HVAC Failure Simulation

HVAC equipment data analysis and failure simulation

ELECOMP Capstone Design Project 2018-2019

Sponsoring Company:

Bosch Thermotechnology Corporation
65 Grove Street,
Watertown, MA 02472
http://www.boschheatingandcooling.com

Bosch Thermotechnology is continuing their support of the Program they initiated last year:
https://web.uri.edu/elecomp-capstone/project-details-by-team/bosch/

Company Overview:

In North America, Bosch Thermotechnology is a leading source of high quality heating and cooling systems, water heating systems and comfort heating systems. In particular, the company offers BOSCH tankless water heaters, floor-standing and wall-hung boilers, air-source and water-source heat pumps, as well as controls and accessories for every product line.

Bosch Thermotechnology is committed to reinventing energy efficiency by offering smart products that fit together and work together as integrated systems which enhance the quality of your life in an ultra-efficient and environmentally friendly manner.

The Bosch Group has been a leading global supplier of technology and services in the areas of Automotive, Industrial Technology, Consumer Goods and Building Technology for over 100 years. The company was founded in Stuttgart, Germany, in 1886 and today has more than 300 subsidiaries in over 150 countries.

Every Bosch product is built with one goal in mind; to enhance the quality of your life every day by providing solutions which are both innovative and truly beneficial.

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A few visits may be needed to discuss the project at the Bosch facilities in Watertown, MA. At least one member of the team should have a means of transportation to and from the facility.

Project Motivation:

The residential and commercial HVAC industries use various components to design their heating and cooling systems. Over the years, systems have evolved to include more and more electrical and software based components (on top of the numerous mechanical components necessary for good heat transfer). Due to the increased number of components within an HVAC unit, there is an increased number of parts that can fail in the field. Bosch is a company devoted to quality and the brand Invented for Life; therefore we pride ourselves in having reliable, high quality products. Our customers purchase our solutions because of our reliable products and low failure rates. The purpose of the project is to determine why today's HVAC components fail, how they fail, and propose solutions to extend the life of these components in the units (specifically Air Source Split Air Conditioning Units, and Water Source Heat Pumps).

Anticipated Best Outcome:

- Modify/upgrade the existing embedded system design
- Modify/upgrade existing GUI for improved UX
- Demonstrate sensor data capture, analysis and reporting
- Simulate actual HVAC failure using failure data patterns
- Enable cloud storage for data

Project Details:

This project is a continuation of work completed by last year's ELECOMP capstone graduates. More information can be found here:

https://web.uri.edu/elecomp-capstone/project-details-by-team/bosch/

Expectations for April 2019 is to have the team present a working prototype of that covers the following details:

- Upgrade current version of the embedded system. Since the available prototype is fixed on one HVAC unit, the team can work on designing a portable version.
- Integrate additional hardware (eg: pressure sensor)
- Upgrade current version of the GUI. The GUI will now have better data visualization and include trends, alarms etc.

- The SW will be able to generate a report with inputs (temperature, humidity etc.,) and outputs (Blower, compressor etc)
- Produce controlled faults/failures in specific mechanical/electrical systems using data analysis. The systems can include (but are not limited to):
    - Blower/Fan motor
    - Compressor
    - Electronics
    - Run/Start Capacitors
    - Reversing valves
    - Thermal Expansion Valves (TXV)
    - Heat exchange coils
    - Water Pumps (where applicable)
    - Pressure switches
- Provide schematics for all proposed design improvements and prototype where applicable and feasible
- Enable cloud storage for the sensory system data

Overall System Concept:

Two heat pump systems will be considered for this project.

1. **Inverter Ducted Split (IDS) Air Source Heat Pump:**

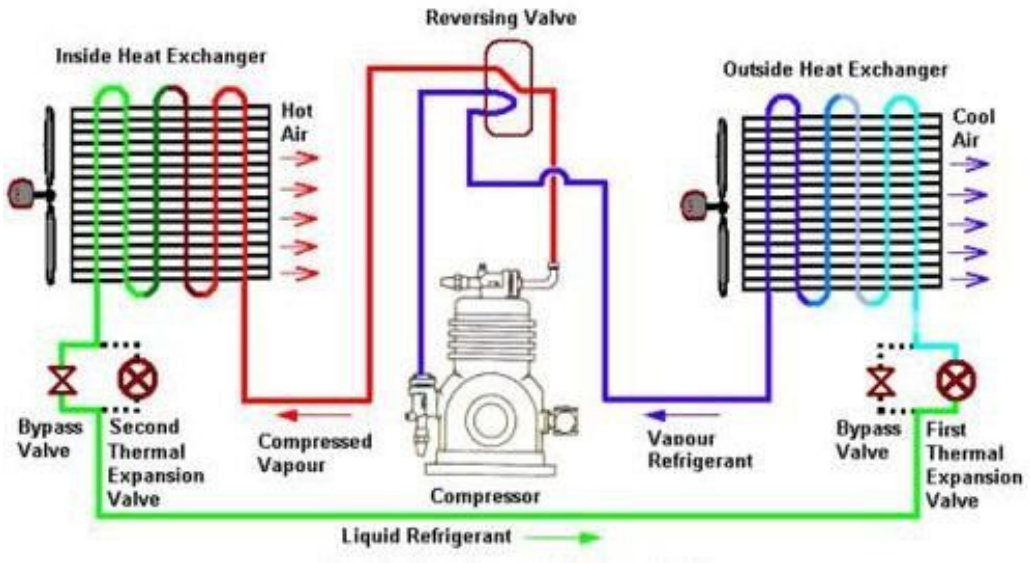
These high-efficiency, robust, and quiet Inverter Ducted Split system heat pumps are available in four sizes ranging from 2 to 5 ton capacity. The system boasts a variable speed inverter drive which adjust the speed of the compressor to optimize comfort, while keeping sound levels to a minimum and utilizing just the right amount of energy to achieve maximum efficiency.

2. **Water-to-Air Geothermal Heat Pump:**

Bosch geothermal heat pump systems are some of the most energy and cost efficient on the market, as well as the greenest technology for heating and cooling your home. The technology utilizes the constant temperature of the earth which makes it extremely efficient all year long in virtually any climate.

Block Diagram:

Basic Heat Pump Operation/Concept



**Samples web image*

Hardware/Electrical Tasks:

- Devise/Propose means of modifying the current sensor network in order to make it portable
- Create requirements document for proposed hardware improvements
- Determine a list of hardware that can improve functionality (eg: pressure sensor) and propose ways to integrate them into the current embedded system.
- Provide documentation on all changes.
- Devise test cases for hardware verification

Firmware/Software/Computer Tasks:

- Propose/develop algorithms for tracking a reporting component failures
- Propose/develop improved graphics interface for monitoring system performance
- Software verification and testing
- System Integration testing
- Research different data storage and sharing technologies
- Documentation/Reports

Composition of Team:

- 1 Electrical Engineer and 1 Computer Engineer

Skills Required:

Electrical Engineering Skills Required:

- Knowledge of digital and analog circuits
- PCB design and layout
    - *Preference will be given to seniors enrolled simultaneously in ELE391: Course on PCB Design, to be taught by Mike Smith*
- Design specification
- System/Integration testing

Computer Engineering Skills Required:

- Proficiency in C
- Experience with object-oriented programming
- Experience with graphic user interface (GUI) design
- Mobile/web app development experience
- Networking experience
- Familiarity with building Automation Systems is a plus
- Familiarity with HVAC systems is a plus

Anticipated Best Outcome's Impact on Company's Business, and Economic Impact

Completion of this project will be a huge bonus to the Bosch team by providing deep insights into field failure rates. In today's world, heating and cooling solutions are necessities to homeowners, renters, and all of humanity. As an HVAC equipment producer, we need to understand our field failures to better ensure that our customers never go without heating and cooling. This necessity is especially true in New England winters and southern summers. The students participating in this project would receive valuable hands-on engineering experience as well as contributing to a great brand and quality products.

Broader Implications of the Best Outcome on the Company's Industry:

As with any quality engineered product, this information will allow Bosch to continue developing quality products and ensure that our units never fail while in the field. As our competitors in the space continue to grow, we at Bosch must continue to grow as well to remain competitive with the market.