Optimizing Efficiency and Reducing Costs in a Milk Cooling System

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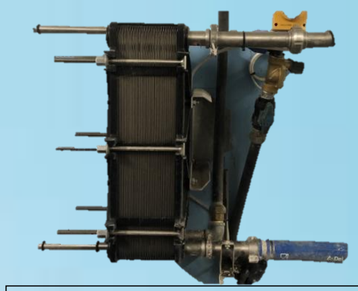
Aim

This project was to analyse, model amd simulate the existing milk cooling system in place in order to optimize heat transfer and reduce operational costs in a milking cooling system.

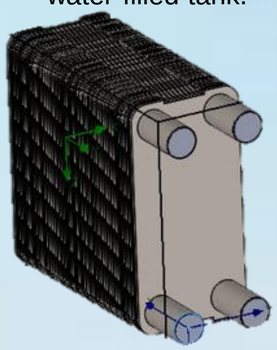
Background

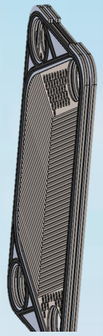
Milk exits a cow at 35˚ C, it must be cooled quickly to below 4˚ C to preserve quality. This system consists of a plate heat exchanger to pre-cool milk with groundwater (~8˚ C) and a refrigerated bulk tank to bring milk to 4˚ C and a heat recovery system captures waste heat from the refrigerant used in the cooling process. It stores it in a heat recovery tank to preheat water for cleaning, therefore reducing water heating costs. This project focuses on two key components, the plate cooler and the heat recovery tank and with the help of SolidWorks flow simulation, the efficiency improved.

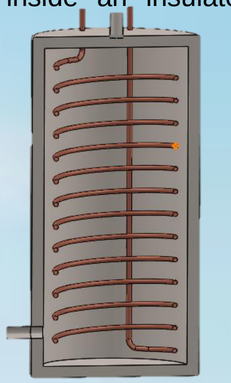


SolidWorks Modelling

- **Plate Heat Exchanger**: A series of plates with fins to promote turbulence and gaskets to prevent mixing designed in a counter-flow configuration.
- **Heat Recovery Tank**: Shell-and-tube design with **copper coils** that circulate hot refrigerant inside an insulated water-filled tank.

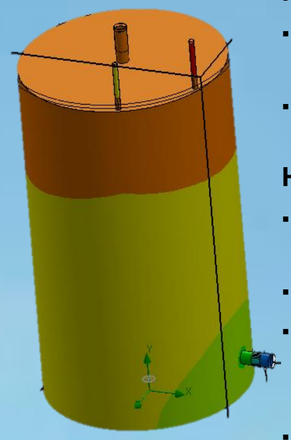


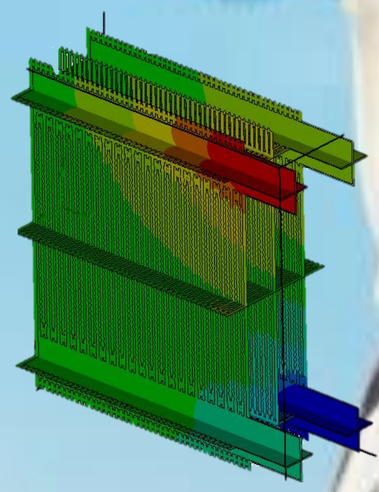




SolidWorks Simulation

- SolidWorks **Flow Simulation** was used to analyse:
- **Temperature distribution**
- **Mass flow rates**
- **Boundary conditions**
- Measured inlet temperatures (milk: 35˚ C, water: 8˚ C, refrigerant: 70–77˚ C)
- Cut plots and surface plots showing heat exchange visually
- Output goals defined for **fluid outlet temperatures**, allowing validation against real measurements





Improvements

Plate Cooler:

- Increased from 43 to 50 plates → 14% more surface area
- Reduced milk outlet temperature to **18˚ C** (vs. 20˚ C originally)

Heat Recovery Tank:

- Tank volume increased by **50%** (from 950L to 1440L)
- Coil surface area increased by **230%**
- Inlet water temperature raised from **8˚ C to 25˚ C** by reusing the outlet water from the plate cooler.
- Water outlet temperature improved from **36˚ C to 69˚ C.**

Results

Component	Fluid	Location	Original	New
Plate cooler	Milk	Inlet temp	35°C	35°C
		Outlet temp	20°C	18°C
	Water	Inlet temp	8°C	8°C
		Outlet temp	25°C	28°C
Heat recovery tank	Refrigerant	Inlet temp	70°C	70°C
		Outlet temp	30.26°C	66°C
	Water	Inlet temp	8°C	24°C
		Outlet temp	37.72°C	69°C

The milk outlet of the plate cooler was reduced from 20˚ C to 18˚ C. The outlet water from the plate cooler was reused as the inlet to the new heat recovery tank at 24˚ C, the increased surface area of coil heated the eater up to 69˚ C in the improved system. Showing below in the table saving €1.71 per milking which is small but adds up to a substantial €1197 for a full year.

System Component	Energy Saved (kWh)	Cost Saved (€)
Milk Cooling (Bulk Tank)	0.45	€0.18
Hot Water Heating (Gas Heater)	15.33	€1.53
Total Savings per Cycle	15.78	€1.71
Estimated annual savings (700 milkings)	11046	€1,197.00