COMPFREEZE

Sixth Framework Programme

Project no: Contract N° 512950

Project acronym: COMPFREEZE

Project title:
Improving the competitiveness in the European frozen food industry through the development of new freezing equipment based on CO_2

Instrument: *Co-operative Research Project (CRAFT)*

Thematic Priority:

Publishable Final Activity Report

Period covered: from 1/11-2004 to 1/11-2006

Date of preparation: 1/11-2006

Start date of project: 1/11-2004

Duration: 2 years

Project coordinator name: Lars Reinholdt/ Kim Christensen
Project coordinator organisation name: Danish Technological Institute

Revision: 1

Publishable Final Activity Report

1 Project execution

A Co-operative Research project (CRAFT) under the name COMPFREEZE, "Improving the competitiveness in the European frozen industry through the development of new freezing equipment based on CO_2" has been carried out.

The project has received grants from the Sixth EU Framework Programme under the Craft agreement. Craft projects are aimed at small and medium-sized businesses (SME's) that face mutual challenges and together hope to increase competitiveness. The project has been running for the past 2 years.

The overall objective of this project is to increase the competitiveness among SME's in the frozen food industry by developing low-temperature freezing equipment and thereby enabling the SME's possibility of increasing productivity. This proposal will focus on the freezing process using CO_2 as a refrigerant in order to;

1) create knowledge of the connection between the quick-freezing process and the quality of the product by using various types of freezers to control the process.
2) implement the developed knowledge in new freezing equipment so better product quality at lower operational costs is ensured.

By using CO_2, a safe and environmentally-friendly technique is introduced which protects the ozone layer and reduces the global warming effects. Recent research programs focus on the performance of the CO_2 installation. However, the benefits and consequences of using this refrigerant are neither well-known nor quantified.

Companies from the Netherlands, France and Denmark have participated in the project. The project group can be divided into two main parts.

The one group comprises the end-users who produce frozen foods (ice cream, mushrooms, sweet pies, meat) and they are: MasterFoods, Van de Leur, Cool Logistics and F&F Europe BV. They deal with how freezing influences certain product quality parameters. Research is carried out by using modelling software and by carrying out experimental tests. The project manager of this part of the project is TNO (Environment, Energy and Process Innovation).

The other group comprises companies that produce freezing equipment and they are: Scanima A/S, spiral freezer manufacturer, Dybvad Stålindustri A/S, plate freezer manufacturer, Gram Equipment, ice cream freezer manufacturer and York Refrigeration, i.a. CO_2 refrigeration systems. This group mainly concentrates on CO_2 freezing and refrigeration equipment. Danish Technological Institute, Centre for Refrigeration & Heat Pump Technology, is project co-ordinator of the entire project.

The figure shows how the project is organised. The main objective is to develop freezer and refrigeration equipment based on CO_2 and to investigate how CO_2 as refrigerant influences the product quality. This is how the project is linked:

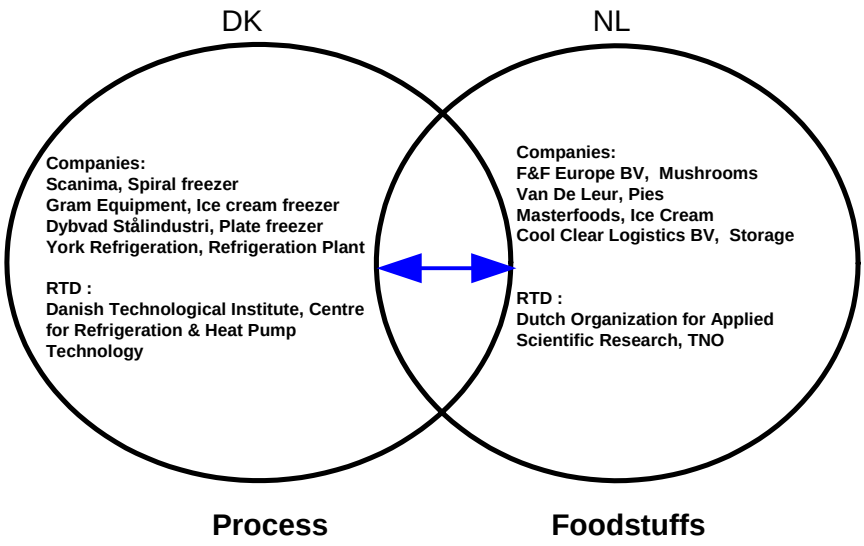

Figure: How the project is organised.

To achieve the objectives the project group has gone through the following steps.

Literature survey:
Fundamental knowledge has been established and it has been used to point at the main quality parameters of the food products involved in the project and also to point out the main external parameters that influence the parameters. In addition, more software models have been created to be able to calculate the processes in the food and also to be able to design the freezing equipment.

Interviews with food producing companies:
To enhance and optimise the freezing process it is important to know the boundaries and limitations of the products. That takes place by gathering the knowledge and experience from the food producers. During these interviews main quality parameters and main barriers of improvements are clarified. Furthermore, main reasons for losses in quality and efficiency are detected.

Software models:
All information is structured in software models. Models for food properties, food freezing, and equipment design are created. These models are essential for the latter part of the project and in order to fulfill the objectives of the project.

Freezing equipment prototypes:
Prototypes have already been produced by the 3 equipment manufacturers. This is hard and costly work. These prototypes are now in the laboratories of DTI. The equipment is documented through calculations and drawings.

Design, construction and building of test rig:
A test rig has been designed and established at DTI. The test rig is essential for all tests that will be carried out in the project. The freezing equipment will be attached to the test rig and tested. These tests are necessary in order to validate the design and performance of the freezing equipment, but also in order to the carry out the food freezing tests.

Initial tests of freezing equipment:
Initial tests on the freezing equipment have been carried out. The spiral freezer, plate freezer and ice cream freezer show significantly increased performance and the capability of freezing at lower temperatures. However, smaller changes to the prototypes have been made.

Freezing tests with improved freezing equipment:
By using the optimised freezing equipment it was possible to freeze food products at much lower temperatures and to investigate the consequences. Various freezing tests have been carried out and results have been compared to simulations to validate the model used.

All activities have been carried out according to the schedule and the application and contract.

The COMPFREEZE project has generated remarkable results. Some of these results are already in use and other results will be implemented in the future.

The results of the project are twofold as the project has a software component and a hardware (freezing equipment) component. The software results and experiences of the project are added to the existing and new software packages and are available to companies working in the field of frozen foods manufacturing and to refrigeration machinery installers. Economically advantageous hardware results, in terms of new CO_2 freezing equipment and specific new knowledge of freezing processes, are available to end-users in the food industry from the companies participating in the project.

During the project, advanced calculation tools for design and calculation for performance developed for freezing equipment such as plate freezers, spiral and impingement freezers and ice cream freezers. The simulation model (WINTIX) for FEM analysis of freezing of food and simulation of the impact of the freezing process on most important quality parameters for foodstuffs such as ice cream, meat, pies and mushrooms – optimised processes to improve quality. These tools are now in use to further optimise design and used for specific predictions of performance.

The project has shown that proportionality between product quality and nucleation rate exists and a simple Arhenius-like empirical equation for the nucleation rate of ice crystals can be used. This makes it possible to simulate food quality parameters based on experimental tests.

New understanding and experience with CO_2 as refrigerant have been achieved. Much higher heat transfer during pool boiling and operation close to triple point are possible and increase of performance shortens the freezing time. The level of safety in production facilities is ensured and there is little impact on personnel. The systems are easy to operate and maintain and safe high pressure components are available and hot gas defrost is easy to use and effective.

From a safety, environmental and technical point of view, CO_2 is superior to other refrigerants such as ammonia and R22 in freezing processes.

During the project, enhanced freezing equipment for CO_2 has been developed and prototypes and commercial model have been produced.

- A new ice cream freezer – double capacity and freezing at lower temperatures which gives thicker ice cream and increased output for the customer.
- New plate freezer – enhanced for operation with CO_2 and hot gas defrost which enables freezing at lower temperatures and increased output.
- New spiral freezer – flexible belt and chain design, hygienic design, lower temperatures and optimised air flow which makes it more flexible in use, easier to clean and gives increased output from the freezer.
- New impingement freezer – much higher heat transfer than existing freezers.

Freezer prototypes and commercial models are built and investigated under laboratory conditions and field test. Two patents have been taken out on the freezers during the project. End-users of the COMPFREEZE project have installed CO_2 based refrigeration and freezing equipment during the project and experiences are gained from the practical use for these new installations.

Improved freezing methods are tested for various food products and experience is documented and implemented in process lines with improvement of the freezing process for ice cream and handling and freezing process for pies and mushrooms. The participating food producers have expanded their documentation ability on the quality of food products and increased the effectiveness of own production processes.

The project has also verified the calculation and simulation models by comparing results from measurements and tests.

2 Dissemination and use

A substantial part of this project has been to distribute the results and experience to the food industry as well as among manufacturers of freezing equipment within the EU.

RTD has disseminated the knowledge by means of papers at conferences and articles in refrigeration journals. The theoretical work and the experience with manufacturing at the demo plants have been reported. After laboratory and field tests a phase of the publication of results has been carried out. Within the project, a strong network between companies (contractors), suppliers and costumers has developed. These groups will continue to operate also after the term of the project and support the dissemination of the new techniques.

RTD is in possession of considerable competence within foodstuff freezing with CO_2. In order to ensure that such know-how also will become accessible to the European SME's after the conclusion of the project RTD will regularly hold one-day conferences and courses within food freezing with a special view to disseminate knowledge about the natural refrigerant CO_2.

This project has been of great interest to manufacturers, fitters and users in the food and refrigeration industry because of the potential impact as mentioned above.

Among the SME's involved in the consortium, results are already being used through:

- Internal education within the companies:
  - Education of technicians and sales people – 3 courses for each company have been carried out.
  - CO_2 – handbook (design guide) prepared and shipped to companies.
  - All presentation available to the companies.
  - Ability to persuade customers about the beneficiaries of CO_2 freezing equipment through the new-found knowledge.
- External education: a total of 6 courses with respect to CO_2 and food freezing have been carried out in Denmark, the Netherlands and England – this will continue in the future – here the developed design guide is very important.
- Planning and launching market entry of the developed prototypes for freezing equipment.
  - New ice cream freezer is already sold in 4 commercial models.
  - New spiral freezer is sold in 2 models and impingement freezer is marketed.
  - Plate freezer for CO_2 is sold in 10 applications.
- Establishing a new interest for investing in CO2 freezers among players within the food industry.
  - Contractors of the COMPFRREEZE have participated in more than 10 exhibitions where the new products have been shown.
- Mass use of the results through more than 20 articles and presentations worldwide.

The know-how that is generated at the SME's in this project results in future quick-freezing plants being manufactured in the same way as the plants developed in the course of the project and they will set the standard for the future.

Based on the conclusions of the design guide, manufacturers, end users (food industry) and governmental organisations are be able to learn from the project and follow the recommendations in order to contribute to the reaching of the overall project objective.

A website has been established and results obtained from the project are posted on the site.

Throughout the project, the results have been gathered and translated into well-documented guidelines and recommendations. The CO_2 design guide and other general papers from the project are important in this respect.

The project group has worked closely with the government supported HFC free Info Centre in Denmark. This Centre coordinates the work carried out to abandon the global warming substances and support the use of natural refrigerants such as CO_2. During this work standards and regulations have also been discussed.

Developing higher standards regarding environmental friendly production processes is an issue, where a change of refrigerant can contribute directly. As mentioned earlier that can e.g. take place by reducing the green house gases let out into the atmosphere by the food industry. Ambitious goals have been set by the EU, and it will take initiatives like those presented in this project to reach these goals.

The reader is asked to read the individual report called “Final plan for using and disseminating the knowledge”.

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