Electronically Commutated Motor (ECM) Case Study

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A Report of BPA's Energy Efficiency Emerging Technologies Initiative

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An Emerging Technologies for Energy Efficiency Report

The following report was funded by the Bonneville Power Administration (BPA) as an assessment of the state of technology development and the potential for emerging technologies to increase the efficiency of electricity use. BPA is undertaking a multi-year effort to identify, assess and develop emerging technologies with significant potential for contributing to efficient use of electric power resources in the Northwest.

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Contract Objective

The objective of this contract is to provide engineering services, design considerations, and recommended controls sequence for the heat pump condenser loop pump replacement and system upgrades. The new pump will have an Electronically Commutated Motor (ECM). The system upgrades will consist of replacing small circulation pumps with 2-way flow control valves at each heat pump.

Project Location

The office building is located in Kalispell, MT.

Existing Mechanical System

The existing mechanical system to be modified is a water source heat pump type utilizing a supply well and injection well (source) coupled to an internal building loop (load) with a flat plate heat exchanger. The load side of the system (internal building loop) is comprised of a primary/secondary piping system with constant speed pumps on both the primary and secondary sides. There are (2) ¾ HP primary pumps piped in parallel sized to provide approximately 60% of the required flow at design conditions. These pumps operate 100% of the time. Upon a need for either heating or cooling, the heat pump(s) and secondary circulator(s) are engaged.

Proposed Upgrades

The proposed upgrades will occur in two phases:

Phase 1: Replace one of the existing ¾ HP pumps with an ECM type that will decrease the energy consumption. It will be sized based on the full block load conditions of the building and be adjusted through its integral variable flow controls to provide a constant flowrate in order to meet the potential full flow required by the system. This will allow the existing piping system to be kept in place.

Phase 2: The primary/secondary pumping/piping system will be converted to a "header" supply/return system with motorized control valves for each heat pump. This will permit a variable flow system and take full advantage of the energy saving ECM technology. The minimum require flowrate through each unit will be adjusted, allowing the new pump to operate at its minimum rate.

Design Considerations

Typically, an ECM pump would be used in a variable flow application to maximize the operational efficiency. Because the ECM pumps readily available in the North American marketplace are relatively smaller HP (<2HP), their flow and head capacities are limited. Design should generally incorporate variable flow, low head piping elements, and closed piping systems to permit the lowest pumping energy associated with ECM pumps.

Application Examples

ECM pumps should be considered for most variable flow and many constant flow applications. Various manufacturers have performed case studies indicating that even in constant speed systems, the ECM pumps provide higher efficiency and lower operational costs when compared to their induction type counterparts. When used in variable flow systems such as hydronic heating and cooling systems, the operational saving is even more. Hydronic radiant floors, variable chilled systems, geothermal, and domestic hot water recirculation systems are a few examples where ECM technology can be applied.

Recommended Control Sequence

For Phase I of the heat pump condenser loop upgrade, the pump will be programmed to run 100% of the time, similar to the existing pump system. This is required because the existing system utilizes a primary/secondary loop design where flow through the primary loop must remain, regardless of the mode of the individual heat pumps. The specified ECM pump has an integral control system that monitors pressure across the pump. The maximum flowrate will be a function of the buildings instantaneous load, typically during morning warmup, and shall be programmed within the pumps integral control system.

A main feature of the ECM pump technology is how their speed can be controlled without significant energy losses. Most include integral controls that can respond to internal pressure changes or can be controlled with an external controller based on temperature differential Phase II of our upgrade will include the conversion of the system to take advantage of the integral differential pressure controller.

The piping will change from a primary/secondary system with each heat pump requiring individual pumps to a simple supply/return header system with a single pump and 2-way flow control valves on each heat pump. With the new system, when individual heat pump are "called" for heating or cooling mode, the 2-way control valve will be open and their compressor engaged. This will reduce the pressure differential across the supply and return header. The new ECM pump will sense this reduced pressure and increase in speed and flow. As each heat pump is engaged additional flow will be provided. As zones are satisfied, the heat pump will be disengaged, and the flow control valve will close, increasing the differential pressure in the system, which in turn will cause the ECM pump to decrease speed. This constant differential pressure control mode is typical with most ECM pumps and requires no external controls.

Required Commissioning

Upon installation, the commissioning process for the specified pump is relatively easy. With the required flow and resulting pressure differential known, the pump can be programmed to provide the flow with its integral controls. It will do so at the minimal required energy consumption. A digital manometer will be used to verify flow.

Bonneville Power Administration (BPA) Energy Efficiency Emerging Technologies (E3T) Style Guide

Purpose
The purpose of all report writing is to “provide unbiased, independent, empirically based information to decision-makers.”

Syntax and writing style

Clarity of communication is essential to our efforts. Reports produced for E3T should be guided by the following principles:

- Writing style should be terse and analytical. Some of the best reports are a concise presentation of key elements.
- Figures and other visual representation should be included where they best convey information while minimizing accompanying text.
- Acronyms and uncommon terms should be defined so that all audiences will understand the report.
- Avoid using acronyms and uncommon terms in the Executive Summary. Define these in the main body of the report.
- Use third-person, objective voice, providing a clear understanding of cause, effect and responsibility.

Format and pagination

Reports shall be provided in Microsoft Word using Arial 10 point font. Other than the executive summary and appendices, reports shall use sequential (1, 2, 3, etc.) pagination rather than sectional (1-1, 1-2, 1-3, followed by 2-1, and 2-2, etc.) pagination. Tables and figures may be numbered consecutively or by section.

Citations

All supporting research shall be cited using MLA Formatting and Style Guide, Works Cited format:
http://owl.english.purdue.edu/owl/resource/747/05/

Assumptions

All assumptions shall be documented and their effects clearly explained.