Massena Electric Department (MED) Water Heater Project

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Introduction

Sponsored by Massena Electric Department, based in Massena, NY, the driving need of this project is to be able to economically advance water heating systems in the most efficient, effective, safest, ethical, and modernized way; using an SD card to save data, or a Wi-Fi adapter to transmit real-time data to a mainframe, which can be gathered to determine the status of the system. Doing this to the unaffected system will create a more modern technological system that will comply with modern technological laws and constraints, whilst also leaving room for creativity and improvisation. Having the product be more modern will help to reassure customers that the system falls in line with modern conventions and laws, and will help companies producing the equipment understand it in a more clear and defined way. Additionally, making the price of the equipment cheaper, with affordability being a solitary concern, for users and manufacturers alike, will help to make the equipment more affordable to produce, and acquire.

Background

Turning an everyday-use water heater into a water heater than can transmit data via Wi-Fi

In the modern world, technology is constantly being improved to incorporate a more modern approach to past technological inventions. Some of these changes improve cost effectiveness and sustainability; while others involve collecting and sharing data about devices we use. Electric Domestic Hot Water (DHW) heaters account for significant energy usage, often at times of peak electricity use; This project is designed to measure that usage.

Objectives

Develop a system to:

- Collect temperature and energy usage data from an electric resistance DHW heater
- Store the data on a local SD card or transmit it via the internet to a host computer, and
- Develop a program to analyze the data

Design Requirements

Needs	Wants	Like-to-haves
Read amperage, the temperature of water going into tank, coming out of, and water inside tank, and save on SD card for analysis, as txt or csv file	Easy and quick installation of temperature reading components and transmitter	Protection from user interference of the system
Gather data on electrical power usage	Fully automate the system	
Be compatible with any electric resistance water heater system	Cost effective – maintain as low a cost as possible	

Cost Estimates

Name	Quantity	Estimated cost (Ea.)
Arduino UNO and SD reader	1	$35.00 + $15
Arduino relay	1	$15.00
Thermocouple AD8495	3	$12.00
Clamp ammeter	1	~$33.00
Mini Breadboard	1	$2.00
Galvanized electrical box	1	$6.00
Thermostatic mixing valve	1	$72.00
Water heater tank insulation blanket	1	$44.00
	Total:	$258.00

Initial Research

During the initial design, the following information was gathered:

- Arduino Uno modules are viable options to use for programming the system
- Arduino IDE would be easier to code the modules, versus doing it on python, or otherwise
- An Arduino shield would be simpler to use as a Wi-Fi module

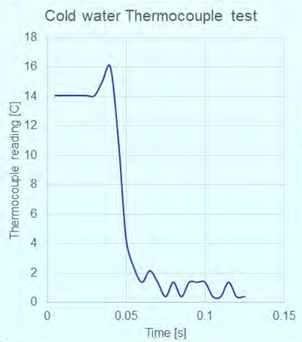
Electrical Assembly

Thermo-well and Purpose

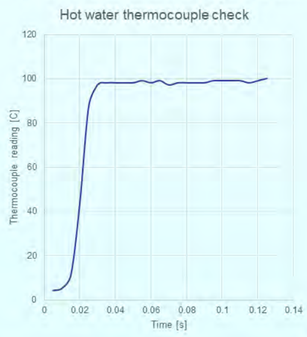
The “thermo-well” is a way to place a sensor inside the tank. Having this sensor will allow the ability to gather information on what the temperature is inside the tank. This is for experimental purposes only.

Thermocouple workability

Cold water reading check



Hot water reading check



Temperature setting

Temperature selection

The temperature for outgoing water was selected to be 125 degrees Fahrenheit. The temperature was selected to be the average of 120 and 130-degrees Fahrenheit. This was because below 120 Fahrenheit there is increased risk for legionnaires disease, and at 130 Fahrenheit, scalding starts to occur. The desired temperature selected was calculated by using the following methodology:

$$\frac{(120+30)degrees\ F}{2} = 125\ degrees\ F$$

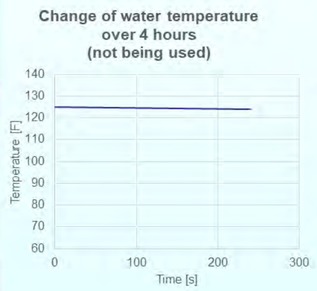
Potential to raise tank temperature

While the temperature can safely be selected to be 125 degrees Fahrenheit, there is potential to raise it, if there are other controlling components to negate the scalding effect, while in use. This, however, still opens door to serious burns from the tank, following the timestamps below:

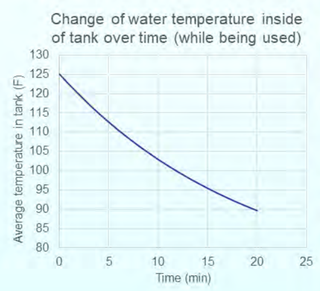
- 120 Fahrenheit = more than 5 minutes
- 125 Fahrenheit = 1-1/2 to 2 minutes
- 130 Fahrenheit = about 30 seconds
- 140 Fahrenheit = less than 5 seconds
- 150 Fahrenheit = about 1-1/2 seconds
- 160 Fahrenheit = 1/2 second

Theoretical Heat Transfer Effect

Stagnant



Dynamic/transient



Tempering valve and Insulation blanket

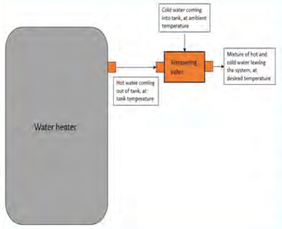
Tempering valve

The purpose of the tempering, or mixing, valve is to be able to manipulate the outgoing water temperature from the tank to the desired temperature, while maintaining a high temperature within the tank

Insulation blanket

This will make the overall heat transfer of the system drop, which will save energy during reheating. Also protects from potential burns. Preferred R8 or higher

Theoretical usage of a tempering valve & future work



The main use of the tempering valve is to manipulate the system by not using as much hot water from the tank, and mixing it with some cold water, coming from another line. This will be tested by implementing a mixing valve into the system, while performing experiments in future research and testing. These tests will help determine whether a mixing valve is a helpful component in further advancing the system

Theoretical usage of an insulation blanket

The use of the insulation blanket is to help maintain the internal temperature of the tank. Having this will help to maintain a higher tank temperature for a longer period of time, which will help to save more energy, during the reheating process.

Conclusion

Electric Domestic Hot Water (DHW) heaters account for a major usage of energy in the modern world, especially in areas that get significantly colder than others. Unfortunately, modern water heaters are not equipped to draw less energy for heating up, due to the components to do so being too expensive, while providing little to no results. With this in mind, research was done and formulated to tackle this issue, and analyze the power usage, while maintaining a relatively low cost. From the data gathered, the most reliable way found to potentially fix this issue is to use a tempering valve, along with an insulation blanket. Having these components will help to increase the amount of time, where hot water is available, and providing a way to draw less energy to reheat the system after its previous use.

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