CCS-Lund Collaboration MS Thesis Topics
Control Architecture & Fault Detection

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Summary

The purpose of this note is to outline an area of collaboration between CCS and the Department of Automatic Control at Lund University. The intent is to develop a series of MS thesis areas and to have MS students working in CCS design centers with UTC mentors. This document describes one area that is of mutual interest and also gives a structure for the collaboration in listing thearea, the mentors, the location that the student will work at and identifies the type of publishablework that is expected to emerge from the work.

MS Thesis Topics

Air-cooled mini centrifugal heat pump control architecture design

Mini-centrifugal compressor technology could be the key to enable compact system design for small tonnage air-cooled air-conditioning or refrigeration systems, especially for system using low GWP refrigerants. Such system inherited control challenges from both centrifugal chiller and air-cooled heat pump including

1) Surge detection and control for centrifugal compressor

2) Actuator couplings, such as fan, main-EXV, sub-EXV, compressor, HGBP valve and etc.

3) Controller robustness for a large range of operating conditions.

The challenge is to analyze system controllability and design robust control architecture/algorithm for such complex systems ensuring efficient operation all the time.

I&R research program: mini-centrifugal air-cooled heat pump. I&R research (highly confidential project since it involves disruptive technology).

Adaptive Superheat Control

Electronic expansion valves (EXV) are used to control suction super heat in typical refrigerating system. Control objective is to prevent liquid carryover to compressor and improve system efficiency. However, most of PID controllers employed are designed and tuned for design conditions and cannot automatically adjust and meet control requirements at off-design conditions due to strong system non-linearity.

For example, the system will have dramatically different gain and time constant of superheat loop depending on whether the system in heating or cooling operation, high or low load operation, high or low lift conditions, etc.

The challenge is to design optimal and adaptive algorithms to deal with system nonlinearity and coupling with other actuators.

Program: Any programs using EXV, especially heat pump. For instance:

- *30KQV (Air-cooled NG Screw Heat pump)*
- *Modular chiller*

Fault detection and diagnostics

Hundreds and thousands of commercial chillers are working in various conditions. Different kinds of faults would occur during their operating, for example, sensors bias, actuator disfunction, heat exchanger or compressors degradations, etc. Some of the faults that finally impact customers would be complained and then be repaired. But many of them will not be noticed by customers, even though they may affect the chillers' operation seriously. It is hard and even impossible for service team to find these faults for so many chillers via regular services. Therefore, how to detect and diagnosis the faults in time even in advance is a helpful and necessary topic. In addition, challenges come from the available data is limited due to the added cost to the chillers if additional sensors are required.

The challenge is to design robust and computationally-effective algorithms to filter, analyze massive field data for selected faults and recommend actions.

Program: digital twin, connected service

Mentor and Supporting Team

- Pei Sun, Liang Chang (mentors)
- Weijuan Wang, Runfu Shi (product team)
- Lishan Wang, Degang Fu, James Fan (supporting team)

What is new & publishable?

The listed topics are practical problems in Carrier and also common commercial HVAC problems. Novel control and FDD technologies will bring great value to HVAC industry and so the actual implementation will have to be protected. The material that should be publishable in some form are the following:

- Model based design industry practice for mini centrifugal heat pump.
- Adaptive superheat control architecture for typical refrigeration system.
- Fault detection and diagnostics applications in HVAC system.

Location

The primary working location will be at the UTC Climate, Controls & Security Shanghai R&D Center in Shanghai, China. The student will work closely with both senior and junior engineers (which

will be learning along with the student).