Deliverable H - Prototype III and Customer Feedback

Group Members:

Anmol Brar 300247248
Kate Valentine 300217812
Liangyi Jinjing 300234642
Rayane Laouadi 300250220
Tristan Ruel 300272156

March 27th, 2022

Abstract

Prototype III was successfully constructed and tested for its operation and its components. The operation of the whole system was checked by measuring the inlet and the outlet air temperature. The solar panel that powers the supple fan was tested during a sunny day to measure its output in terms of peak voltage and current. The water condensation was checked by measuring the water collected at that level when humid or moist air was drivin through the piping system. The shutoff valve that controls the outdoor air was checked during cold conditions simulating winter conditions when cooling is not needed. All the testing was successfully completed as planned. There was a lot of feedback from clients and users of the system particularly to improve the cooling efficiency of the heat exchanger, position and orientation of the solar panel to maximize its output, and the inclination of the outlet pipe to collect the most of the condensed water.

Table of content

List of Figures

List of Tables

1.0 Introduction

In the previous deliverable we have developed a testing plan of prototype III. The objective was to check the operation of a complete prototype system. The prototype III consists of a heat exchanger chamber, inlet pipe, outlet pipe, circulation fan, sump pump and regulation valve of outdoor air. All these components were connected together to perform the testing of the prototype. In this deliverable we will present the results of the testing plan and gather feedback from potential clients/users.

2.0 Results of prototype test plan III

2.1 Operation of the system

The testing plan of prototype III consists of bringing warm outdoor air at temperature T_{in} into the inlet pipe which itself is connected with the heat exchanger chamber. The supplied outdoor air will exchange heat with the cool storage medium of the heat exchanger chamber and exits at a cooler temperature T_{out}. A supply fan is placed between the heat exchanger chamber and the inlet pipe. The fan is powered by a battery with a maximum power of 60 W. The inlet and the outlet air temperature and the flow rate were measured continually for one hour. After the end of the measurement time the values of the temperature were reported. The temperature of the storage medium was also measured. Four values of the outdoor air temperature were considered. Figure 1 shows a snapshot of the heat exchange chamber of prototype III. The measurement results are shown in table 1 below:

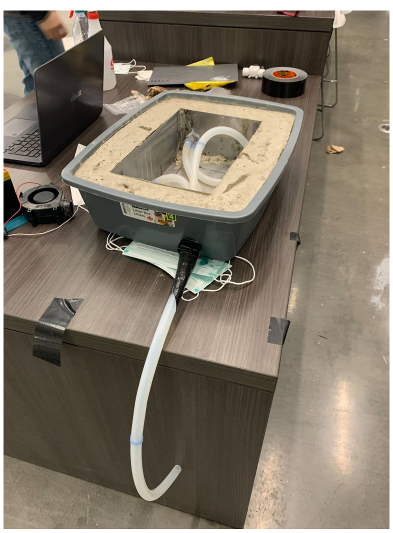


Figure 1: Heat exchange chamber Prototype III

Table 1: Measurement results

Flow rate (L/s)	T_{in} (ºC)	$T_{storage}$ (ºC)	T_{out} (ºC)
10.0	25	18	20
10.0	28	18	21
10.0	30	18	23
10.0	32	18	24

2.2 Measurement of the solar panel power

A solar panel (module) composed of five panels joined together with a nominal peak voltage of 2.5 V and a current of 0.13 A. The panel was facing the south and inclined at an angle of 45º from the horizontal (this is equal to the latitude angle of Ottawa). The measurement was done at noon time during two sunny days. Table 2 shows the measurement of the solar panel output.

Table 2: Measurement of the voltage and current of the solar module

Voltage (V)	Current (A)
2.0	0.10
2.1	0.12

2.3 Measurement of the water condensation inside the outlet pipe

The wetted tissu was placed after the supply fan to humidify the outdoor air at a fixed temperature of 30 ºC. The relative humidity at the tissue level was maintained at roughly 60% for the operation of the system. The humidity level at the outlet pipe was measured continuously for one hour. At the end of the measurement, both the humidity level at the inlet and outlet pipe were reported and an amount of water collected at the sump pump level was weighted. Table 3 shows the measurement results of the water condensation in the pipe.

Table 3: Measurement of water condensation

Relative humidity inlet (%)	Relative humidity outlet (%)	Water (g)
62	100	3.0
65	100	3.5
59	100	2.8

2.4 Operation of the shutoff valve

The operation of the shutoff valve was tested during a cold day condition with a temperature lower than 18 ºC. We checked this visually and the valve was working as planned when the temperature is lower than 18 ºC.

3.0 Analysis of prototype III

The operation of the system of prototype III was successful. The outlet air temperature was found to be lower than the inlet air temperature by a few degrees celsius.

Similarly the solar module was working as planned. The measurement of the peak voltage and current during a sunny day at noon time (when sunlight was perpendicular to the solar panel) were very close to the nominal peak voltage and current as reported by the manufacturer of the solar panel.

Likewise, the measurement of the water condensation was as well successful. The relative humidity at the outlet pipe was close to 100 percent which means the air was saturated and the remaining water was condensed at the sump pump level. Indeed the collected water at the sump pump was significant (higher than 2.8 g).

Lastly, the shutoff valve was working properly when the outdoor air temperature was below 18 degrees celsius as designed.

4.0 Feedback from potential clients/users

"I like the idea, very innovative. Now you just need efficiency."
-Mike L, Environmentalist

"I understand that this is small scale, but I'm sure you guys could explore different layouts for your pipes inside of the heat exchanger that might result in a better heat exchange."
-Liz K, Process Engineer

"You guys have done such amazing work!"
-Fareed S, Student

"I love how you guys have the supply fan in your intake, seems to work well. I think you could probably use a stronger fan though, that will get you some more airflow."
-John V, father of student

"I would buy this!"
-Louis L, Student

"You know what would be really interesting, if you actually programmed the solar panel to pivot accordingly throughout the year to maximize power from sunlight."
-Kim B, teacher

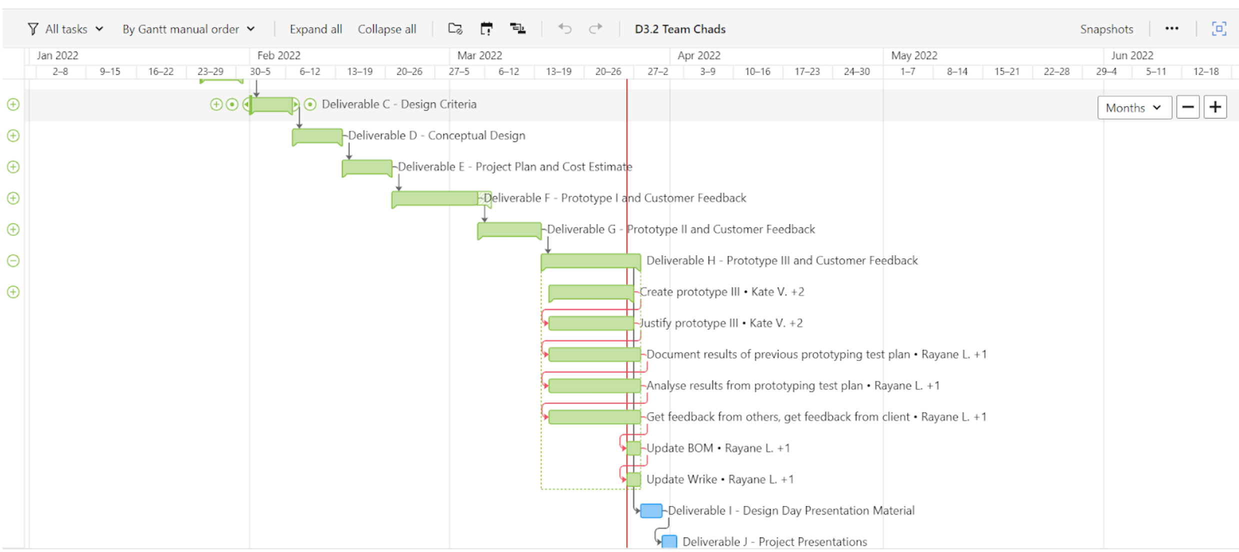
"This is so cool. I'm so impressed! The only suggestion I would have would be to incline the pipe outlet just a bit."
-Avery N, student

"You guys are awesome and so is your design. Super pumped to see what you bring to the table for design day."
-Calvin H, Civil engineer

Our demonstration of the prototype to potential clients and interested users has resulted in useful feedback. We received feedback to improve the efficiency of the prototype. The higher the efficiency the lower the outlet air temperature. Our prototype resulted in not very low temperature to fulfill the cooling requirement of homes. Some potential clients suggested redesigning the heat exchanger pipes system, especially the spacing between the pipes and the length of the pipe to increase the heat exchange between the air and storage medium. Another suggestion was to increase the flow rate of the supply fan. As for the solar panel, some potential clients suggested orienting the solar panel on a monthly basis to maximize the solar throughput of the panel, or to use a sun tracking system to orient the panel so that sunlight is all the time perpendicular to the solar panel. As for improving the water collection in the pipe it was suggested to incline the outlet pipe at an angle of 30-60 degrees from the horizontal.

The overall feedback was quite useful, and may be implemented into our final design, depending on time constraints. With design day approaching so rapidly, some of the feedback may not be feasible to implement. However, as lifelong learners who are all interested and invested in this project, these comments are extremely useful, whether we implement them or not. We were happy to receive lots of praise for our final prototype, and this upped the team's morale going into design day.

5.0 Wrike update



https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=qMnFIvX2K3lZCP3rphXjiKJi8UCgPhJn%7CIE2DSNZVHA2DELSTGIYA

6.0 Conclusion

This work addressed the operation of the heat exchanger prototype III as a system and checking its components functionality. Namely, the operation of the prototype was verified in the lab to make sure the results are as planned. To this end we measured the inlet temperature of the outdoor air and the outlet temperature after the outdoor air passes through the pipe system of the heat exchanger. We tested the system for three values of the inlet temperature (25, 28, 30, 32ºC). The corresponding outlet temperature after one hour of testing was respectively 20, 21, 23, 24 ºC. The component testing included the solar panel and the water collection at the sump pump level, and the operation of the shutoff valve. For the testing of the solar panel the voltage and current were measured during a sunny day at noon time when sunlight is maximum. We found approximately the same peak voltage and current as the nominal values supplied by the panel manufacturer. For the water collection testing we used humid outdoor air (by placing wet tissue after the supply fan) and we measured relative humidity at the inlet and outlet. We found the outlet's relative humidity was all the time 100 percent indicating that the air is saturated and the excess water was condensed at the sump pump level. Indeed the water collected at the sump pump level was about 2-3 grams. The operation of the shutoff valve was successfully verified by sending cold outdoor air with temperature lower than 18ºC and visually checking the valve operation. Our prototype demonstration to potential clients and users has attracted a lot of attention and we received very useful feedback to improve the efficiency of the prototype and its components.