Performance Assessment and Active System Monitoring for Refrigeration Systems

The refrigeration system in a supermarket is an important part of the business for the supermarkets, both in terms of the possibility it provides and because of the associated cost of operating the system. It provides the possibility of selling chilled and frozen food but on the other hand the operation of the refrigeration system is associated with a significant cost. Cost efficient operation of the refrigeration system is therefore very important for the supermarkets. To ensure that the systems are operated cost efficient a performance assessment scheme is required. In addition, there exists a need for algorithms that ensures or improves the performance of the system. A supermarket refrigeration system is usually a complex and distributed control system, and it can therefore be difficult to assess the performance without a formal method. The main interest for a supermarket, with respect to the refrigeration system, is to optimise the total cost of ownership (TCO). However, directly measuring TCO provides some challenges. It can therefore be beneficial to divide TCO into performance criteria, which can be quantified and measured. For supermarket refrigeration systems the performance criteria can be divided into three categories: quality-, energy- and reliability-related criteria. Hence, it is important to operate the refrigeration system such that it ensures good quality of the stored goods as energy efficient as possible without compromising the reliability of the system. A performance function that quantifies and measures the criteria has been developed in this project. The quality is measured by the control errors in the system because there is a connection between the quality of the stored goods and the ability of the refrigeration system to provide the required temperature. A deviation from the controller set-point corresponds to a temperature deviation, which will eventually harm the stored goods. The energy efficiency is measured by the coefficient of performance, COP, which basically is the delivered cooling power divided by the consumed electrical power of the system. The reliability criteria is measured by the switch frequency of the compressors in the refrigeration system. The reason is that excessive compressor switching will wear down the compressors too fast and thereby decrease the reliability of the system due to a higher demand for maintenance. The proposed performance function provides a method for assessing the operational performance at a plant-wide level and is therefore providing a tool for improving the plant-wide performance. The performance function has been used in different setups to improve the performance of the refrigeration system. Static and the dynamic performance of the refrigeration system has been addressed in the project. The proposed methods for improvement relies on a minimum of detailed knowledge about the refrigeration system. In addition, since a refrigeration system often operates in steady state an active system monitoring setup has been proposed, to enable improvement of the dynamic performance.