PROJECT NO: FP6-508726

ICEMAKER

Development of a low cost, low power consumption system for manufacturing ozonised fluid ice for fishing via absorption system

Co-operative Research (Craft)

Horizontal Research Activities Involving SMEs

Publishable Final Activity Report

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Project Coordinator Name: Narcís Clavell

Project Coordinator Organisation Name: Centre de Recerca i Investigació de Catalunya

Version 01 - Final

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1. PROJECT EXECUTION

PROJECT OBJECTIVES

Ice is considered an indispensable commodity in the fishing industry, both for the preservation and distribution of fresh fish. In order to remain fresh, fish requires ice immediately. Ice keeps the fish fresh, wet and brilliant at just the right temperature for preservation without having to use monitoring devices such as thermostats, hygrometers, etc. Ice is an excellent cool accumulator as well as a highly practical and economical cooling system.

Many small and medium sized fishing vessels operating in European waters do not dispose of onboard ice generators for the conservation and storage of fish. Therefore, to ensure that fish arrive at the port in optimal condition the quantity of ice required for the day needs to be estimated and loaded onto the boat at the beginning of the fishing day. These types of vessels depend on having close access to fishing terminals and ports equipped with ice making machinery. Given that they do produce ice onboard both the costs of purchasing ice at the port as well as its posterior handling and unloading are increased. Furthermore, the ice looses its energy during transportation and handling. Moreover, if not enough ice is brought onboard the fish catch may not arrive to its destination in optimal conditions or even worse the catch may not be fit for sale and hence go to waste, entailing both economical and environmental repercussions.

A number of commercial onboard ice generators are currently available on the marketplace, but are based on mechanical compression systems, which require a mechanical or electrical power source. Compressor systems are commonly used on larger fishing vessels, with powerful engines suited to the substantial energy requirements of traditional onboard ice making systems. Such compressor systems have a high capital costs and high running costs (increase in fuel costs) and are bulky. To quote an example- a typical commercially available ice generating machine producing 6 tones of flaked ice/day would cost from 1.500€ to 1.800€ (without taking into account installation costs). The continuous power consumption would be in the order of 15KW and could weigh around 1.000kg[2] and is thus, not well suited, to the needs and budgets of small to medium sized fishing vessels.

By providing small and medium sized vessels with a means of self-sufficiently producing their own steady supply of fresh ice onboard will ensure that ice does not have to be used sparingly and thus the fish catch can be maintained as fresh as possible and the optimal benefits of abundant ice obtained. A clear need exists among small and medium sized vessels for ice manufacturing systems which are adapted and improved to meet the needs of small and medium sized vessel, in particular in terms of reduced energy consumption, reduced size and weight, and at a cost that the market can tolerate.

CO-ORDINATOR CONTACT DETAILS

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N.I.F. A-61474359

CONTRACTORS INVOLVED IN THE PROJECT

Partic. Role[1]	Partic. no.	Participant name	Participant short name	Country	Date enter project	Date exit project
CR	1	PIASA	PIASA	Spain	M1	M24
CR	2	SPIRATUBE	SPIR	Spain	M1	M24
-	-	-	-	-	-	-
CR	4	INDUSTRIA TÉCNICA VALENCIANA	ITV	Spain	M1	M24
CR	5	BALIKILER DENIZ URUNLERI URETMI TURIZM ITH. IHR. VE TIC.LTD. STI	KILIC	Turkey	M12	M24
CR	6	AQUABIOTECH GROUP	ABT	Malta	M1	M24
CR	7	DOULOPOULOS SHIPYARDS LTD	DOUL	Greece	M1	M24
CR	8	OREMAR	ORE	Spain	M1	M24
-	-	-	-	-	-	-
CR	10	INTEGRAL ENERGY TECHNOLOGY LTD.	INT	Germany	M1	M24
CO	11	CENTRE DE RECERCA I INVESTIGACIÓ DE CATALUNYA, S.A.	CRIC	Spain	M1	M24
CR	12	PERA INNOVATION LTD	PERA	UK	M1	M24
CR	13	FELTALÁLÓI ES KUTATÓ KÖZPONT SZOLGÁLTATÓ, KFT	FKK	Hungary	M1	M24

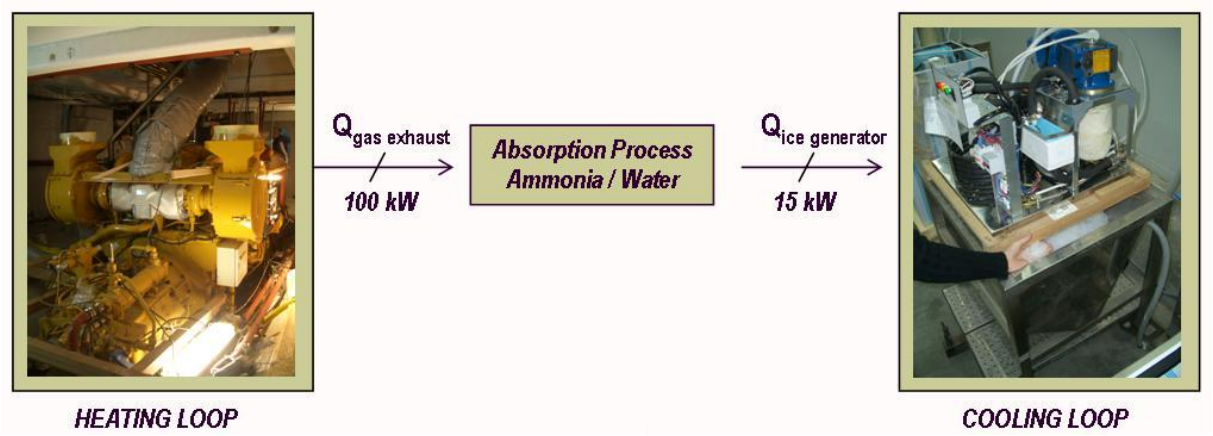
WORK PERFORMED AND RESULTS ACHIEVED

During first steps of the project, a market survey was carried out. The objective was to ensure that the technology developed corresponds to the needs of the market place, the price sensitivity, as well as the acceptance of the proposed equipment into the market. A questionnaire and a cover letter introducing the project and its objectives was draft and with the help of all partners was translated into different languages; Spanish, Greek, Hungarian and France. The questionnaire could be filled in on Internet web page: http://www.cric.es/PROJECTS/ICEMAKER_Questionnaire/index.htm.

The questionnaire was advertised on several on-line specialized magazines, a massive emailing was done, and a telephone survey was carried out to gain an improved and more in-depth overview. Based on this market survey as well as the experience of the partners, the general input requirements were defined.

[1] CO = Coordinator / CR = Contractor

The next step in the project was to define the final specifications of the fluid ice generator as well as the absorption process. The IceMaker prototype was installed into a fishing vessel of the OREMAR partner. The vessel called 'Nova Tia Cinta' has a total length of around 25 meters and was designed for coastal operations. The engine exhaust and its specifications were used to calculate the required thermal energy. Considering the worst case, that is when the fishing vessel leaves port to fish, a thermal energy of around 100 kW was determined. On the other hand, the ice demand was used to calculate the required cooling load. Considering that 1.500 kg of fish have to be preserve, a cooling load of around 15 kW was determined.



Once the thermal energy as well as the cooling load was determined, the design of the main parts of the IceMaker prototype started:

- *Heat pipe design*: CFD modeling was carried out in order to assess the basic heat transfer between exhaust and generator of the absorption unit. One of the biggest obstacle in the heat pipe design was the small space available and the creation of a universal unit well suitable for all sea going fishing vessels. Due to the size and the orientation of the heat pipe it was impossible to install the heat pipe onboard. Discussions with the partners resulted in a slight change in this approach. It was decided to use a heat exchanger installed in the exhaust gases line, without any bypass for the gas flow rate.

- *Absorption process design*: ASPEN PLUS simulation program was used for estimation and opotimization of the behaviour of the real system. The specification of all streams in the system as well as energy consumptions of the various items of equipments was determined. Finally, the commercial available equipments that could be fitted to the simulation results obtained were selected and a possible design for the absorber item was proposed.

  The most important problem during the project was the use of ammonia as refrigerant. After discussions with the members of the consortium it was decided to design the system as compact as possible in order to keep the ammonia under control. Once the absorption process was degined and all equipments selected we realized that was impossible the integration of the compact solution on-board due to space limitations into the vessel.

  In addition, a new European legislation appeared one year ago that compels the use of strict security rules regarding the use of ammonia in vessels. All partners was agree that if the IceMaker system have to follow this new legislation, all extra equipments could increase a lot he final price of

the prototype. For all these reasons, during the project it was agree to forget the use of ammonia as refrigerant and try to find alternatives solutions.

- *Refrigeration cycle*: After discussions with the partners it was decided to use an electrical compressor using R404 as refrigerant. The electrical compressor used was the model 4CC-9.2-40S from BITZER Company with a refrigerant capacity of around 15 kW and an evaporation temperature of -11.5 º C. According with the specification defined was decided to use two fluid ice generators DWT 200 provided by VORTEX company assembled in serial configuration in order to allow a refrigerant capacity of 17.5 kW with a water salinity of 3.5 % NaCl and a nominal concentration of ice crystals of 25%. These two equipments were connected using a combined configuration taking advance of a direct expansion and a flooded evaporation.

- *Seawater cycle*: A high reliability ice concentration loop was designed. The ice crystal content is controlled by the pressure drop so is adjusted. The main achievement of this loop is that avoid the use of electronics in order to keep it simple and robust making it easy for the operator.

- *Ozone seawater pre-treatment cycle*: The ozonation system was designed considering that safety is a must, since the machine operates in a closed room, autonomous and unattended operation as well as the ozone gas is delivered into the ice tank. The Ozonia's Membrel MKII/1 ozone generator was used so several modifications were included to successfully integrate Ozonia's machine into the ozone station that will fit in the IceMaker project.

  The ozone destructor is a vertical tube with various beds of pellets of Carulite® to catalytically destroy any ozone passing through it. This configuration guarantees all the ozone generated in the system and not dissolved in the liquid ice is destroyed when it goes through the partially fluidised beds of pellets.

During the last part of the project, each of these parts of the prototype were integrated and installed on-board of the 'Nova Tia Cinta Vessel'.

Finally different studies in the fish quality improvement were carried out. The firs one related with the influence of the ozone seawater pre-treatment into the fish quality and the second one a study comparing the fish quality using liquid ice or flake ice. For this propose a fish freshness meter of the Distell Company was used.

2. DISSEMINATION AND USE

OVERVIEW OF THE EXPLOITABLE KNOWLEDGE

Exploitable Knowledge (description)	*Exploitable product(s) or measure(s)*	*Sector(s) of Application*	*Timetable for commercial use*	*Patents / IPR protection*	*Owner & Other Partners Involved*
Ozonated fluid ice generator system	Compact fluid ice generator system using non disinfected water controlled with an ice crystals concentration loop	Ice production Fishing industry	2008	Patents to protect the design planned	Vortex, Oremar
Design of the stable absorption refrigeration system to be used in vessels	Low consumption, compact absorption refrigeration design. Stable out to sea.	Fishing industry Sea transport of goods and persons.	2008	Patents to protect the design planned	Oremar
Ice concentration control automatically adjustable	Ice concentration control	Ice production	2008	Patents to protect the design planned	Vortex

Result A – Ozonated fluid ice generator system

The result achieve is a compact fluid ice generator system that does not need disinfected water, due to it will be provided with an ozonation system that will disinfect the water used to produce the ice. Ozone is a proven water disinfectant, and is preferred to alternatives such as chlorine or hydrogen peroxide as unlike these chemical treatments, ozone leaves no residual chemicals in the water stream, i.e. it a non-persistent chemical (ozone breaks down after reacting, to form oxygen gas). Ozone also has the advantage that it can be generated at the point of use, whereas other chemicals must be transported and stored.

This last advantage allows the realization of a compact system composed by an ice machine and ozone generator that is able to produce fluid ice using non treated water (from sea for instance), the cold generated by a refrigeration system and the electrical power to run the ozone generator

The cooling load could be provided by an absorption refrigeration system as the developed in Icemaker project or another kind of refrigeration process (conventional compression system, adsorption refrigeration system…). Therefore this device is not only restricted to small or middle vessels, but any sized ship. In fact, this system is suitable to any other case with no treated water is available, not necessary in fishing vessels.

As seen in the *Figure 1*, it has been taken the best of the design of the fluid ice generation system to carry out the ozone transfer, using the concentration tank for this purpose. Therefore, both systems have been integrated to unique compact system. On the other hand, it has been preferable to carry out this mass transfer in the concentration tank instead the ice machine in order to avoid problems with the ice generation and the modification of this complicated equipment.

On the other hand fluid ice is an attractive alternative for the preservation of fish and other foods. Fluid ice production is highly energy efficient (requiring some 40% less energy than traditional systems), has the attributes of rapid cooling (completely surrounds the food, and in doing so, excludes any air pockets), excellent preservation of food quality, and is easily distributed via pumping.

Result B – Design of stable absorption refrigeration system to be used in vessels

The result achieve is the design of a refrigeration system based in absorption technology capable of functioning in an onboard environment and that will be able to generate, from the heat generated off the vessel's engine, the cold needed to generate ice or to refrigerate a freezer chamber. Unlike conventional vapour compression systems which require a mechanical compressor assembly; the waste heat contained in the fishing vessel's engine exhaust can be used to heat the refrigerant to high temperatures and pressures in absorption refrigerant systems. This fact supposes important energy savings, due to the only mechanical work to be done it will be the needed to drive the absorption working par (ammonia-water) through the refrigeration cycle.

On the other hand, the absorption refrigeration systems are composed by some equipment (distillation column, absorber …) that can present operation problems in an unstable surface as is the case out to sea. In order to provide the needed cooling load successfully, the absorber machine has to be robust enough to work without problems in this kind of environment. Some measures that have to be in consideration for this purpose follow:

- No film-circulating of liquid inside the heat exchangers devices. In the case of the absorber, a vertical multitubular heat exchanger could be a good alternative to film exchangers commonly used in commercial absorption systems.
- High-efficiency packed distillation column instead traditional plate columns, due to this kind of equipment will not work correctly when the system will be subjected to movement.
- To carry out the rectification of the ammonia with partial condensation in order to compensate the possible discontinuities in the reflux flow rate.

This absorption refrigeration system could be used not only in fishing vessels to produce ice (flake or fluid), but also to produce the needed cooling load for freezer chambers or air cooling systems in any kind of sea transport vessel (both goods and persons).

Result C – Ice concentration control automatically adjustable

The results achieve is the design and implementation of an ice concentration loop. In order to simplify the cooling unit it was desired to reduce the number of parameters to be controlled. The ice concentration loop is automatically controlled by means of passive mechanical components, which simplifies the use of sensors/actuators (in general any electronic component).

DISSEMINATION OF KNOWLEDGE

Some dissemination activities have been already carried out. However, given the very high competition in the sector, a very strict confidentiality policy must be followed.

The project website (http://www.cric.es/projects/icemaker.htm) has been set up at the start of the project and will continue to be maintained by CRIC for at least 1 year following the official end date of the EC project. It is anticipated that for the end of the project a website external to CRIC will be set up and the SME partners will take 'handover' of this website and domain name to allow site modifications based on commercial needs going forwards. Additionally a secure project portal website has been established (follow link in the page of the project) to create an interactive repository of project information, allowing project partners to review, share, disseminate information between each other in a structured way relating to project work, results and deliverables.

Regular press releases are planned for the magazines in the fields of various of the SME end users, initially with very little technical content, and keeping all intellectual property confidential, to generate interest in the technology, and to start to identify potential licensees and spin-off applications.