Unit Operations in Dairy Processing: separation, standardization, thermal processing including pasteurization, homogenization, concentration.

Learning Objectives

- Basic processes and equipment used in manufacture of milk and milk products
- Key objectives (outcomes) of each unit operation

Flow through pipes and valves using pumps

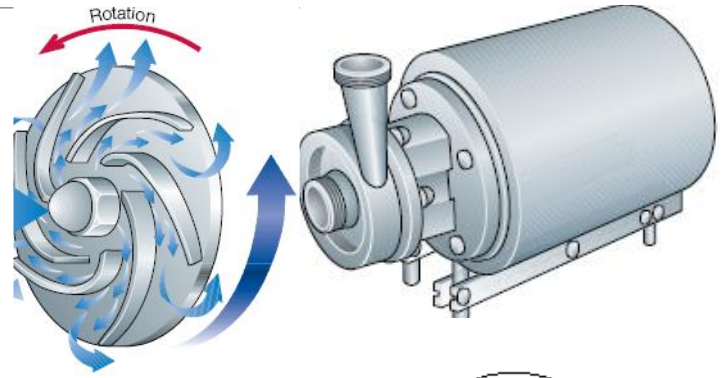
Goal: Transfer of milk from one unit operation to another unit operation

- Energy (pressure)
- Frictional loss (walls, directional changes)
- Low velocity flow (laminar fluid flow profile (no mixing)
- High velocity flow (Turbulent fluid flow profile (Mixing)

Pumping

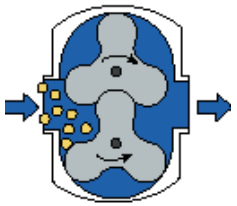
Centrifugal (kinetic) pumps

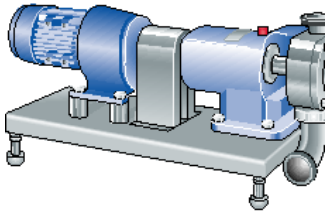
- Transfer of energy via a high speed impeller
- High volume, low pressure, non-pulsating



Positive Displacement pumps

- Physical transfer of a volume of liquid from one position to another
- Low volume, high pressure, metered flow, self priming
- Rotary, piston, lobe, gear, screw



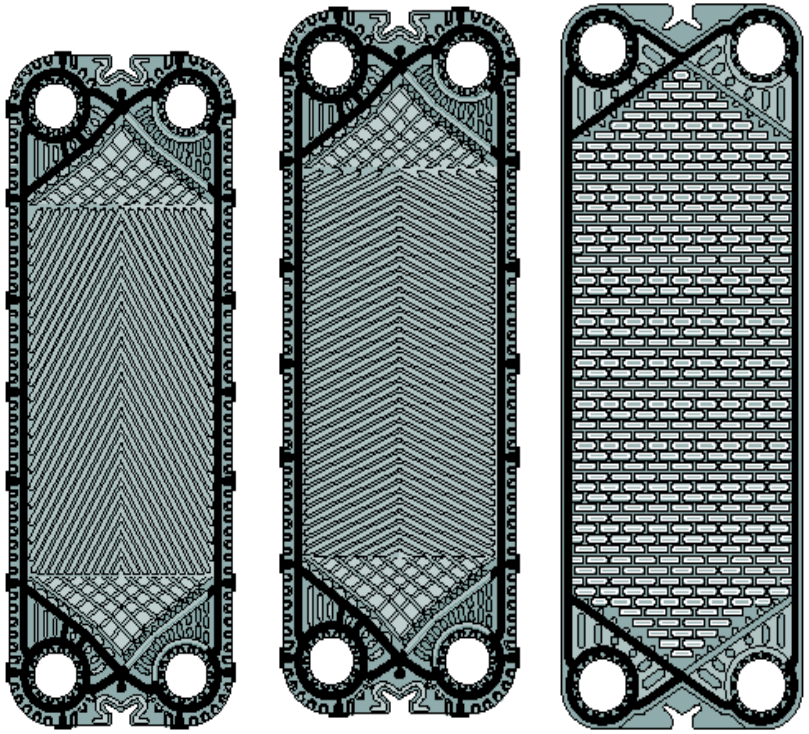


Heat Transfer

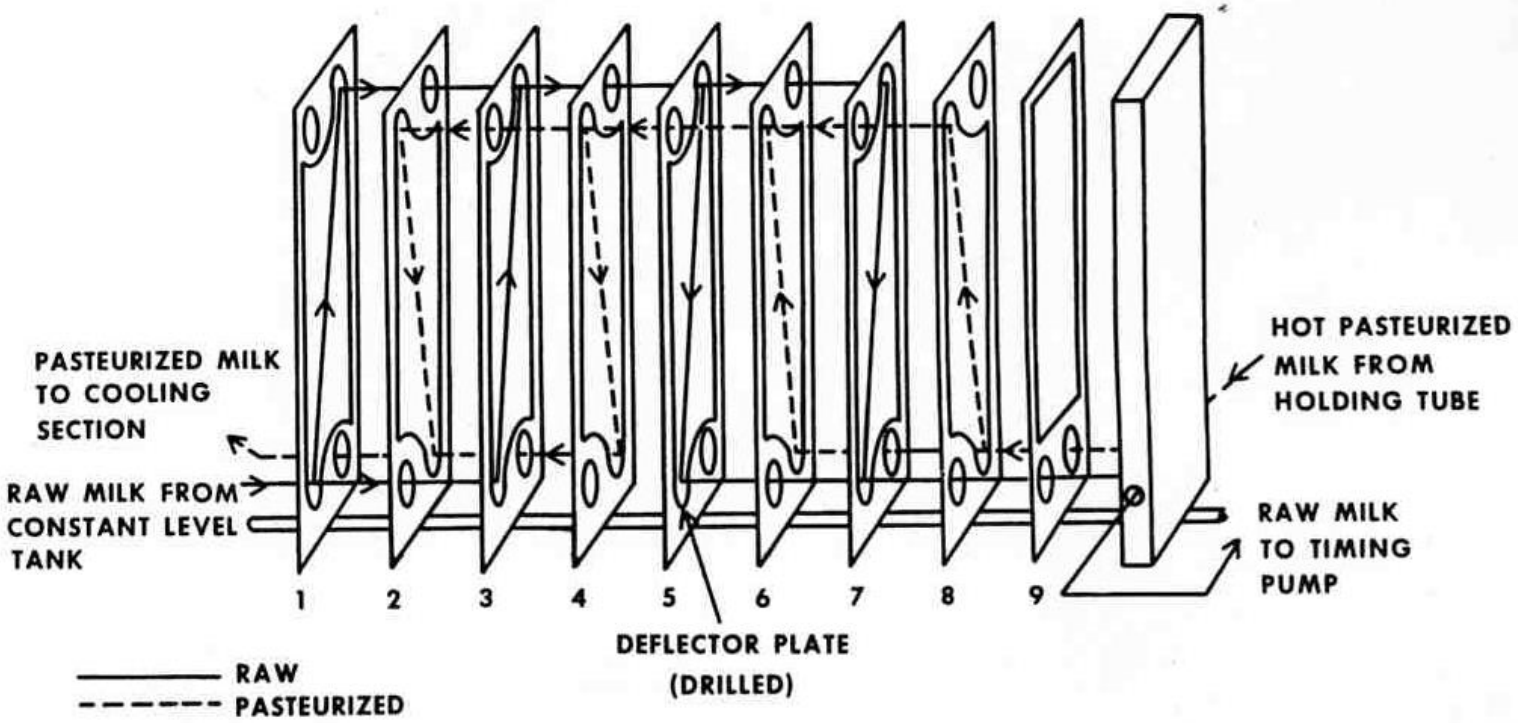
Goal: add or remove energy

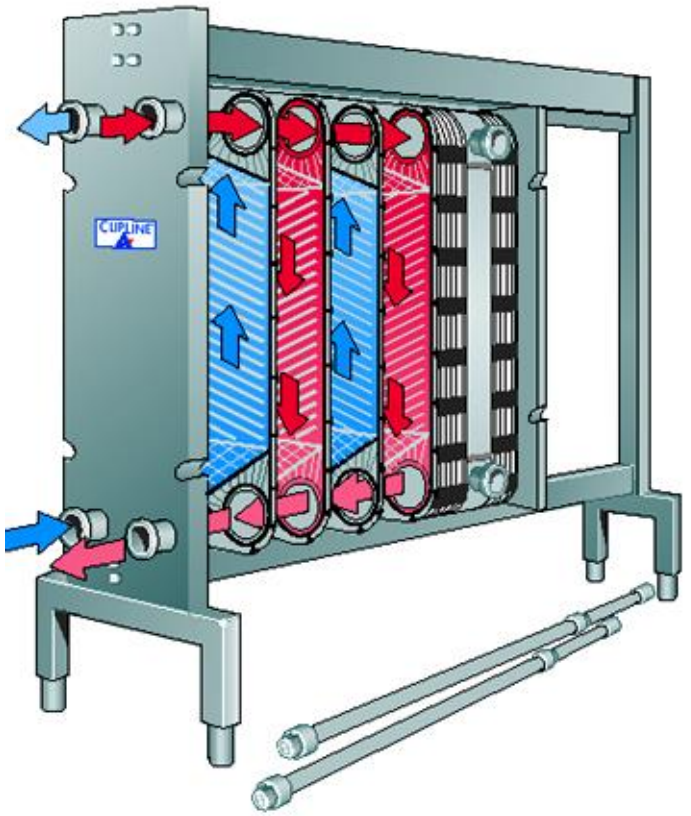
Conduction – particle to particle

Forced Convention – Turbulent mixing



Heat Exchanger(heating, regeneration, cooling sections)





Centrifugal separation

Goal: Accelerate the natural separation due to density differences and size

- Physical separation of a heavy (more dense) phase from a lighter (less dense) phase (Fat globules are less dense than other components of milk)
- Larger the particle the better the separation (all else being equal)
- The lower the viscosity the better the separation (warm vs. cold milk separation)

Cream Removal by Centrifugal Separation

(Fat globules are less dense than other milk components)

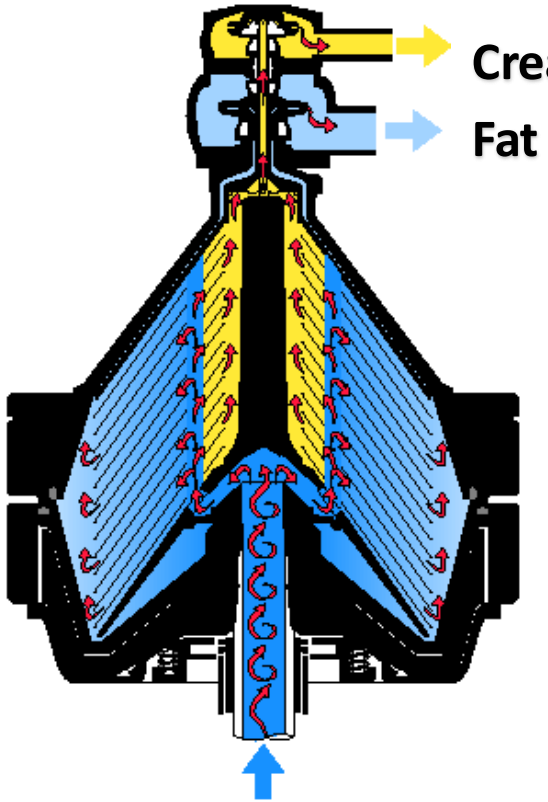


Fig 6.2.1 Gustaf de Laval, inventor of the first continuously working centrifugal separator.

Feed: "Unstandardized "milk

Standardization

- adjustment of fat content

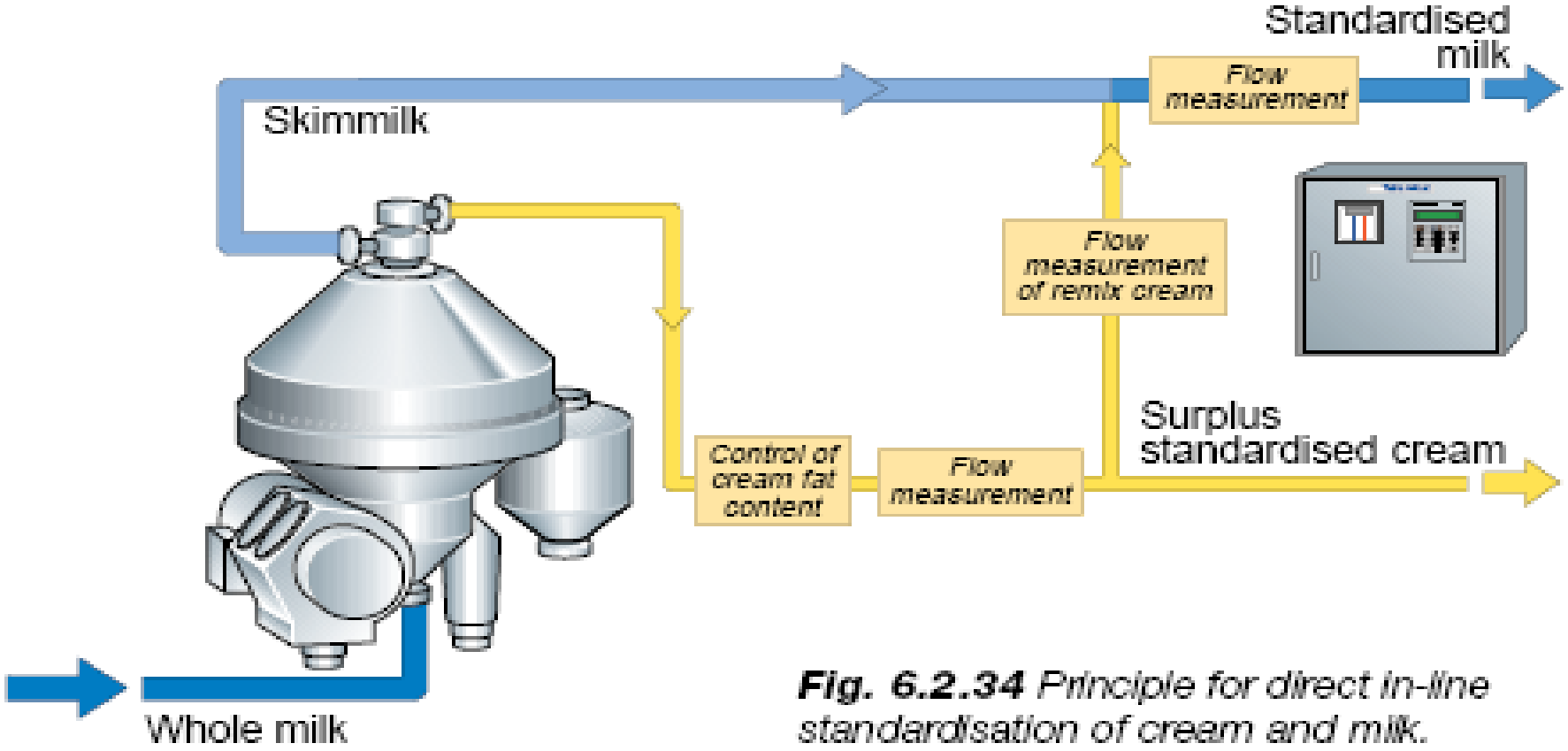


Fig. 6.2.34 *Principle for direct in-line standardisation of cream and milk.*

Dairy Processing Handbook/chapter 6.2

Blending & Mixing

Typically defined as combining miscible liquids or dispersing a powder or solid into a liquid.

Steps:

Wet, sink, disperse, solubilize

Common Issues

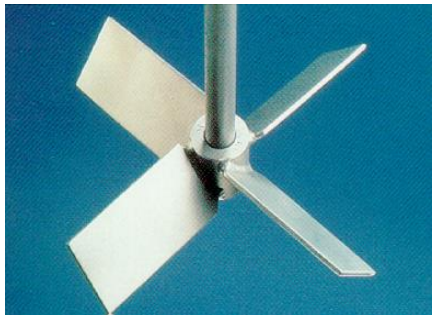
Using an existing tank whose agitator was not sized for the process

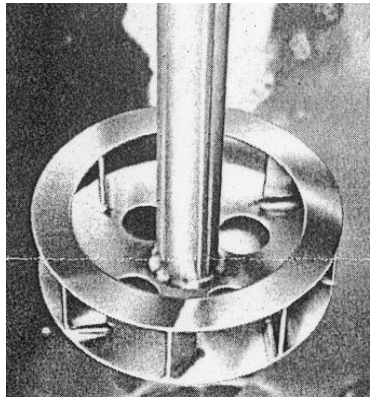
Using the wrong impellers

- Sweeps do not provide adequate flow or draw down
- Radial impellers could leave solids out at the edges

Incorrect mixer positioning

Mixing Equipment



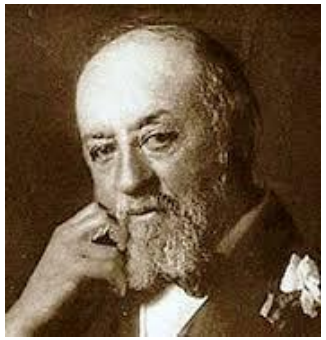


Pasteurization – A Definition

" the process of heating *every particle* of milk and milk products to the *minimum required temperature* (for that specific milk or milk product), and *holding it continuously for the minimum required time* in equipment that is *properly designed and operated*"

Louis Pasteur (1822-1895)
Wine and Beer spoilage prevention by heating

THE FIRST INFANT MILK DEPOT IN AMERICA.
Nathan Straus Pasteurized Milk Station, East Third Street Pier, New York City, 1893.



Nathan Strauss

Pasteurization - Objectives

- render milk safe and nutritious by killing all microbial pathogens that may be present in the milk and could be transmitted to people
- improve the keeping quality of milk

It does not kill all non-pathogenic microorganisms and will not inactivate some heat stable bacterial enzymes.

Does Pasteurization Improve Food Safety?

See: Cifelli et. al, 2010

1938, milk products were the source of 25% of all food and waterborne illnesses that were traced to sources, but today they account for far less than 1% of all food and waterborne illnesses.

Table 1. Regulatory, Medical, Educational, and Public Health Authorities That Have Issued Position Statements That Warn of the Risks of Raw Milk Consumption

American Academy of Pediatrics
American Medical Association
American Veterinary Medical Association
Association of Food and Drug Officials
Centers for Disease Control and Prevention
Health Canada
International Association for Food Protection
National Association of State Public Health Veterinarians
National Environmental Health Association
US Food and Drug Administration
World Health Organization

Time/Temperature Relationships

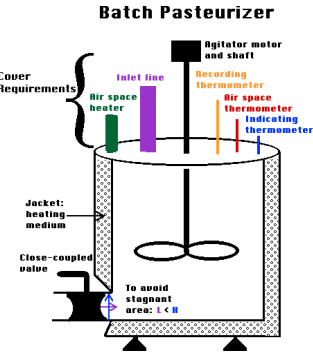
Dependent upon many factors including:

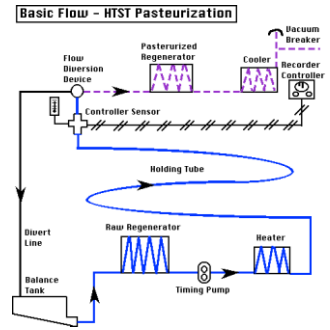
- Total bacterial population
- Nature of the medium (acidity, salt, sugar conc.)
- Type of organism

Minimum Time/Temperature Relationships for Pasteurization of Milk

Fluid Milk Processing (adjustments related to protective Effects of additional ingredients in other formulations)

Temperature	Time	Process
145 F	30 minutes	Vat (LTLT)
161F	15 seconds	HTST





Target organisms: Mycobacterium tuberculosis and Coxiella burnetti, (5 log reduction)

Grade "A"

Pasteurized

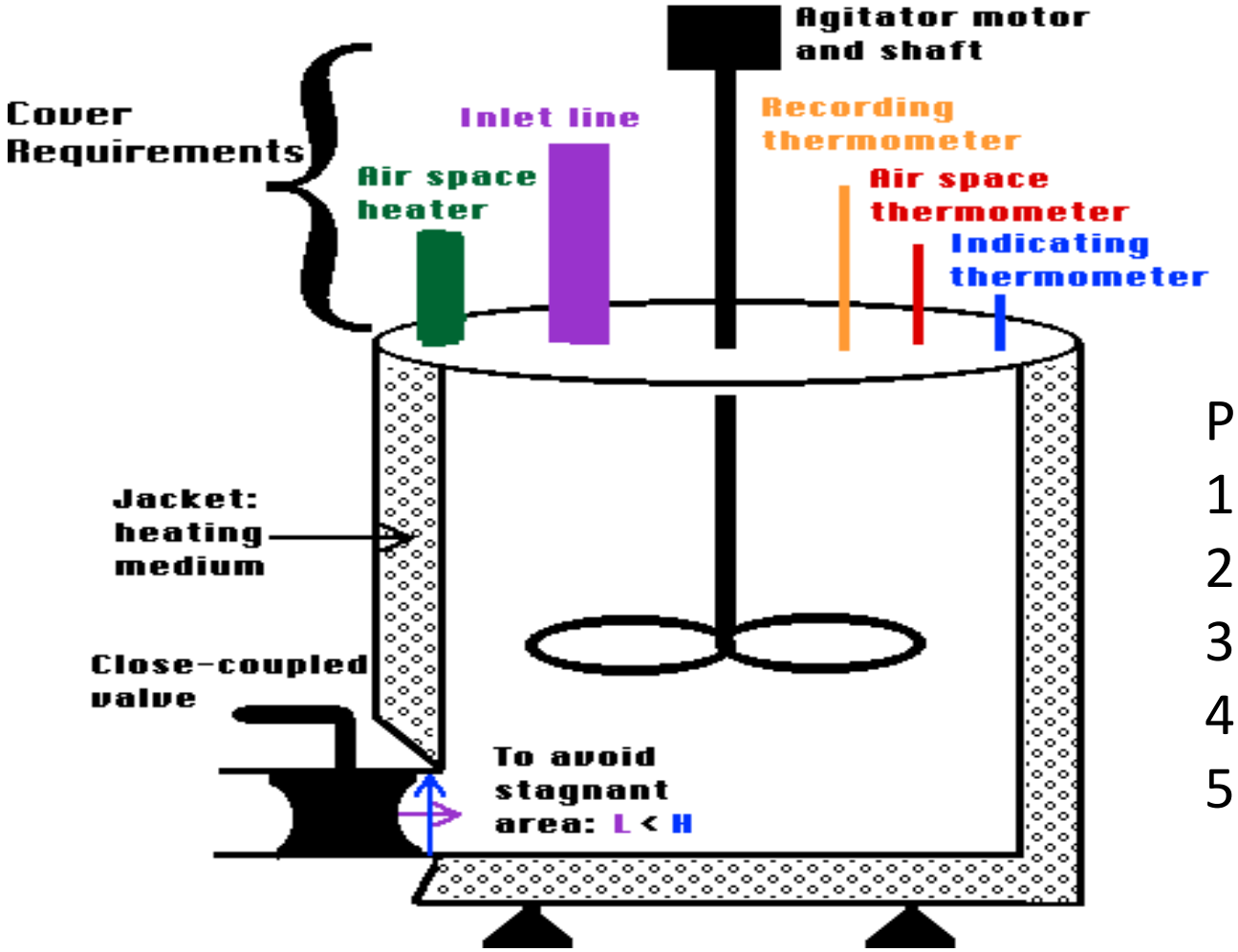
Milk

Ordinance

(Includes provisions from the Grade "A" Condensed and Dry Milk Products and Condensed and Dry Whey--Supplement I to the Grade "A" PMO)

2017 Revision

U.S. Department of Health and Human Services
Public Health Service
Food and Drug Administration

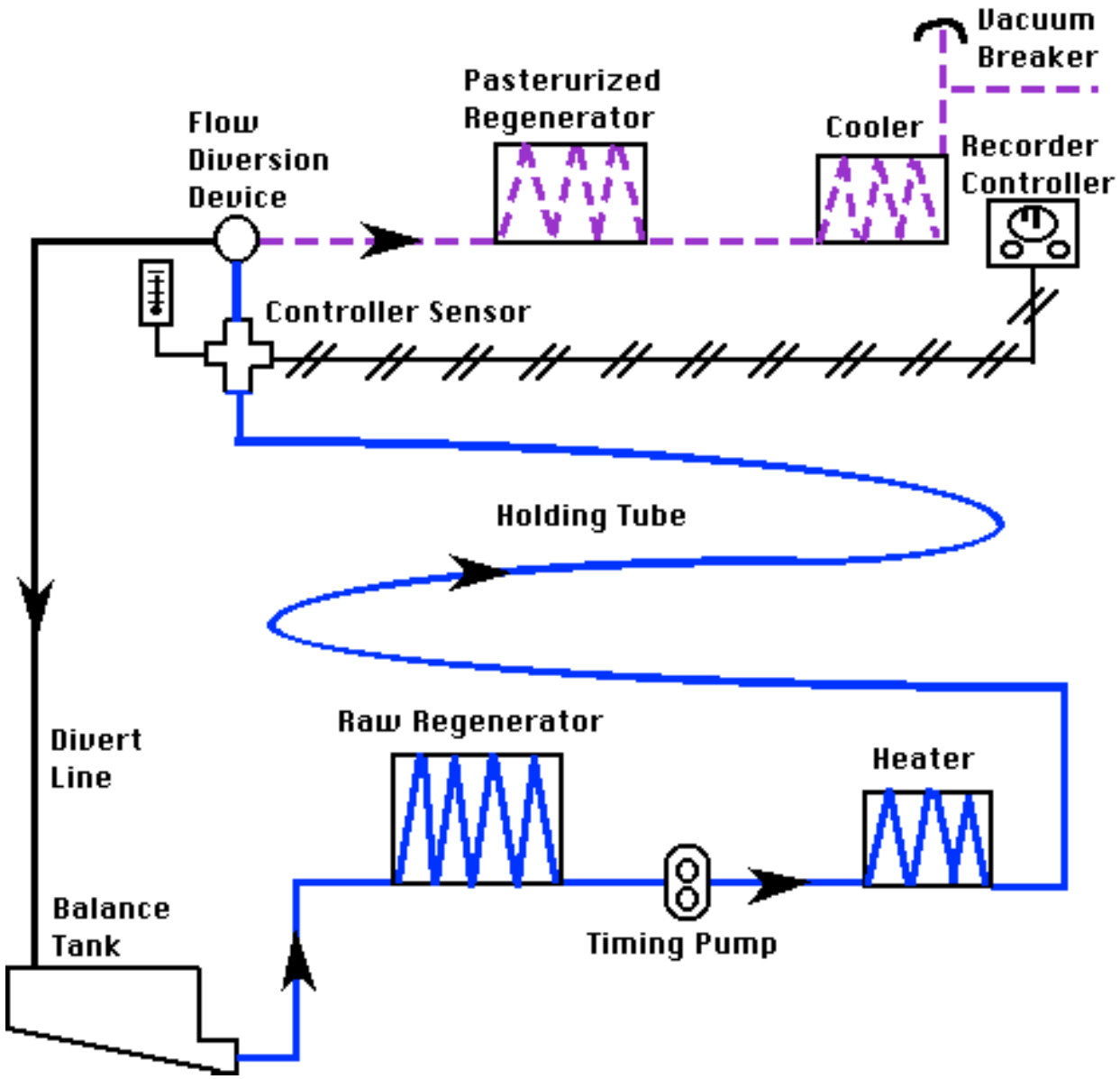


Batch (Vat) Pasteurizer

Pp 86-89, PMO

1. Time and temperature controls
2. Airspace heating
3. Inlet/Outlet Valves and connections
4. Design & Installation of valves/connections
5. Recording charts

High Temperature Short Time Pasteurization



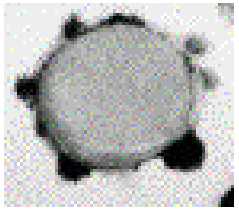
Pg 89, PMO
High Temperature Short Time Continuous Flow Pasteurizers
Pg 99, PMO
Pasteurizer records, equipment tests, and examinations

Homogenization - Purpose

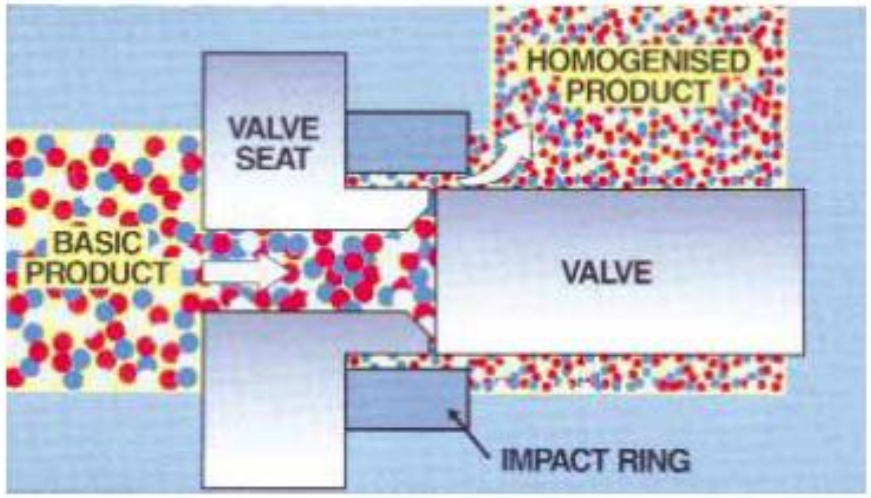
- Reduce the size of fat globules to effectively
- Reduce the rate of rise (separation/creaming) to be negligible for all practical purposes.
- minimize density difference between continuous phase (milk serum) and discontinuous phase(emulsified fat)

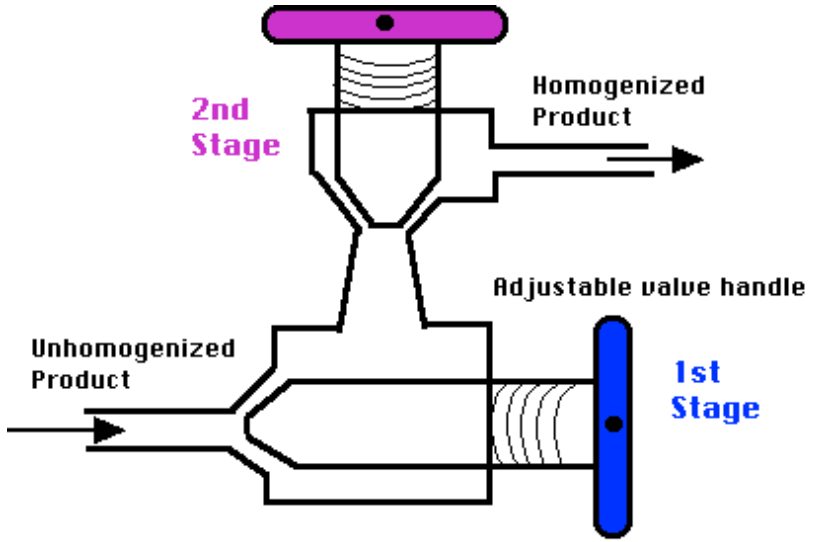
Homogenization - Description

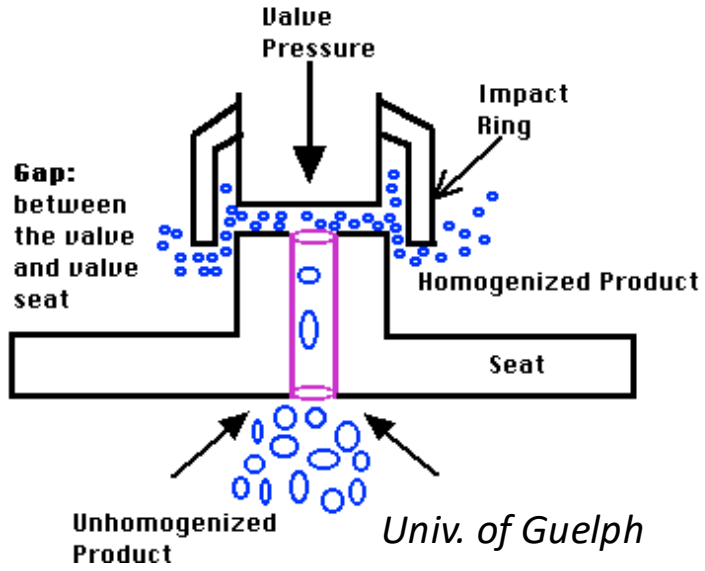
- Operating Pressures – 500 – 3000 psi
- Operating Temperature
  - Sufficient for liquid fat
- Homogenization valve
  - narrow channel/orifice/gap
- Two stage (2000psi and 500 psi)
  - Higher pressure – sufficient energy to break up fat globules to smaller particles
  - Lower pressure – to break up loose aggregates/clusters
- Change in the nature of the fat globule membrane
  - Adsorption of whey proteins and caseins
  - reduction in density differences between fat globules and the aqueous phase



Homogenizer Valve





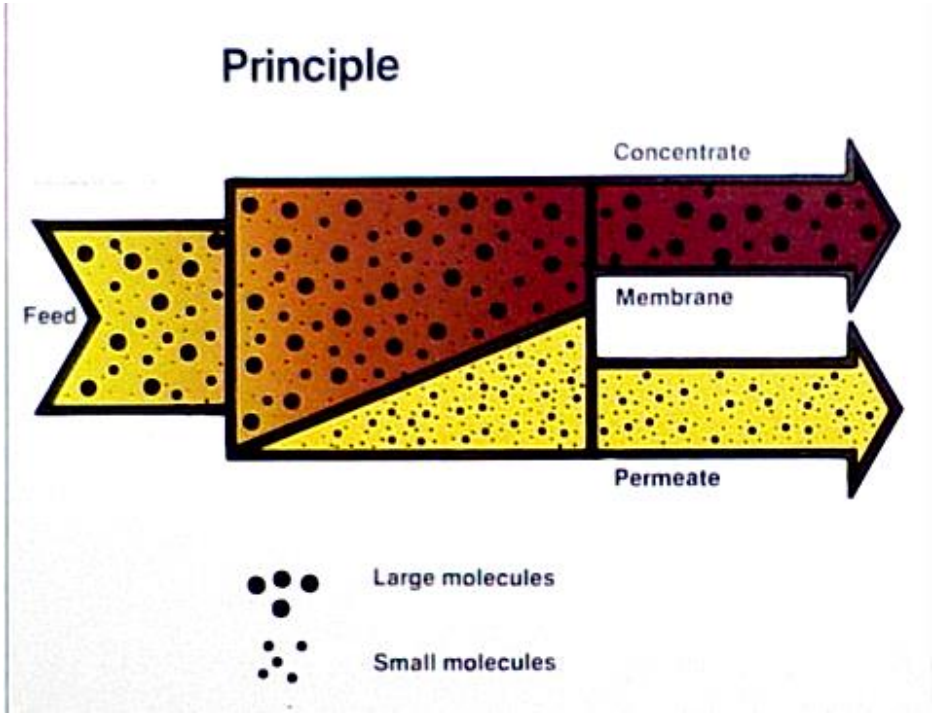


Univ. of Guelph

What is membrane processing?

. . . A process for the filtration of solutions and/or suspensions under pressure through a semi-permeable membrane

Molecular or Macromolecular Sieve



CONCENTRATION (EVAPORATION)

Processes & Technology

Vacuum evaporation (water removal)

- Pressure less than atmospheric pressure
- Boiling point lowered due to partial vacuum
- Heat is transferred from heating medium (steam) to the food
- Removal of latent heat of vaporization
- Vapors removed from boiling liquid
- More energy efficient for water removal than spray drying.

What have we learned?

- Pumping and handling of dairy fluids
- Centrifugal separation (fat standardization)
- Thermal processing (heat exchange, pasteurization)
- High pressure homogenization (fat globule size reduction and stabilization)
- Mixing and blending objectives and equipment (wet, sink, disperse, solubilize)
- Concentration processes (vacuum evaporation, membrane processing)

Thanks for your attention!

Questions? Comments?

Unit Operations in Dairy Processing:

separation, standardization, thermal processing including pasteurization, homogenization, concentration.