Evaporation of Difficult Products

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Agitated thin-film evaporation overcomes common problems

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The key to efficient, economical concentration, distillation or devolatilization of a product is selecting the technique best suited to the process.

Tubular evaporators of batch or continuous types, such as forced circulation, rising film and falling film, have been widely used successfully with a variety of materials. However, they have been less successful with heat-sensitive, viscous, fouling or high-boiling liquids.

Degradation due to long residence time, fouling of the heat transfer surface, plugging of tubes, and low heat transfer coefficients and high pressure drops due to high viscosities are common operating problems.

How agitated thin-film technology works

Agitated thin-film evaporation has been very successful with difficult-to-handle products. Simply stated, the method quickly separates the volatile from the less volatile components using indirect heat transfer and mechanical agitation of the flowing product film under controlled conditions. The separation is normally made under vacuum conditions to maximize ΔT while maintaining the most favorable product temperature, and to maximize volatile stripping and recovery.

A variety of thin-film evaporator designs is commercially available today. Thin-film evaporators can be either vertical or horizontal, and can have cylindrical or tapered thermal bodies and rotors.

The agitated thin-film or "wiped-film" evaporator consists of two major assemblies: a heated body and a rotor. The rotor may be one of several zero-clearance designs (wiping), a rigid fixed-clearance type or, in the case of a tapered rotor, an adjustable-clearance construction may be used. The majority of thin-film evaporators in operation today is the vertical design with a cylindrical fixed-clearance rotor.

Within the vertical design evaporator, the product enters the unit tangentially above the heated zone and is distributed evenly over the inner circumference of the body wall by tne rotor (Fig. 2). Product spirals down the wall while bow waves developed by the rotor blades generate highly turbulent flow and optimum heat flux (Fig. 1). Volatile components evaporate rapidly. Vapors can flow either cocurrently or, more commonly, countercurrently, and are ready for condensing or subsequent processing as they leave the unit.

Non-volatile components are discharged at the bottom outlet. Continuous washing by the bow waves minimizes fouling of the thermal wall where the product or

Fig. 1. Operating mechanisms of agitated thin-film evaporation.

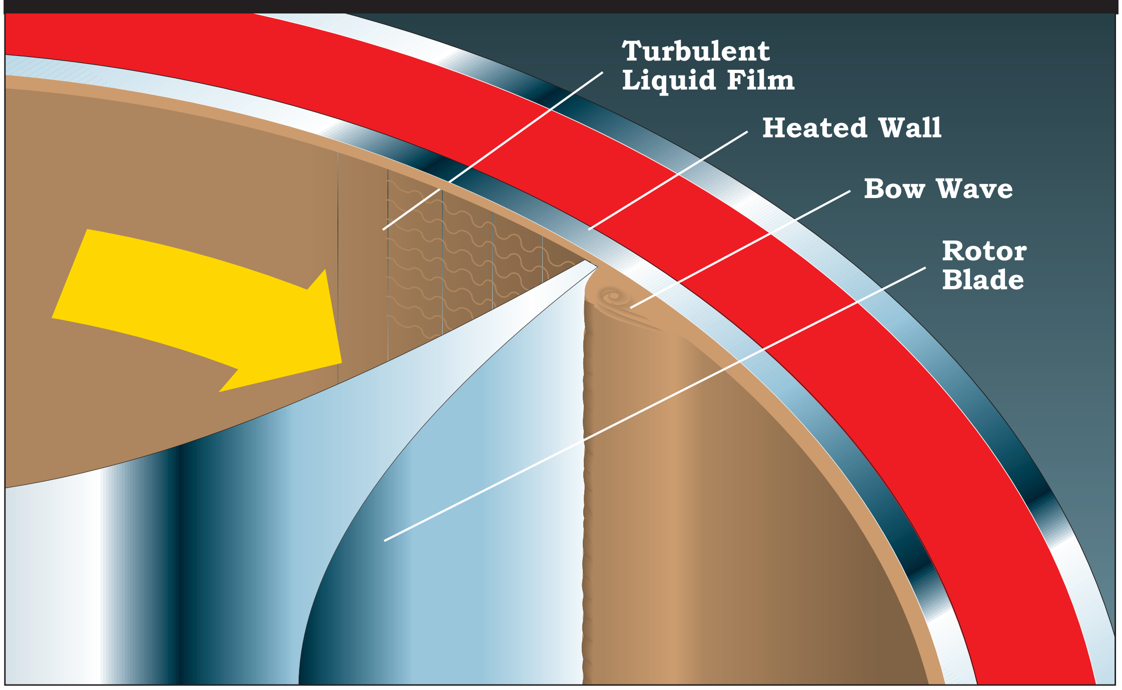
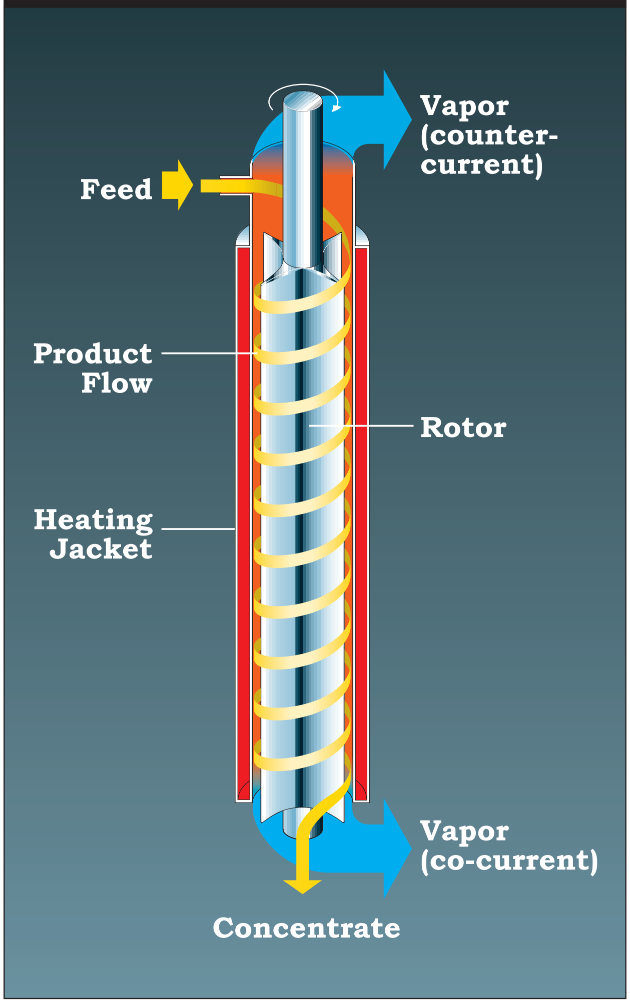


Fig. 2. Vertical agitated thin-film evaporation.



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residue is most concentrated.

The combination of short residence time, narrow residence time distribution, high turbulence and rapid surface renewal permits the agitated thin-film evaporator to successfully handle heat-sensitive, viscous and fouling streams. Low product inventory and operation at near-equilibrium conditions in the process zone are important for highly reactive products. Agitated thin-film evaporators have a wide processing flexibility, and a single system can often be designed to process different products under varied operating conditions.

Agitated thin-film technology is a good choice for processes or products containing vaporizable or partly vaporizable components that must be removed to improve quality, yield/recovery, operating economy or environmental containment.

Sensitive organic chemicals

Agitated thin-film evaporation systems are widely used in the distillation of high-boiling and temperature-sensitive organics. The short residence time and the ability to operate at low internal pressure and without static head (reducing boiling points) results in products of excellent quality and high yields.

When stripping an organic volatile from a fluid, a bottoms with minimum volatile content can be obtained. This is accomplished by a high mass transfer rate in the diffusion of volatiles from the thin agitated film. Many such organic materials are hard to handle because of their high boiling points, high melting points, tendency to foul heat transfer surfaces and the potential for degradation when exposed to heat.

Typical applications for this process include:

■ Purification of chlorinated hydrocarbons, monomers and other chemical intermediates;

■ Purification and separation of components in petrochemicals and in natural oils;

■ Purification and separation of fatty acids;

■ Purification of isocyanates;

■ Purifimprovements of essential oils;

■ Improved shelf life and reactivity for herbicides, insecticides and fungicides.

Concentrating foods, pharmaceuticals

Temperature-sensitive food and pharmaceutical products with the highest quality standards can be successfully concentrated by thin-film processors. Diluted feedstocks can be concentrated to final specification in seconds without recirculation, thereby preserving quality and yield.

As the solids content of the stream increases, temperature sensitivity and viscosity generally increase, creating the need for short residence time. Agitated thin-film technology fulfills these needs while inducing high heat transfer.

Typical applications are:

■ "Drying" of lecithin to 99.5%;

■ Concentration of sugar solutions to 99.9%;

■ Concentration of enzymes, vitamins and proteins;

■ Concentration of fruit and vegetable purees;

■ Concentration of cheesebase;

■ Concentration of biological solutions;

■ Stripping of solvents from vegetable and plant extracts;

■ Removal of water and solvents from fermentation broths (e.g., antibiotics).

Resource recovery

Agitated thin-film evaporation systems are used extensively in the purification and recovery of resources such as solvents and oils. The ability of agitated thin-film evaporation systems to handle difficult streams and their flexibility make them well-suited to this application.

Typical applications for purification and recovery include:

■ Recycling solvents from paints, greases, oils and resins;

■ Recovery of organic products from tars and residues;

■ Recovery of acetic acid from waste residue streams;

■ Vacuum distillation and purification of used motor oils;

■ Distillation and recovery of pure glycerine from crude streams;

■ Volume reduction of inorganic salt

streams in the nuclear industry;

■ Recovery of polymer in plastic-coated paper recycling.

Devolatilization of viscous products

For many products, viscosity increases rapidly as concentration rises or polymerization reactions near completion. This is an area where mechanically agitated, transported thin-film processors provide a significant advantage.

Specially designed rotors make it possible to transport materials with viscosities of up to 15 million cp through the evaporator. Agitated thin-film evaporators also provide higher heat and mass transfer efficiencies for viscous fluids than are possible with other equipment, such as flash pots and vented extruders.

Typical applications for devolatilization are:

■ Removal of reactants, solvents and monomers to ppm levels from engineering and other thermoplastics;

■ Removal of monomers and volatile solvents from acrylic resins;

■ Removal of free phenol and water from phenolic resins;

■ Reaction and removal of caprolactam from Nylon 6;

■ Removal of monomers from silicone polymers;

■ Reaction and removal of condensates from polyesters.

The mechanical and process technologies for mechanically agitated thin-film evaporation systems are proven and reliable and should be considered whenever an application proves difficult for conventional tubular evaporators. Frequently a tubular and agitated thin-film evaporation combination is the optimum solution.

■ To receive more information on agitated thin-film evaporation—LCI Corporation, Charlotte, NC.

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