CAREER EPISODE 2

INTRODUCTION:

Time duration	July 2013 to June 2014
Location	Moscow, Russia
Organization	Sealed Air Corporation
Project	
Position	S & I Engineer

CE 2.1

This career episode describes my engineering activities at Sealed Air Corporation, where I started working after graduation and serving army. Sealed Air is a knowledge-based company and one of the world's largest manufacturers of packaging materials and equipment.
At the beginning of my career one of the main company goals was the global Synergy program. All the main calculation and development was done in the companies Moscow office. Commissioning and equipment tests were carried out at the customer's plant in the Belgorod region.

BACKGROUND:

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Synergy program appeared after our corporation acquired the Diversey company, which specializes in hygiene solutions and washing systems. The main aim of this program was Food Shelf-life Extension. This gives a food safety for the end customer, and profits for food producers. This program was developed by the management of two divisions of the corporation:

- Cryovac - food packaging division
- Diversey - cleaning and hygiene division

The program was implemented mainly for chilled meat shelf-life extension. As mentioned above, one of the advantages of this program was profits for food producers, which is realized through a decrease of investment loss if freezing.

Consequently, due to the extended shelf life, the average meat producer can sell the entire volume of chilled products, which will reduce losses by 1-1.6 million Euro. Shelf-life Extension program comprised of 4 projects:

- Half carcasses rinsing with a Chlorine Dioxide
- Automatic belt washing of the deboning conveyor
- Using Odor Absorbing Shrink Bags

- Chilling packed meat

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I joined the last project where main goal was the development, installation, integration into an existing line and testing of a chilling system. Work was carried out under the supervision of my manager and by a team of engineers.

Equipment development working group included:

- Mechanical, Electrical and Software engineers from our factory in Switzerland (R&D)
- Engineers from third-party companies specializing in the production of refrigeration equipment (BMS)

Equipment installation working group included:

- Local commissioning engineers (S&A)
- Engineers from the customer

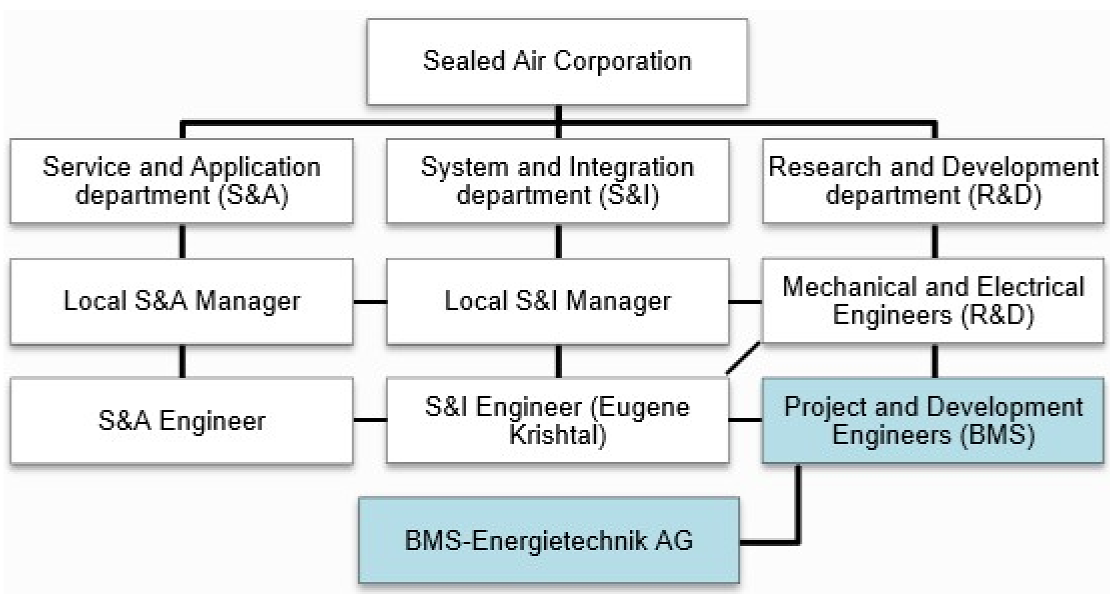

Chart of the organizational structure

PERSONAL ENGINEERING ACTIVITY

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My Roles & Responsibilities

As a project engineer, I was responsible for developing a general concept and calculating key indicators, as well as participated in negotiations and meetings with our suppliers and customer representatives. I did the following tasks in this project:

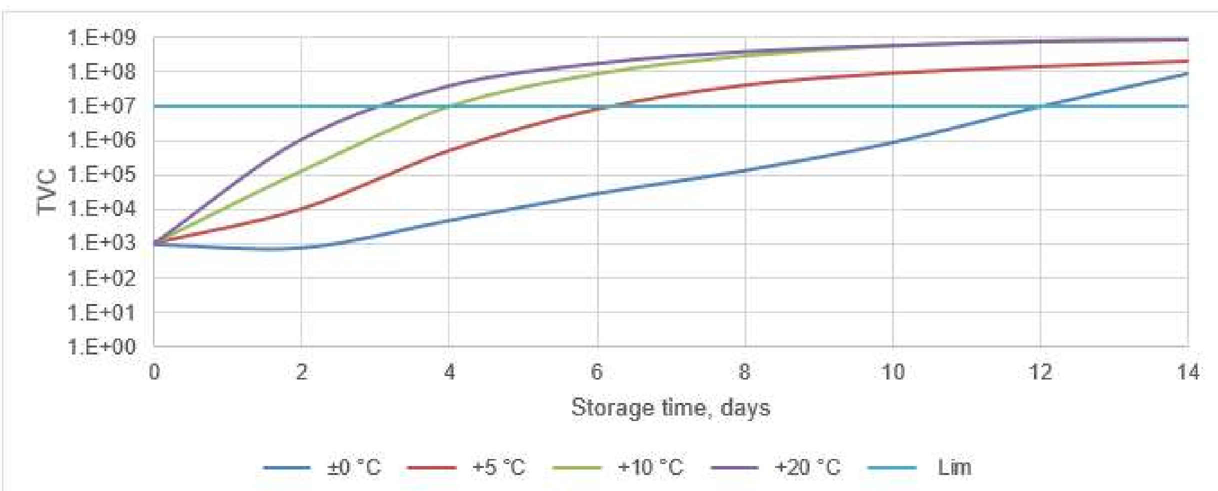
- Determined project specifications by studying product design, customer requirements and standards.
- Preparation and execution of calculations
- Conceptualizing of solution using 2D/3D layouts
- Preparing of technical offers and engineering documents
- Budget definition by calculating labor, material and related costs.
- Communicating and coordinating with internal resources and external suppliers to complete projects on time and budget

CE 2.5

Indicator of meat quality and its shelf life is TVC ratio (the Total Viable Count of bacteria, or the number of bacteria per cm^2):

- TVC = 10^4 - maximum initial seeding before packaging
- TVC = 10^6 - unpleasant smell
- TVC = 10^7 - shelf life limit
- TVC = 10^8 - discoloration and mucus formation

Processing, packaging and storage temperatures significantly affect to Shelf-life. Experiments have shown that reducing the temperature of the meat cut surface reduces the number of bacteria and increases the shelf life.



Effect of temperature on the shelf life of meat. TVC - the number of bacteria per cm2

The first task was to determine the dependence of the change in the number of bacteria on the chilling time. For this, I visited, together with our S&A engineer the plant of a customer for testing. Tests were carried out on the neck packing line, which consisted of 4 main components:

- Bag loader (BLR2) – for loading meat into a ready shrink bag
- Vacuum Packaging Machine (VS95TS) – for evacuation and sealing of a shrink bag
- Shrink Tunnel (ST98) – for thermal shrinkage of a bag
- Water Removal Tunnel (WR81) – for remove water from a packaged meat surface

The chilling of the products was carried out after the shrink tunnel. After the tests, we obtained the results shown in the tables below.

Table 1 – Cut (Pork Neck) temperature at different stages

Temperature of vacuum bagged meat	7,5°C
Temperature after shrink	28,0°C
Temperature after shrinking and blowing	16,0°C

Table 2 – Cut (Pork Neck) temperature after chilling water with temperature 1-3°C at different stages

Packaging processes	Chilling time		
	10 sec	20 sec	40 sec
Vacuum bagged, shrinking, chilling	8,5°C	7,0°C	6,8°C
Vacuum bagged, shrinking, chilling and blowing	12,0°C	11,0°C	11,0°C

Table 3 – Control measurement of temperature and the number of bacteria on the meat cut surface after heat shrinking and blowing

Cooling time, sec	Temperature, °C	TVC
0	28°C	57×10^3
20	11°C	24×10^3
30	11°C	11×10^3

Table 4 – Bacteria count comparison after 21 day of shelf life for Pork Neck

Time of chilling after shrink tunnel, sec	TVC
0	$2{,}7\text{-}5{,}4 \times 10^4$
10	$2{,}1\text{-}2{,}4 \times 10^4$
20	$36\text{-}75 \times 10^3$
30	$16\text{-}34 \times 10^3$

Chilling has significant impact on bacterium count. Minimal dipping time (10 sec) already gives noticeable count reduction. Benefits summary after testing:

- Less discoloration after shrink
- Increase bag seals strength.
- More secured sealing
- Shelf life extension

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Industrial Testing

Next step was industrial test. The idea was to use basic hot water shrink tank ST85 with minor modification. After it was necessary to determine the principle of cooling water: using ice or a heat exchanger. The first option is much cheaper, the second is more effective. Further, according to calculations, I showed that water cooling with ice does not satisfy production standards. To do this, I had to remember the thermodynamics course from my university. Also, textbooks on thermodynamics and heat transfer helped me to execute calculations.

Maximum ice maker capacity, that was installed at this meat factory, was 350 kg ice per 24 hours. The average capacity of the packaging line was 3 cycles per minute. This corresponds to the fact that one cycle took 20 seconds. In each cycle 8 cuts (Pork Legs) were packed. Work at the plant was in one shift lasting 10 hours. Evaluation was by two criteria: the amount of ice required and heat transfer coefficient.

CE 2.7

First Evaluation

Formula Heat Release

$$Q = (T_{11} - T_{12}) \times c_p \times m;$$

Where:

Sign	Value	Description
T_{11}	28 °C	initial temperature of a meat surface after shrinking
T_{12}	3 °C	final (recommended) temperature of a meat surface
c_p	2760 J / kg °C	pork heat capacity
m	8,8 kg	weight of the heated meat surface (3 mm) of all cuts (8 Legs) per cycle (20 sec)
Q	605493 J	Heat release from meat per one cycle

Formula required amount of ice:

$$m = \frac{Q}{((T_{22} - T_{21}) \times c_i + \lambda)} = \frac{(T_{11} - T_{12}) \times c_p \times m}{((T_{22} - T_{21}) \times c_i + \lambda)};$$

Where:

Sign	Value	Description
T_{22}	0 °C	final ice temperature
T_{21}	-7 °C	initial ice temperature
c_i	2260 J / kg °C	ice heat capacity
λ	330000 J / kg	specific heat of ice melting

As a result, for chilling of 8 Legs was required 2,63 kg (minimum) per cycle, or 1320 kg for 10 hours of work. This value is significantly higher than the amount of ice that an ice machine can make.

CE 2.8

Second Evaluation

Heat transfer coefficient α is the amount of heat that passes per time (sec) from a more heated to less heated thing through 1 m^2 of heat exchange surface at a temperature difference between them of 1°C:

$$\alpha_i = \frac{Q}{s_1 \times \frac{m}{m_1} \times (T_{11} - T_{21}) \times t};$$

Then minimum heat transfer coefficient for minimum ice weight (2,63 kg per cycle) was 852 W / m2 °C. Heat transfer coefficient between meat and ice:

$$\alpha_{mi} = \frac{1}{\frac{1}{\alpha_1} + \frac{1}{\alpha_2}};$$

This value should be higher than minimum heat transfer coefficient: $\alpha_{mi} > \alpha_i$

Heat transfer coefficient between meat and water:

$$\alpha_1 = \frac{\alpha_{11} \times t_1 + \alpha_{12} \times t_2}{t_1 + t_2};$$

Heat transfer coefficient between water and ice:

$$\alpha_2 = \frac{\alpha_{21} \times t_1 + \alpha_{22} \times t_2}{t_1 + t_2};$$

In total:

Sign	Value	Description
α_1	411 W / m^2 °C	Heat transfer coefficient between meat and water
α_2	9 908 W / m^2 °C	Heat transfer coefficient between water and ice
α_{mi}	395 W / m^2 °C	Heat transfer coefficient between meat and ice
α_i	852 W / m^2 °C	Minimum heat transfer coefficient

Heat transfer coefficient between meat and ice less than minimum heat transfer coefficient. From this we can conclude that during one cycle of operation (20 s) the ice will not be able to take the necessary amount of heat to reduce the temperature of the meat surface from 28°C to 3°C. This suggests that even if the customer has a more powerful ice maker, it will not provide the required chilling of water and meat. Therefore, the development of a water chilling system using a heat exchanger was required. I reported this calculation was to the manager, who gave the task of developing a concept of water chilling with a heat exchanger.

CE 2.9

Capacity of Chilling Equipment

The required capacity of the chilling equipment was 40 kW. After this it was necessary to determine the nature of the waterflow in the tank. Next, I calculated the heat transfer coefficient in the chiller without the forced water flow and with the forced water flow. With the free fluid flow, the heat transfer coefficient depends only on the physical properties of the coolants. With the forced fluid flow, the heat transfer coefficient depends on the physical properties of coolants and the conditions of interaction.

Heat transfer coefficient without forced water flow

Equipment process	α, W / m ° C
Lifting - lowering (~ 3)	1600
Chilling at the bottom of the tank (~ 15 s)	280
Mean value (~ 18 s)	500

Heat transfer coefficient with forced water flow

Equipment process	α, W / m ° C
Lifting - lowering (~ 3)	1600
Chilling at the bottom of the tank (~ 15 s)	890
Mean value (~ 18 s)	1000

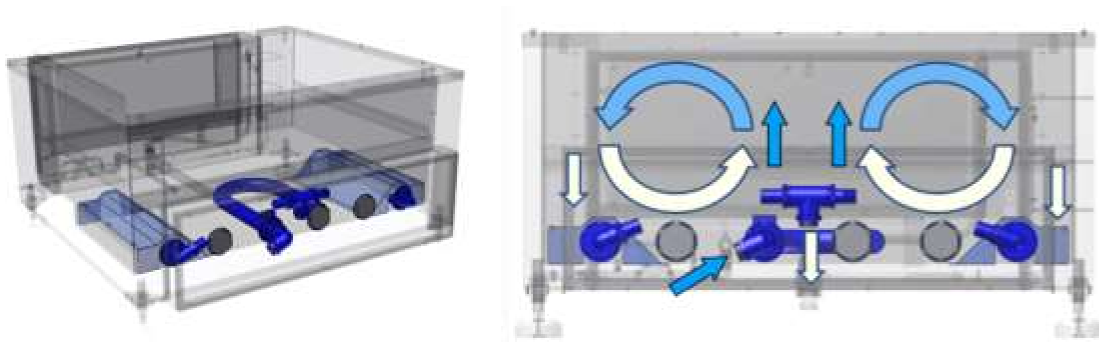
After calculating with what cooling capacity of heat exchanger was required and what type of water flow in the tank had to be, I proceed with the modification the equipment itself.

CE 2.10

I made chilling tank based on a shrink tank with minor modification:

- Removing the heating elements
- Connection points for supply and discharge of water
- Both dosing and draining supposed to keep controlled temperature of water in the tank

Connection points for supply and discharge of water were arranged in such way so as to ensure the turbulent circulation of water in the tank and to improve the heat exchange between packaged meat and water.

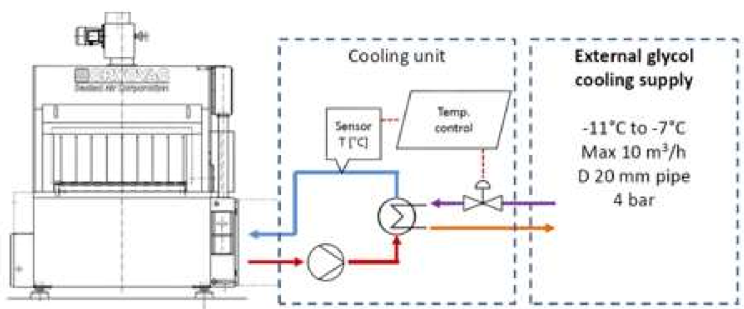


Water supply and drain elements of the Chilling Tank

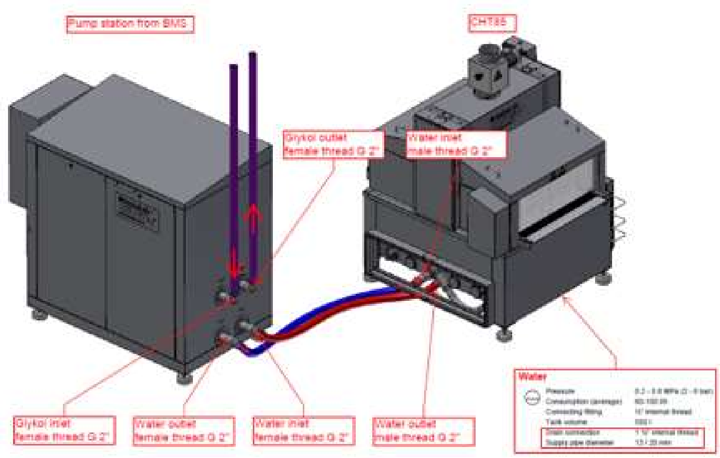
The development and manufacture of a heat exchanger was carried out by the company BMS-Energietechnik AG. Specialists of this company helped me with calculations for the required cooling capacity.

The main refrigerant in modern food processing factories is Propylene glycol. Unlike ammonium, it is not poisonous and can even be consumed with food. For example, propylene glycol is used for cooling of half carcass. Therefore, this coolant was used as a coolant for chilling water. The main elements of the Cooling Unit:

- heat exchanger
- glycol valve
- water pump



Scheme of operation and interaction of the chilling tank and cooling unit

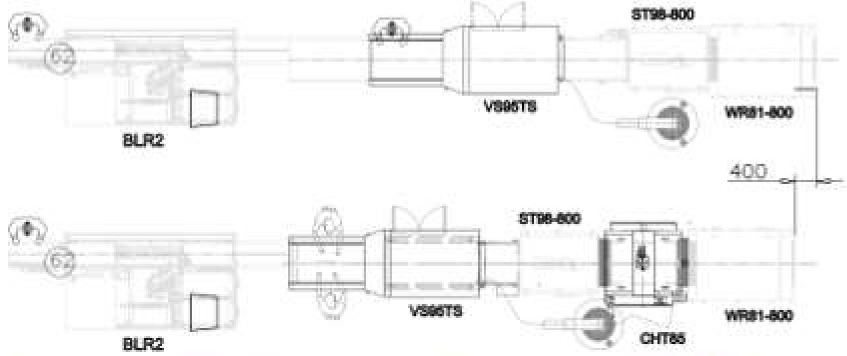


Chilling Tank and Cooling Unit

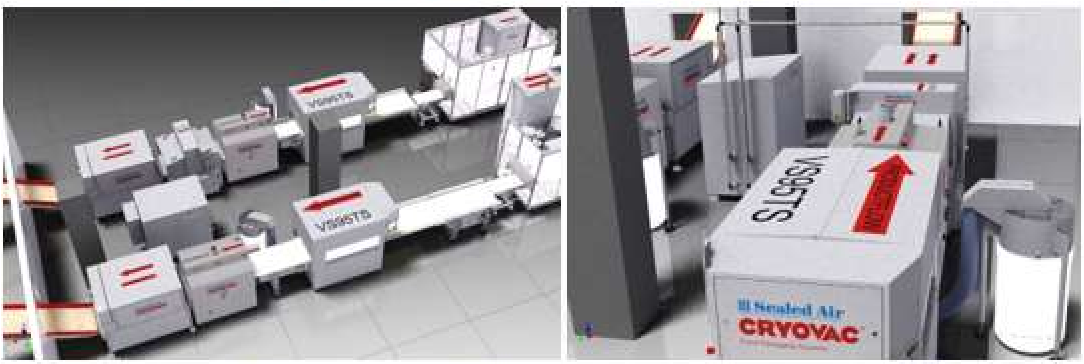
CE 2.11

After the approval of all technical issues and agreements, I defended the final technical offer to the customer. When we signed a contract, production was carried out for 4 months, after which all equipment (Chilling tank and Chilling unit) was tested at our factory in Switzerland, after that the equipment was transported to the customer. Installation and commissioning of equipment was done at site.

The water supply was organized by a circuit located above the machines and the passage between the Chilling unit and the 5th line. I used AutoCAD for the change of the existing line on the factory layout. Detailing the line in 3D was carried out using the Inventor.



Equipment layout of the 5th line before and after the integration of the Chilling Tank



3D-model of the existing 4th line and the upgraded 5th line, considering additional equipment and with contours of water and propylene glycol supply

The installation was done together with engineers from our side and with the working group from the customer. After the equipment was installed and synchronized with the entire line, I tested the same. During working, chilling tank maintained a stable water temperature. Temperature fluctuations were 2.6°C – 3.0°C. At the same time, the glycol valve was open at 8.92% - 22.8%.

CE 2.12

While I was doing this project, I had a chance to work closely with experienced engineers acquired their professional knowledge, skills and attitude through constant interaction. I also worked closely with customer representatives to resolve issues of integrating equipment into an existing plant. I learned a lot from experienced colleagues not only in terms of professional growth, but also interpersonal skills.

As a result of good planning and effective team work involved at each step of the projects, the customer purchased these chilling systems for the beef plant and for their new pork plant.

CE 2.13

Summary

This project helped me to implement and expand my knowledge in the field of hygiene, food shelf life and development of technological equipment. I learned how to interact with various departments and companies to achieve the task. I also built and maintained strong working relationship with key internal and external parties, as well as diversified understanding of industry operations, drivers and risks.

The developed project helped to increase the shelf life of chilled meat from 21 to 35 days which entailed in both improving food safety for the end customer and increasing the profits of food producers.