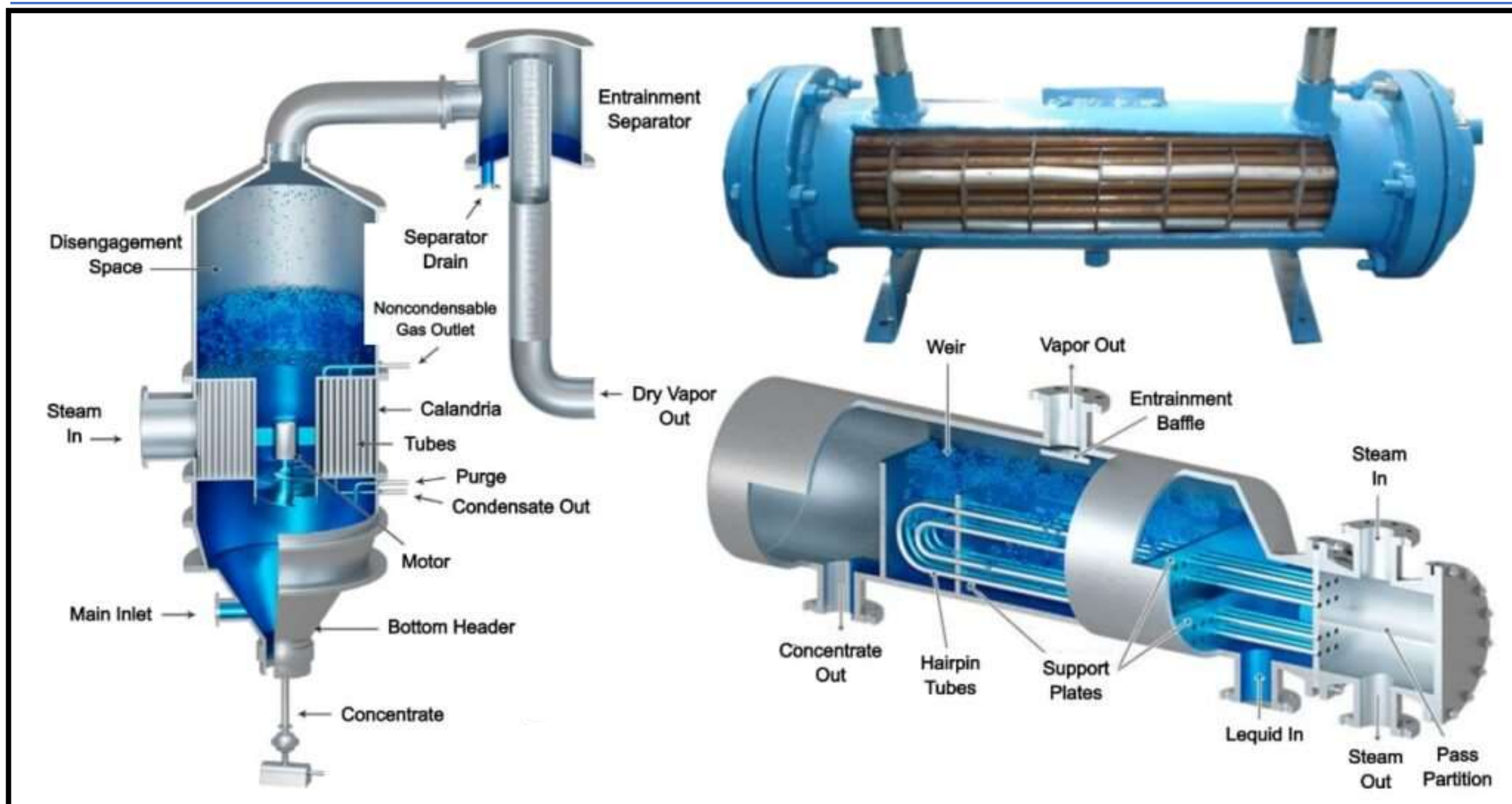




SINGLE AND MULTI-EFFECT EVAPORATORS

Table of content

1. Introduction to evaporators

2. Types of evaporators

3. Single Effect evaporators

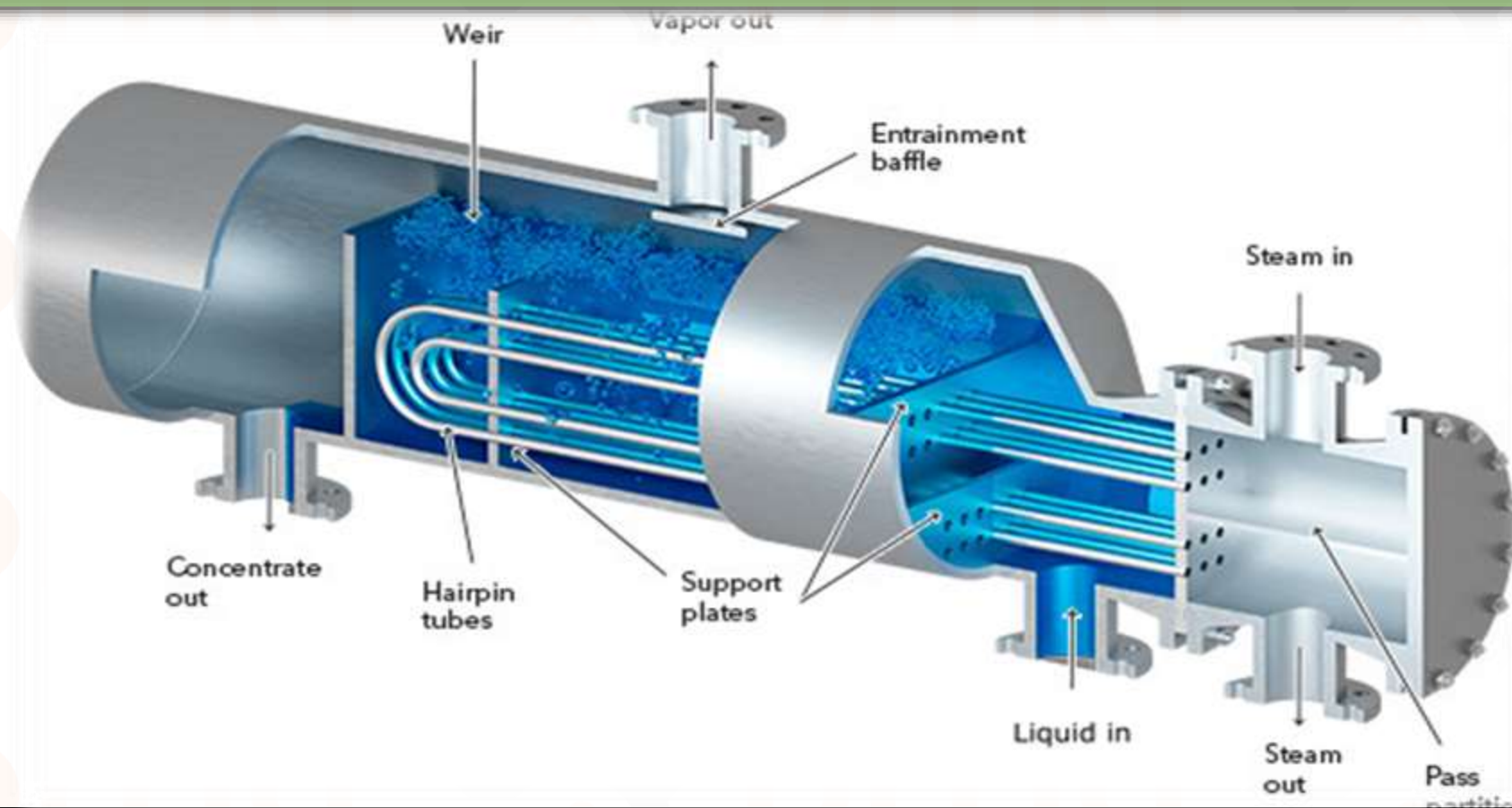
4. Multi Effect evaporators

5. Difference between Single and Multi-effect evaporator

6. Conclusion

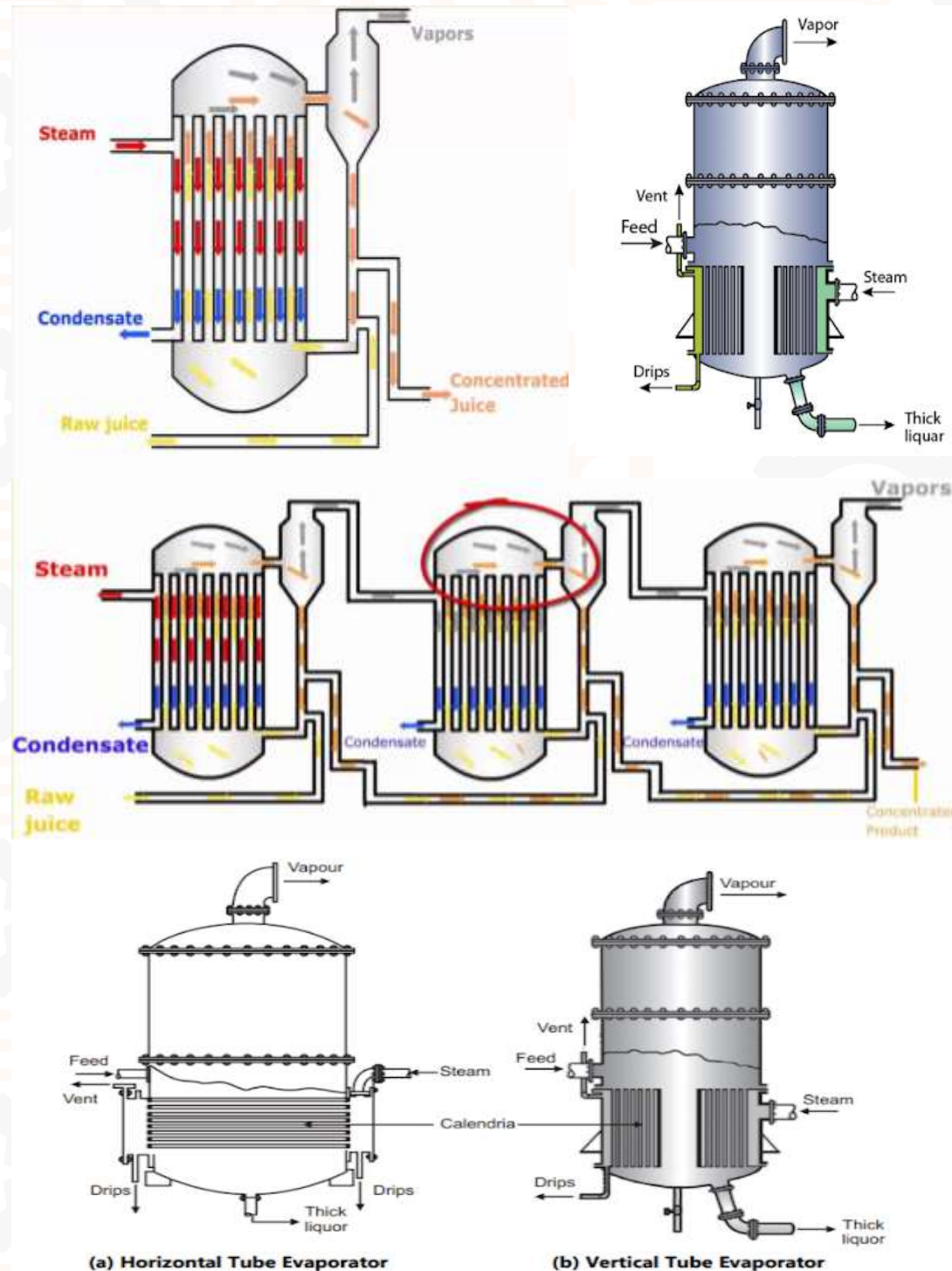
7. Reference

1. Introduction to evaporators



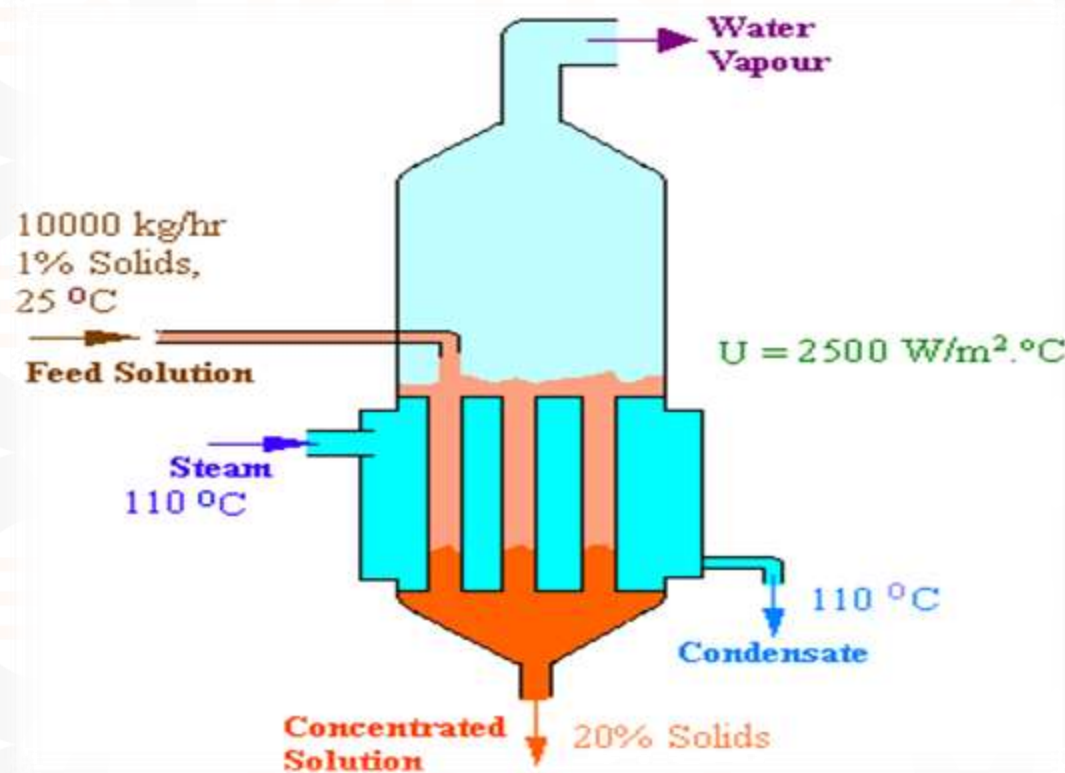
- An evaporator is a machine that is used to convert liquids into a gaseous state through the transfer of heat.
- The raw material which has been fed into the evaporators passes through heated tubes and the heat gets evaporates the water within the raw material.
- Widely used in processing industries, work best in low-temp applications in food, pharma industries, and in effluent treatment.

2. Types of evaporators



1. Single-effect evaporator
2. Multi-effect evaporator
3. Horizontal-type natural evaporator
4. Vertical-type natural evaporator
5. Long tube vertical type
6. Falling film type
7. Forced circulation type
8. Agitated Film Evaporator
9. Open pan solar Evaporator
10. Open cattle or pan

2.1 Factors affecting evaporation process

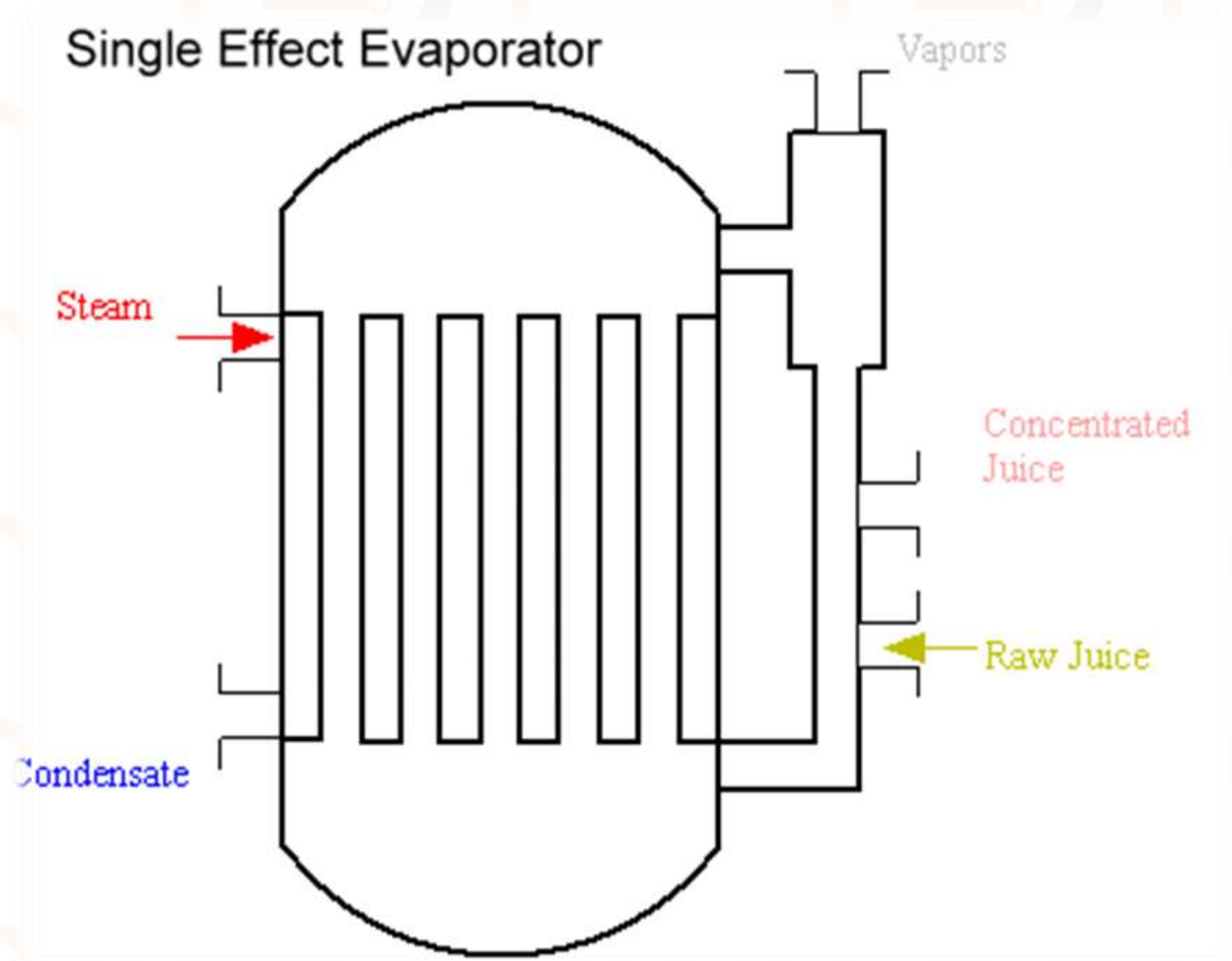


The rate of evaporation in evaporators depends upon the following factors:-

1. Rate of heat transfer to the liquid.
2. Quality of heat which is required to evaporate each kg of water.
3. Max allowable temp. of the liquid.
4. Pressure of evaporation.
5. Changes that may occur in the food during evaporation.

3. Single effect evaporator

- The Liquid enters the bottom of the tubes and rises.
- Steam enters from the side and it goes down in tubes and makes indirect contact with the liquid to give up its heat.
- Steam condenses and leaves as condensate.
- Liquid heats rising to the top, vapors form, and both the heated liquid and vapors, enter a chamber on the side called the separator.
- The liquid leaves from the top and again enter the bottom of the evaporator section and after it condenses it is be removed from the section from the side as a concentrated liquid.



3.1 Functions of single effect evaporator

The single effect evaporator has two functions

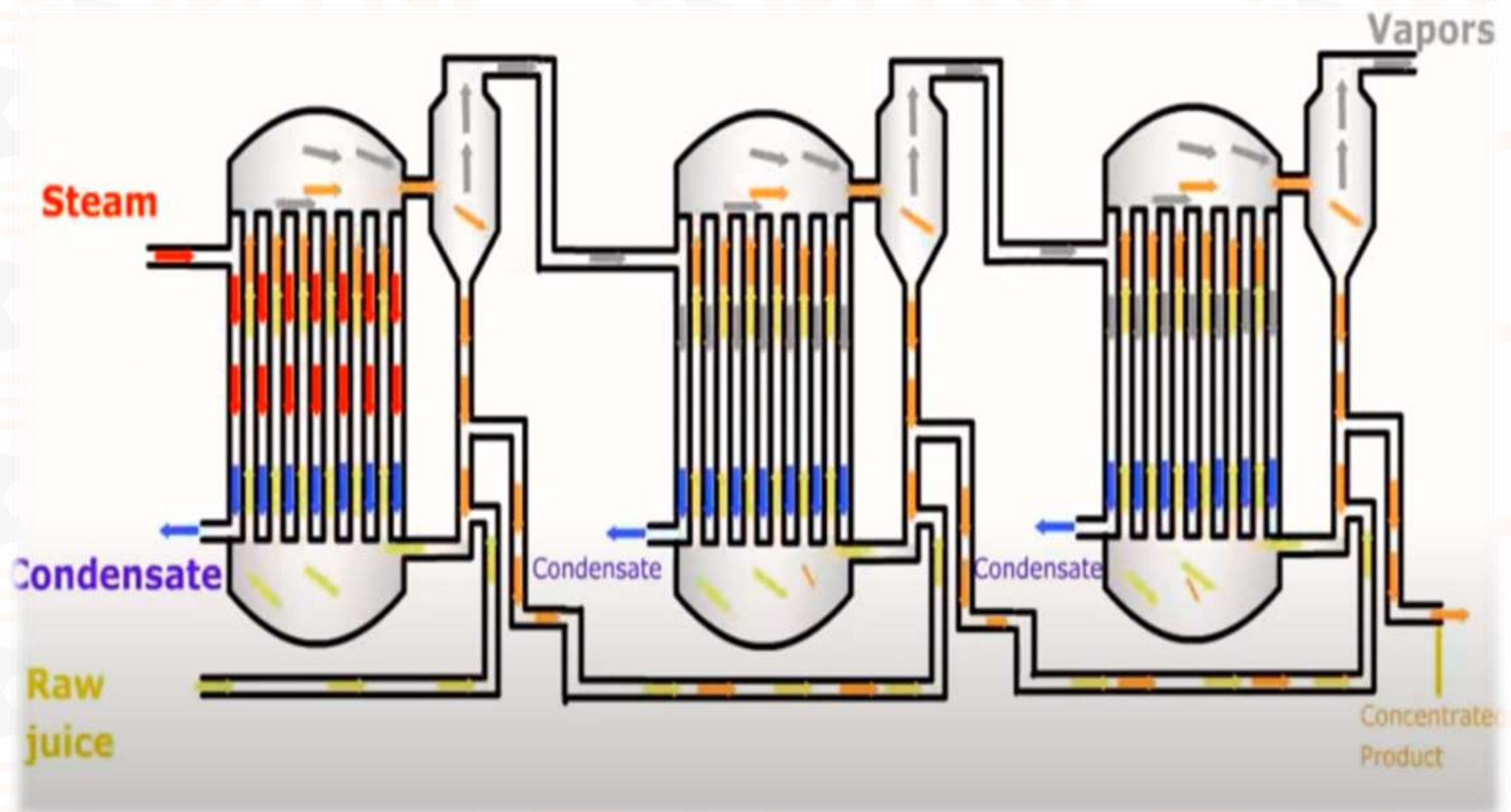
- To exchange heat and
- To separate the vapor that has formed from the liquid.

Further practical considerations in evaporators are:-

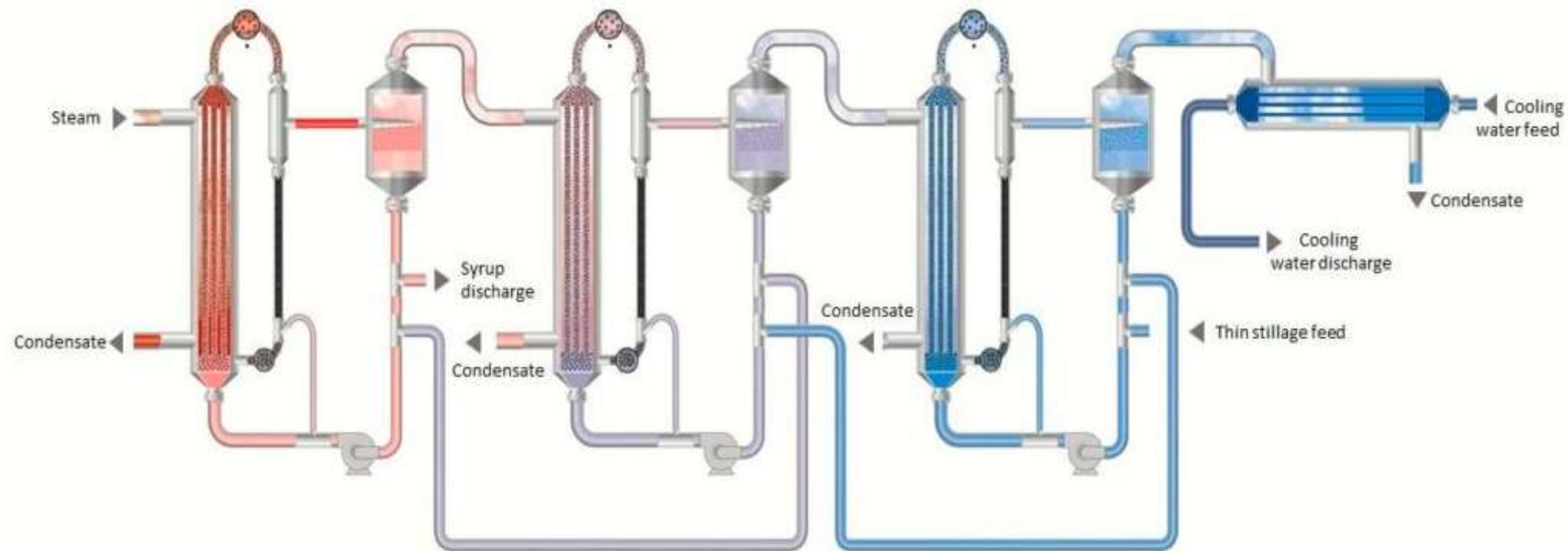
- maximum allowable temperature, which may be substantially below 100°C.
- Promotion of circulation of the liquid across the heat transfer surfaces, to attain reasonably high heat transfer coefficients and to prevent any local overheating.
- Viscosity of the fluid which will often increase substantially as the concentration of the dissolved material increases.
- Tendency to foam which makes separation of liquid and vapor difficult

4. Multi-effect evaporator

- Steam enters the first effect and condensate leaves at the bottom.
- The liquid enters and rises in tubes as it heats to the top.
- Some of the liquid turns into vapor and the rest is concentrated liquid which moves down the vapors where they leave.
- Rather than discharging them into the atmosphere, vapor will enter the second effect.
- Steam enters only in the first effect, the rest of the heating in the second, third effect, and so on is done by the vapors that are been discharged from the previous effect.
- Steam is the focus point as it needs to procure vapor in every effect.



4.1 Construction of MEE



- Consists of a sequence of heat exchangers (vapor-liquid separators), which are used widely in industries to achieve evaporation and obtain desired concentration by using an efficient amount of steam or hot water for evaporation.
- Mostly, evaporators have tubular heating surfaces. The tubes may be horizontal or vertical, long or short and the liquid may be inside or outside the tubes
- Evaporation is normally stopped before the solute starts to precipitate in the operation of an evaporator.

4.2 Features of MEE

Some salient features are as follows:-

- An apparatus that efficiently uses the heat from steam to evaporate water.
- Water is boiled in a sequence of vessels, each of which is at a lower pressure than the last.
- As the boiling point of the water decreases with pressure, the vapor produced in one vessel can be used to heat the next vessel.
- Only the first vessel requires a source of external heat.
- Evaporators with more than four to five effects are rarely practical.

5. Single vs Multi-effect evaporation

Items	Single-effect Evaporator			Multiple-effect Evaporator		
Energy consumption	In a Single-effect evaporator, the energy consumption is much higher than others, 1-ton of water will consume 1 ton of steam in theory.			In a Multiple-effect evaporator, the energy consumption will be less comparatively.		
Floor space	Small space is required			Large space is required		
Energy source	Steam & Power, Need steam pipe network & boiler.			Steam & Power, Need steam pipe network & boiler.		
Automaticity	Semi-automatic			Fully automatic operation, continuous evaporation.		
Model	Single effect	Double effect	Triple effect	Four effect	Five effect	Six effect
Water evaporation capacity t/h	0.5-2	1.2-5	3.6-20	12-120	20-180	80-900
Vapor pressure	0.05-0.1	0.06-0.08	0.06-0.08	0.06-0.08	0.09-0.04	0.06-0.08
Vapor consumption/evaporation capacity (kg)	1.13	0.38-0.57	0.28-0.38	0.23-0.28	0.23	0.2
Evaporating Temperature °C	48-110	48-110	48-110	48-110	48-110	48-110
Circulating cooling water consumption/evaporation capacity(in put water 30°C, outgoing water 40°C.	56	18-28	14-18	12-14	10-12	9-10

6. Conclusion

- Water and any other liquid evaporation processes can take place at any temperature, but the process becomes faster with increases in temperature.
- At elevated temperatures, the molecules of a liquid or water vibrate with increasing intensity as elicited by the prevalent temperature.
- Using a multiple-effect evaporator make the evaporation process more economical. The same as Parallel feed systems, they help in increasing the overall production rate of low viscous products.
- Condensate of the vapor chest can be used to pre-heat the incoming feed.

7. Reference

1. <https://www.shachiengineering.com/evaporators-types-and-uses/>
2. <https://www.sciencedirect.com/topics/engineering/evaporators>
3. <https://www.slideshare.net/SumerPankaj1/single-and-multiple-effective-evaporator-mee>
4. <https://www.slideshare.net/PavelRout/multiple-effect-evaporator-242774077>
5. <https://nzifst.org.nz/resources/unitoperations/evaporation1.htm>

About PMG Engineering

We deliver End-to-End Engineering Design and Construction Management Projects in Food and Beverage Industry.



Meeting Global Benchmarks

In ENGINEERING DESIGN and PROJECT MANAGEMENT
for FOOD and BEVERAGE Industry with SINGLE POINT ACCOUNTABILITY

Process Engineering | Project Management | Mechanical | Electrical | Automation | Food Safety

People Delivering Results

Safe-by-Choice. First Time Quality. Maximize Value.
Objectivity. Ownership. Reliable and Trustworthy Business.

