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Wipe Film Evaporator

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1. INTRODUCTION:

The wiped film evaporator is the ideal system for continuous processing of heat sensitive, viscous and/or fouling products equivalent to distillation column used in process industry. The purpose is to concentrate non volatile solute such as organic compound, suspension of solid in liquid like used lube oil. In this system the vapor is by-product and non-proceeded liquid is residue can re installed along with feed. The operation principally associated with purifying a multi component liquid.

It consists of a single evaporation shell in one or two pieces in construction fitted with a mechanical rotating device called rotor. The rotor has the wiper arrangement fixed on the outer periphery of rotor in such way that they ensure a uniform generation of liquid film over the inside surface of shell. The outer portion of evaporating shell provided with the jacket or limpet coil arrangement to hold the heating fluid. The utility fluid can be handled based on the availability some users preferred to use steam and some preferred to use hot oil or thermic fluid.

Some wiped film evaporators also consist of the condenseravailable in the mid of rotor. It is U shape in construction fixed with the lower shell and inserted from the bottom portion of vessel. The main principle of condenser is to condense the vapor generated during the operation to convert it into distillate.

Whereas non-condenser evaporators, the vapors produced rises upwards, counter-currently to the liquid and, when required, pass through a mist eliminator mounted in the top section. Outlet portion in this type of model from top to large size opening/nozzle have very less pressure drop connected with individual condenser to condensation of vapor.

All type of evaporator required the vacuumed pump in operation, size can be define based on requirement. The vacuumed required in the range of 0.5 mbar is possible through it. The vacuum pump connected in system at last point in the system so that complete system will be in vacuumed and vapors can flow through the vessel to the condenser. The non-condensate vapors reflux provided to the condenser for condensation.

The thermal separation of a mixture a thin film is produced at the heated wall. A distributortray on the rotor distributes the liquid evenly across the periphery. The rotational motion of distributor splashes the liquid over the shell inside wall and then it goes down gradually through the wiper blade which create 0.5 mm liquid thin film over the shell and excessive liquid scraped from the place to downwards. Because of gravity the liquid flows down to the bottom tray and collected via residue nozzle to refeed along with feed.

The concept for flow in the wiped film evaporator assumes that prior to each rotor blade a bow wave is formed. In the gap between the rotor blade and the heating surface, fluid is supplied from the bow wave of a highly turbulent area with intense heat and mass transport. This results in a good heat transfer performance even with viscous products. In addition, the

formation of deposits is avoided, and the intensive mixing also protects temperature-sensitive products from overheating.
Another important task of the rotor is to stabilize the liquid film on the heating surface at high evaporation rates. On the one hand evaporation in the area of nucleate boiling is possible without ruptures of the film. On the other hand, the liquid film is pressed against the heating surface by the centrifugal force.

Key factors in design:

Heat transfer:

Heat transfer is the major principle in this process for evaporator. The continuous flow of heat required across the evaporator from outside surface in terms of steam or thermic fluid in the form of hot oil which flows to the jacket. This heat get transfer to the thin film generated inside the shell. The heat transfer depends on the thickness of shell to be used in design and it is decided based on the stress value of material more the thickness more heat required. But thickness of any system needs to control for better heat transfer rate pertain to low spent on heating fluid.

Vapor separation:

Here the system rotor play an important role, the rotor rotates and form the liquid film inside the shell. During this operation, the liquid droplets form which carries through the evaporator system and lower the vaporization efficiency. Also, the wiper continuous in operation engage with shell inside diameter can erode the metal that means the metal articulation may occur in residue fluid and reduce the life of vessel. Therefore, selection of material and entrainment separator play very important role to control the cost.

Energy efficiency:

The equipment should be designed to use the beast use of available energy which implies the most economical energy input. For example, steam economy per Kg of solvent evaporate to per Kg of stem consumption. Production of stem is directly proportion to the running of boiler house.

Factor affecting the rate of heat transfer:

- The rate at which the heat can be transfer to fluid.
- Quantity of heat required to evaporate the per KG of liquid.
- Maxm. Allowable temperature of liquid.
- Inside vacuumed pressure at which evaporation take place.
- Changes occur during the process.

Practical consideration of evaporator:

- The allowable temperature for evaporator is not more than the 150 C.
- The selection of material should be of having high heat transfer coefficient for evaporator section for better efficiency.
- Viscosity and density of material play an important role in evaporation technique therefore dissolvent material to be control in fluid.
- Some fluid is having the formation of foam which make separation process difficult.

Technique of evaporation for highly sensitive material:

- The retention time of give food particle should be consider where the large volume of liquid into which incoming feed in mixed.
- The average recantation time can be obtained by dividing the volume of evaporator by the feed rate, but substantial proportion of liquid remain.
- Heat sensitive material a proportion may deteriorate and lead to general lowering of product quality.

Product characteristic for critical operation:

Heat sensitivity:

Many chemical and resign are heat and temperature sensitive which required either short residence time or lower heating temperature. This can be achieved by controlling the flow of produce or controlling the rate of evaporation. Minimizing the time in evaporator to reduce the boiling temperature by reducing the pressure in evaporator. Reduction in pressure and temperature reasonably reduce the heat transfer process.

Fouling:

Fouling in heat transfer surface reasonably cause by solid in feed which lead to degradation of product which lead to slow buildup of film on heat transfer surface which cause gradual reduction heat transfer coefficient. Which need to clean the vessel inside by shut down which result in production down time.

Foaming:

Foaming reduces the boiling intensity of liquid on evaporator surface, It varies from the small amount of unstable foam to the large amount of foam. The small amount of foam can break easily but large amount is difficult to break. The foaming can minimize by special design of feed inlet system. IT can also control by adding some chemical inhibitor.

Solid:

The solid particles present in liquid can chock or plug the opening which lead the loss of heat transfer in turn reduce in heat transfer rate and requiring down time for cleaning. Slid increase the fouling effect. The increase of slid may increase the concentrate viscosity which affect the overall heat transfer coefficient, reducing capacity.

2. MATERIAL OF CONSTRUCTION:

The material of construction plays an vital role in system, selection of evaporator material is very important because it not only affect the material cost but the heat transfer coefficient is depend on the type of material. Also, the corrosion and erosion of material is dependent on the type of material being selected.

Benefit of WFE:

- High heat flux
- Low residence time
- Low pressure drop allowing operation down to 1 mbar absolute
- Robust design minimizing maintenance costs
- No dead zones and no liquid hold-up
- Easy to clean suitable for application according to GMP guidelines

Main application:

- Evaporation without mass transfer.
- Moderate evaporation ratio
- Viscous product
- Feed stream containing solid product
- High evaporation ratio
- Stripping

Description of the Setup for fish oil processing:

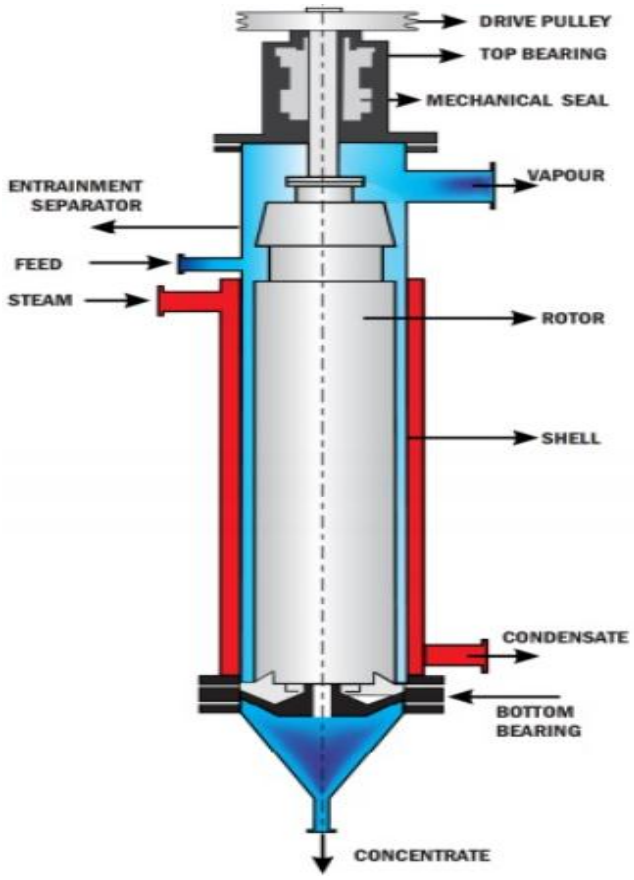
There is huge demand in fish oil byproduct therefore world production of fish oils reaches millions of tons, of which 88.5% is destined for aquaculture, and remains are destined to industrial production, human consumption and development of pharmaceutical products and dietary supplements.

In the modern human diet, there is major sources of Long-Chain Polyunsaturated Fatty Acids (LCPUFAs), specially omega-3 fatty acids. Fish oils are used as healthy additives and ingredients in many value-added food products or health-food capsules, often sold at high prices. This required a complex separation process which can be carry out by using the WFE equipment in series form.

The system proposed in the following proposal is comprised of four (4) Wiped Film Evaporators with internal condensers in series. First WFE will be used to remove lights in the feed and will operate at atmospheric pressure. The second WFE will be run at moderate vacuum and remove the balance of the lights. System will be arranged in such a way that feed would enter first WFE and distillate from last in series will be removed. Similarly, residue (Non separated oil) again feed to second WFE like a reflux for better mass transfer and reprocessing and so on for allin total, raw feed stream will be split in 5 streams where operating temperatures, vacuum levels, feed rates can be adjusted.

The first two WFEs will share a hot oil heating loop and a cooling unit for the internal condensers. The second WFE will have a dedicated vacuum pump. The last two WFEs will have dedicated vacuum pumps and hot oil loops for jacket & bottoms line heating but will share a cooling system for internal condenser & condensate temperature control. A common heating unit with four (4) independent heating loops will be custom made. Process and utility valves will all be manually operated ball or gate valves suitable for appropriate temperatures and pressures.

Condenser cooling & distillate line temperature control will be provided in such a way that there will be three cooling temperature loops. Two different configurations are envisaged to accomplish this. One way will be to go with three dedicated systems where first two WFE will have a common cooling loop for their



condensers and distillate lines. One cooling unit will be used to control high temperature in EV-400 and EV-500 condensers & distillate lines. Alternate route could be to use two cooling units will be used for cold traps exclusively.

In all above proposed set up recommended for separation of byproduct from the fish oil the main advantage is we can prepare the pilot or lab scale plat for testing purpose with the help of those equipment, or we can start with the production in small scale industry. The initial expenditure is high but it can actually help to check the process guarantee before large scale production or scale up of this unit.

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