



MASTER THESIS

For

Stud.techn. Sondre Sætrang
Spring 2009

RSW systems with CO₂ as refrigerant - testing of new system solutions for sea water coolers

RSW system med CO₂ som kuldemedium – utprøving av nye systemløsninger for sjøvannskjølere

Background and objective

R-22 is the most common refrigerant in RWS (Refrigerated Sea Water) systems on fishing vessels today. The Montreal Protocol, which Norway has signed, calls for the phase-out of refrigerants with high GWP (Greenhouse Warming Potential). From 2010 all import of R-22 will be forbidden. Current replacements are artificially developed chemicals like HFCs (Hydrofluorocarbons) or natural refrigerants (found in nature). HFCs have high GWP (Global Warming Potential), between 1300 and 3300 times greater than CO₂. For this reason, the HFCs are charged an environmental tax; HFC-404A, for instance, is taxed about NOK 590/kg. Previous research show refrigerant losses from the Norwegian fishing vessels of about 30% annually on average, and this imposes an environmental problem as well as large costs for the vessel owners.

In close cooperation within GEMINI-center Applied Refrigeration at NTNU and SINTEF the focus is directed toward using natural refrigerants such as ammonia (NH₃), carbon dioxide (CO₂) and hydrocarbons (methane, ethane, propane etc). This community has a world leading position on revitalization of CO₂ (used on transport vessels 60 to 80 years ago). The former professor Gustav Lorentzen with coworkers took out patents in the late 1980s which takes advantage of the carbon dioxides positive properties.

In the laboratories of NTNU and SINTEF, a prototype RSW system using CO₂ as refrigerant has shown very promising results. The system is rigged with measurement instrumentation and experimental results are available, but there is still room for improvements with regards to system design and component optimization. The system has been rebuilt to include a suction gas heat exchanger and this has improved the performance of the evaporator system. In this work it would be focused on optimizing the transcritical system with an adjustable bypass valve in front of the suction gas heat exchanger.

The following questions should be considered in the project work:

1. Literature review of RSW systems
2. Dimensioning and installation of a bypass valve in front of the suction heat exchanger
3. Design and performance of the experimental test of the operation of the installed valve

4. Development of a calculation tool to optimize the combinations of the high pressure and the temperature in front of the expansion valve.
5. Make a draft of a publication of the results from the work
6. Make proposal for further improvements

-- " --

Within 14 days of receiving the written text on the diploma thesis, the candidate shall submit a research plan for his project to the department.

When the thesis is evaluated, emphasis is put on processing of the results, and that they are presented in tabular and/or graphic form in a clear manner, and that they are analyzed carefully.

The thesis should be formulated as a research report with summary both in English and Norwegian, conclusion, literature references, table of contents etc. During the preparation of the text, the candidate should make an effort to complete a well presented report. In order to ease the evaluation of the thesis, it is important that the cross references is correct. In the making of the report, strong emphasis should be placed on both a thorough discussion of the results and an orderly presentation.

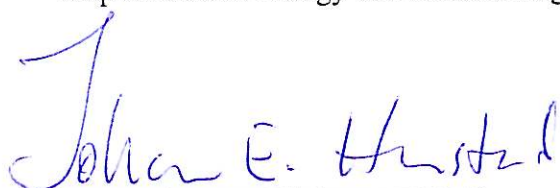
The candidate is requested to initiate and keep close contact with his/her specialist teacher and academic supervisor(s) throughout the working period. The candidate must follow the rules and regulations of NTNU as well as passive directions given by the Department of Energy and Process Engineering.

Pursuant to "Regulations concerning the supplementary provisions to the technology study program/Master of Science" at NTNU §20, the Department reserves the permission to utilize all the results for teaching and research purposes as well as in future publications.

One – 1 complete original of the thesis shall be submitted to the authority that handed out the set subject. (A short summary including the author's name and the title of the thesis should also be submitted, for use as reference in journals (max. 1 page with double spacing)).

Two – 2 – copies of the thesis shall be submitted to the Department. Upon request, additional copies shall be submitted directly to research advisors/companies. A CD-ROM (Word format or corresponding) containing the thesis, and including the short summary and all relevant information used must also be submitted to the Department of Energy and Process Engineering

Department of Energy and Process Engineering, January 12th 2009



Professor Johan E. Hustad
Department Manager



Prof. Trygve M. Eikevik
Academic Supervisor

Research Advisors:

Håvard Rekstad, NTNU, e-mail: havard.rekstad@ntnu.no