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Title of thesis: Experimental investigations of an ammonia/carbon dioxide cascade system for supermarket refrigeration

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## Abstract

A refrigeration system solution for a supermarket has been built in IUC laboratory in Katrineholm. The system is equipped with extensive instrumentations to collect data and perform online diagnosis. Several variations of the system solution are applied for validation and possible modifications.

In the project period we investigated and evaluated the performance of NH3/CO2 cascade system for supermarket refrigeration application in a laboratory controlled environment. The system solution under investigation replicates a medium size supermarket in Sweden. CO2 is used at the low and medium temperature levels with several possibilities available for system variations and parametric analysis.

Overall system evaluation has been performed. Different circulation rates at the medium temperature level have been tested. Control system of the freezing cabinets has been evaluated. The CO2 compressor and cascade condenser performance have also been investigated. The possibilities for gravity circulation have been examined.

The results of the tests show that CO2 system has a reasonable COP with good agreement between the experimental data and computer model. Evaluating the different circulation rates of CO2 at the medium temperature level shows that it should be kept as low as possible and there is no optimum value as in conventional brine in indirect systems. The control of the electronic expansion valve should be based on the evaporating pressure rather than measuring surface temperature of the evaporator. Since a high instability observed in keeping low superheat value in the freezer cabinets, using an internal heat exchanger was avoided not to have high discharge temperature. The CO2 compressor has reasonable performances with good isentropic and volumetric efficiencies. The heat transfer performances in the cascade condenser are almost the same while varying between forced condensation and thermo-syphon scenarios and they all observed to be quite stable. In the gravity circulation test, mass flow of CO2 pulses and temperatures fluctuates accordingly which indicates that the available height is not sufficient enough to maintain continuous flow of CO2. The same trend is observed at all simulator capacities. The pressure drop in the pipes and the heat exchangers are quite small and the main pressure drop sources in the CO2 system are the filters and the mass flow meter which is not overcome by the limited available head.

Based on the experience in designing the system, running and evaluating its modifications, it is possible to conclude the application of a NH3/CO2 cascade refrigeration system would be a comparable environmental friendly and efficient option for a medium size supermarket in Sweden. Moreover, according to the findings of this thesis, there are still spaces to achieve higher overall system performances. Possibility of using gravity circulation would have a positive effect on overall system performances. Additionally, an improvement in overall system performances is reasonably expected, using especially designed components to handle and benefit CO2's feature. They will all direct the future research to improve the efficiency of such refrigeration systems.