtain a longer best-before date as the water activity in a product is reduced by means of heat. This is done in a controlled environment. The dry product must meet specific requirements for instance with respect to being free flowing or dust free, average particle size and distribution, solubility or active-component preservation. The right drying process determines the quality of our final product and is therefore an important component for cost price.
b. The Agitated Thin Film Drying (ATFD) can simply be described as an indirectly heated continuous dryer. The feed can be varied and may be a solution, suspension, wet cake or paste. Depending on the application and client's wishes, drying in a vacuum is possible.
c. The vertical ATFD has a jacketed cylinder with a closely fitting rotor at the centre. During operation the rotor revolves at high speed. The feed distributor spreads the incoming feed uniformly over the top of the cylinder. The rotor blades pick up the material and spread it in a thin film over a heated surface. The product transforms from solution to a dry powder as end product. The generated vapour rises and are captured in a condenser.
d. Eliminates preparatory steps such as concentration, filtration or centrifugation.
e. Feeds can be processed without pre-concentration or dilution.
f. Mild drying technology because of indirect heating and drying in absence of air.
g. Energy efficient drying technology with a thermal efficiency exceeding 90%.
h. Final product is a fine powder that can often render a pulveriser in a downstream step superfluous.
i. Different rotor configurations possible for a variety of applications.
j. No impact on surrounding soil salinity, groundwater pollution or ecology of river bodies
k. Conservation of water resource through recovery and reuse of treated effluent
l. Recovery and reuse of salt used in the textile dyeing process.

6. Scope.

Thermal separation in an evaporator may be conveniently characterized by the viscosity of the nonvolatile stream the concentrate. Typical viscosity ranges for their useful applications. Unless other considerations are important (thermal stability, fouling tendencies), the terminal viscosity frequently dictates the type of evaporator selected. By far, most evaporation applications involve no viscous (less than 100 centi-poise) fluids. Mechanically agitated evaporators are usually specified for terminal viscosities exceeding 1,000 centi-poise and for heat-sensitive, foaming, or fouling products with lower viscosities Applications. The long tube vertical evaporator offers several advantages like low cost, large units, low holdup, small floor space, good heat transfer over a wide range of services.

Disadvantages include like high headroom, recirculation is frequently required, and they are generally unsuited for salting or severely scaling fluids. They are best applied when handling clear fluids, foaming liquids, corrosive fluids, large evaporation loads. Falling film units are well suited for heat sensitive materials or for high vacuum application, for viscous materials, and for low temperature difference.
Mechanically Agitated Thin-Film Evaporators Thin-film evaporators are mechanically-aided, turbulent film devices. These evaporators rely on mechanical blades that spread the process fluid across the thermal surface of a single large tube. All thin-film evaporators have three major components: a vapor body assembly, a rotor, and a drive system. Product enters the feed nozzle above the heated zone and is transported by gravity and mechanically by the rotor in a helical path down the inner heat transfer surface. The liquid forms a highly turbulent thin film or annular ring from the feed nozzle to the product outlet nozzle.

Only a small quantity of the process fluid is contained in the evaporator at any instant. Residence times are low and gases or vapors are easily disengaged. The blades may also act as foam breakers. Typically about a half-pound of material per square foot of heat transfer surface is contained in the evaporator. A variety of 51 basic or standard thin-film evaporator designs is commercially available today. They are either vertical or horizontal, and can have cylindrical or tapered thermal bodies and rotors. The rotor may be one of several "zero-clearance" designs, a rigid "fixed clearance" type or, (in the case of tapered rotors) an adjustable clearance construction may be used One vertical design includes an optional residence-time control ring to manipulate the film thickness to some extent. The majority of thin film evaporators are the vertical design with a cylindrical fixed-clearance rotor.

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