EXPERIMENTAL AND COMPUTATIONAL STUDY OF THE ACCLIMATION OF NEW IT EQUIPMENT

By

NEIL JOHNSON VAZHAPPILLY

Presented to the Faculty of the Graduate School of

The University of Texas at Arlington in Partial Fulfillment

of the Requirements

for the Degree of

MASTER OF SCIENCE IN MECHANICAL ENGINEERING

THE UNIVERSITY OF TEXAS AT ARLINGTON

May 2017

Acknowledgements

I would like to take this opportunity to express my gratitude towards my supervising professor, mentor, teacher Dr. Dereje Agonafer for his constant support, guidance and motivation, throughout my research work. All the advice, words of wisdom and timely support whenever required was the major driving force, which got me the confidence to complete my research work.

I would like to thank Dr. Abdolhossein Haji Sheikh and Dr. Andrey Beyle for taking their time for serving as my committee members. I would like to thank Abel Misrak who guided and helped me throughout the research. I would also like to thank Ashwin Siddarth who helped me save time in the later parts of the research even though he was not part of this project along with my other lab mates for their invaluable support while working late at night at the EMNSPC labs. I would like to thank my roommates Jacob Thomas and Jones Thomas for their help and understanding towards the end of my last semester.

I would like to thank Mrs. Sally Thompson for being the most kind and helpful person throughout my administrative work along with Mrs. Debi Barton.

I would like to thank all my friends in the EMNSPC team. Last but not the least, the most important reason for my completion of this thesis work are my parents Mr. Vazhappilly Kunjuvareed Johnson and Mrs. Rani Johnson Vazhappilly, my girlfriend Soniya Chavan, my sister Neha Paul Koodaly and my brother-in-law Paul Koodaly and the prayers of the rest of my family members and their constant words of motivation. I owe my accomplishment to God who gave me the strength to keep going even at the darkest times of my life.

May18, 2017

ABSTRACT

EXPERIMENTAL AND COMPUTATIONAL STUDY OF THE ACCLIMATION OF NEW IT EQUIPMENT

Neil Johnson Vazhappilly, MS

The University of Texas at Arlington,2017

Supervising Professor: Dereje Agonafer

Acclimation of newly commissioned IT equipment is an important step that is necessary for safe operations. Proper acclimation is required to prevent an unnecessary condensation from forming and causing premature failure in the equipment. Acclimation is particularly important in cold weather shipping where the component or server reaches the destination well below the destination data center's dew point, resulting in moisture and condensate. Operating the equipment before it acclimates might cause damage, while waiting too long for the equipment to acclimate might cost companies expensive computational time. This study tries to address the issue by studying the various factors that affect acclimation and prioritizing them. The goal of this project is to understand the factors that influence the acclimation time and develop a method to predict how long one needs to wait before a component can be installed into the server or the server can be turned on.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

NOMENCLATURE

P Density (kg/m3)

k Thermal Conductivity (W/m-K)

C Celcius

RH Relative Humidity (%)

V Voltage

DAQ Data Acquisition

U Rack Unit (1.75 inches)

OC Open Compute

thrs Time in hours

tc Time constant

Ti Initial Temperature

Tf Final Temperature

Fo Fourier number

Bi Biot number

h Heat transfer coeffiecient (W/m2K)

L Characteristic length

α diffusivity

v Volumetric Flow Rate (cfm)

IT Information Technology

CHAPTER 1

INTRODUCTION

1.1 Need for acclimation

The demand for high data center capacity in the US grew tremendously over the last five years due to the high computational power required by industry. Due to the high demand, production of IT equipment has increased in recent years [6]. These equipment, once manufactured, are shipped to the data centers in various weather conditions. Computing equipment are designed to operate in a specific condition, but some extreme condition shipping leaves the equipment well outside their designed operating condition. This situation is more critical when the shipping conditions are very cold. When these cold equipment reach their destination i.e. the data center which is maintained at a particular temperature and humidity, there is condensation formed on the surface and also inside of the equipment as shown in Figure 1. Powering on such a moist device might lead to failure. To ensure a safe powering on of the device there is a need for acclimation. Acclimation is the process in which an individual organism adjusts to a change in its environment (such as temperature, humidity, etc.).

Figure 1 Condensation on IT equipment

These IT equipment are acclimatized such that the temperature of the equipment reaches the dew point of the data center after which it should be safe to switch on the device.

1.2 Motivation and Objective

1.2.1 Motivation

To address the failure caused due to improper acclimation is the main motivation behind this project. Waiting too little might damage the system while waiting a long time might cause loss of computational time. Understanding the factors that affect the acclimation time is an important step.

1.2.2 Objective

There are 2 main objectives to this project:

1) To identify the factors that affect acclimation.
2) To develop a method or a transient model to predict the estimate wait time before powering on the device.

1.3 Literature Review

One of the most significant works done on the topic of acclimating new IT equipment is by Milnes et. al. That paper is summarized below:

Through experimental work and modeling, the impact of acclimating a system from very cold to very humid conditions was studied on a test rack as shown below-

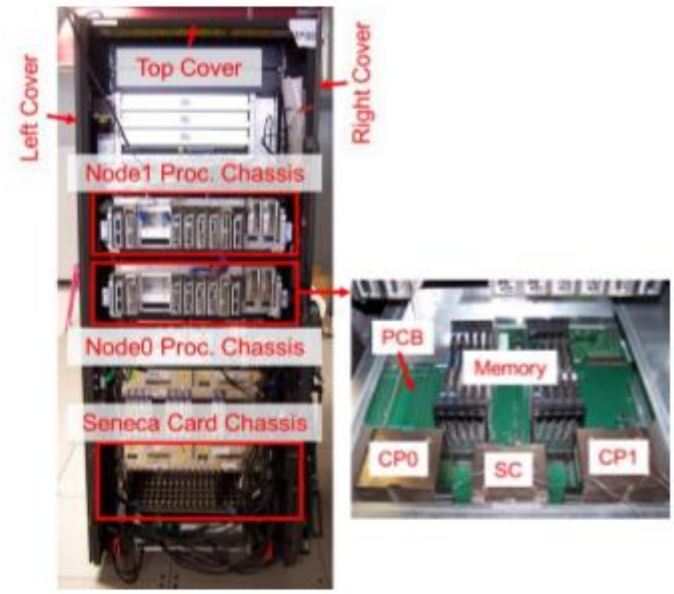

Figure 2 Description of the test rack showing the key drawers and components [1]

Two experimental conditions using environmental chamber:

1) Test 1: -27C and 30% RH to 35 C and 85% RH, temperature and humidity conditions monitored as system acclimated for 48 hours
2) Test 2: -27C and 30% RH to 24C and 54% RH, temperature and humidity conditions monitored for 49 hours, plastic packaging removed 25 hours into the experiment

Acclimation modelling was done to understand the impact of factors like mass, shipping bag removal, and destination conditions on the acclimation time.

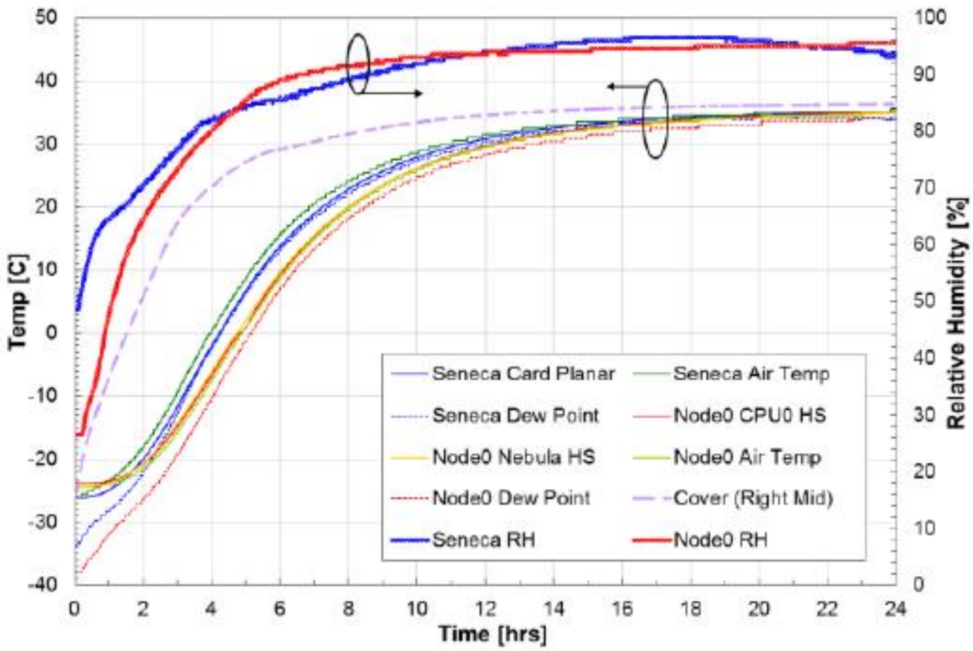

Figure 3. Key temperatures, relative humidities and calculated dew-points within the rack during test 1[1]

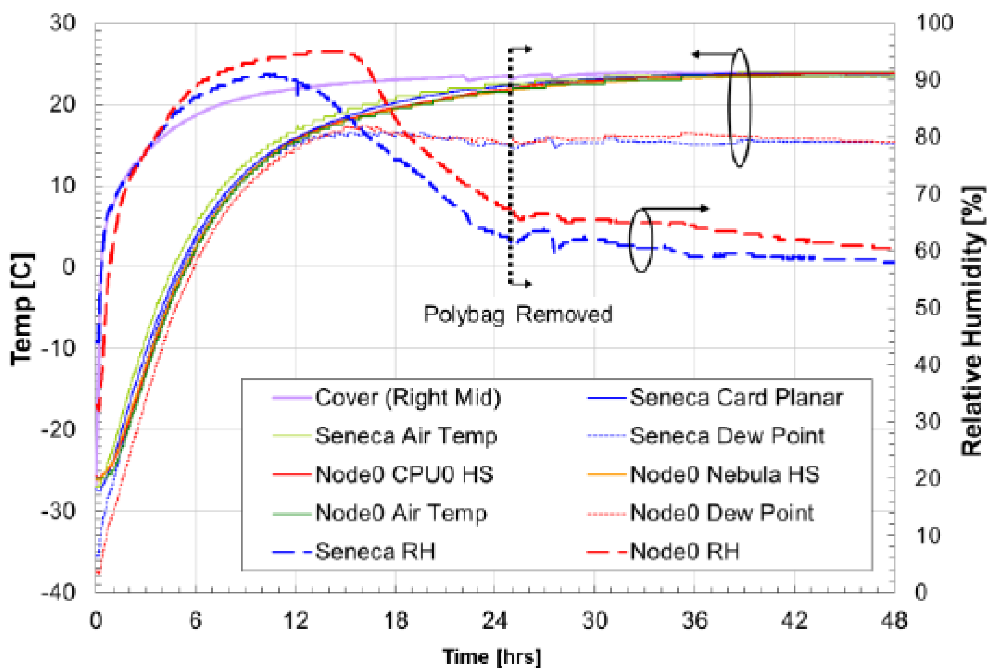

Figure 4. Key system temperatures and relative humidities as the rack is acclimated from -27C to 24C (Test 2) [1]

Recommended	Temp. C	18	23	27
	% RH	60	60	45
	Time w/ bag	**14**	**14**	**12**
	Time w/o bag	**53**	**39**	**26**
A1	Temp. C	15	20	32
	% RH	80	80	40
	Time w/ bag	**19**	**19**	**11**
	Time w/o bag	**72+**	**72+**	**20**
A2	Temp. C	10	25	35
	% RH	80	80	45
	Time w/ bag	**19**	**20**	**12**
	Time w/o bag	**72+**	**51**	**18**

Table1. Summary of modeling results from study of impact of destination environmental conditions [1]

From the results and visual observations,

- It was found that the key source of moisture was the forced air circulation during the heating process
- Need for inspecting the inside and outside of the machine was accented
- Using the lumped capacitance model, it was shown that the cover has time constant of ~2hrs while the other components have time constant of ~6hrs

1.4 Components of this project

There are 2 main components to this work:

1) Experimental
    - Acclimation time for the different components within a server was studied
    - Factors affecting acclimation were identified
2) Computational
    - A transient model was developed in a CFD software to predict the wait time

CHAPTER 2

EXPERIMENTAL WORK

2.1 Equipment used in experiments

- Environmental chamber (THERMOTRON 7800 SE)

  The main component needed for the experimental work was to replicate the shipping conditions and the destination conditions. This was done using an environmental chamber called the THERMOTRON which had the following specification. [7]

  - Temperature Range: (-70°C to +180°C)
  - Relative Humidity Range: (10% to 98% Rh)
  - Ramp rates: (5°C/min - 25°C/min)
  - Workspace volume: 2.7 cubic feet (586L)

  This chamber was suitable since it had the temperature and humidity range within the scope of this project.

Figure 5. THERMOTRON 7800 SE

This Thermotron is attached with a controller where the temperature and humidity profile can be set up as per the experiment.

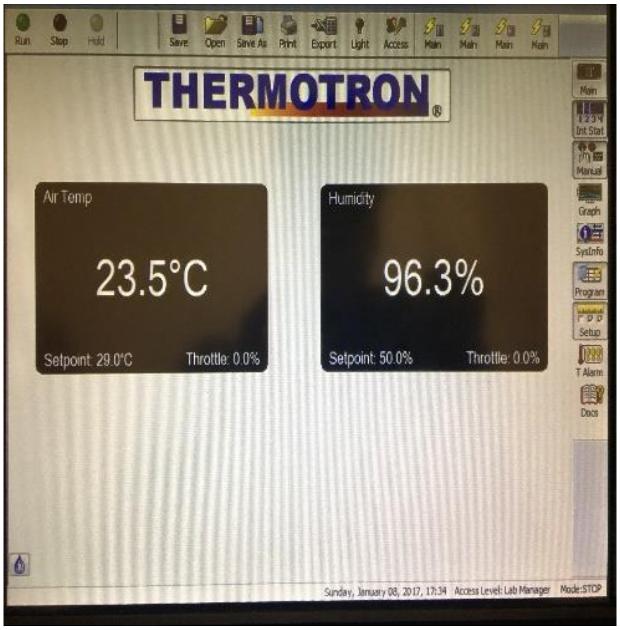

Figure 6. THERMOTRON controller.

- Type-T thermocouples

  Type-T thermocouples were used to measure the temperature which is attached to a multiplexer which is read through a computer to which the DAQ is connected via USB.

  The temperature range that it measures is well within the scope of the experimental test.

- The DHT22 sensors

  DHT 22 sensor is a basic, low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed)

  Simply connect the first pin on the left to 3-5V power, the second pin to your data input pin and the right most pin to ground. [8]

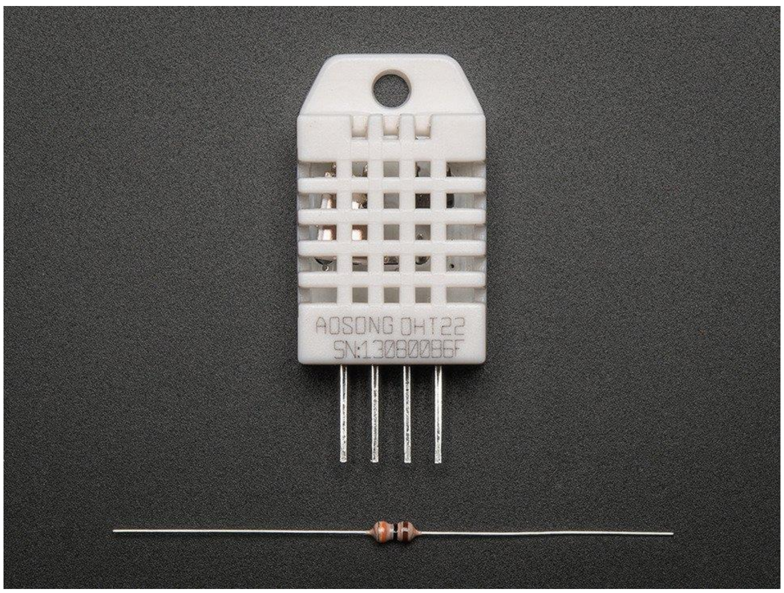

Figure 7. DHT22 sensor [8]

- Arduino board

  Arduino UNO is used to read the sensor readings with the help of a breadboard to connect 5 DHT22 sensors which is connected to the computer through a USB and a simple Arduino code is written to get the readings from all the different sensors The output we get is the temperature and humidity readings, which is copied to an EXCEL sheet to get the graph. [9]

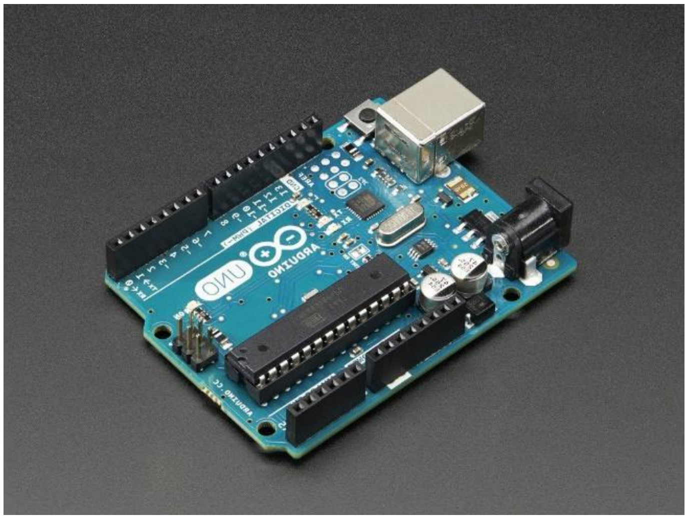

Figure 8. Arduino UNO board [9]

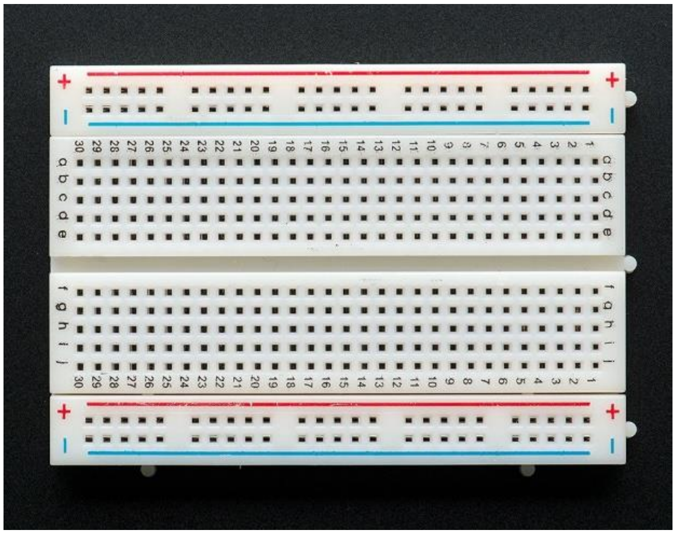

Figure 9. Breadboard

- IT Servers

  For the study of this project, 2 different servers were used to test the acclimation time and compare the results with each other to get the difference in acclimation time of 2 different geometries.

  - 1U HP server
  - 2U Open Compute Facebook server.

Figure 10. 2U OC Facebook server and 1U HP server

2.2 Experimental setup

3 different experiments are performed in the environmental chamber. First experiment was to understand the spatial variation inside the chamber where even the accuracy of the sensors used are measured. Second experiment where the acclimation time of different components within a single server is found out. Third experiment was done to identify the different factors that affect the acclimation time.

2.2.1 Test 1 Spatial variation

To understand the spatial variation inside the environmental chamber, 5 DHT 22 sensors which is a temperature and humidity sensor was attached at different positions inside the environmental chamber as shown in figure 3. The chamber is set to an initial Humidity of 30% for one hour then ramped up to 40% and finally to 50%. After which the accuracy of the sensor was found out to see if it is within the specified range of +/- 2% to +/- 5% by setting the chamber to 85% with an idle time of 1 hour.

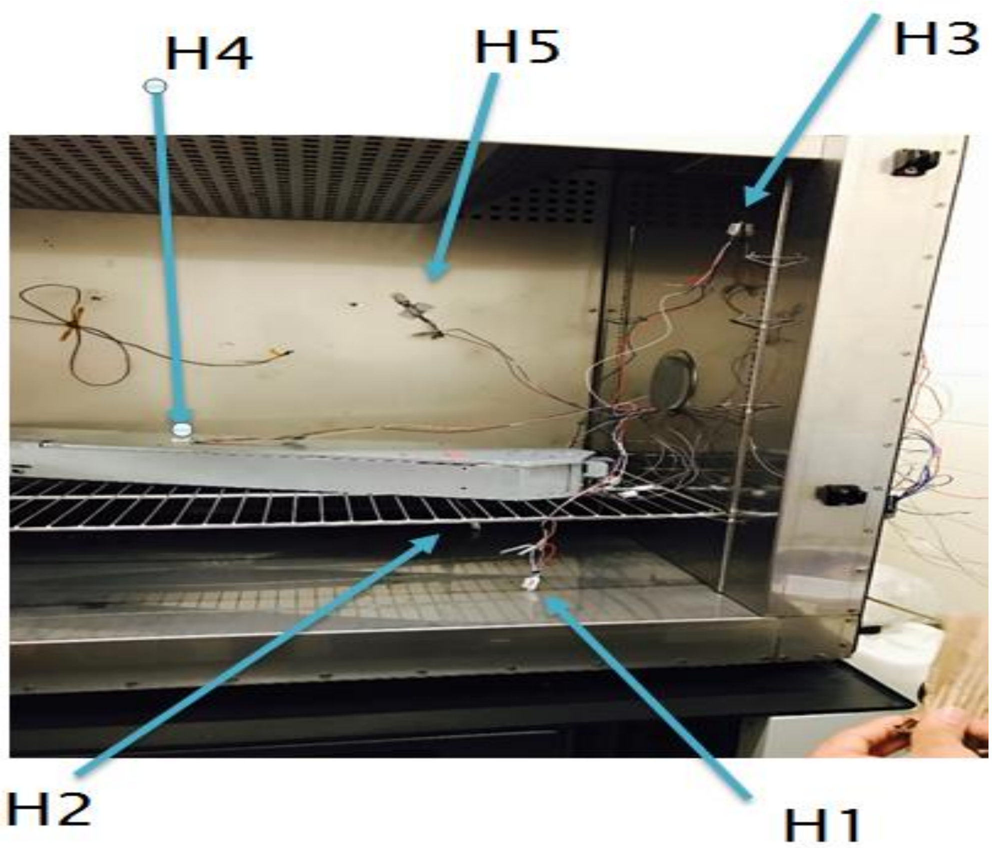

Figure 11. Test1 setup (spatial variation)

2.2.2 Test 2 Component acclimation study

The shipping and destination conditions used in all the tests below were taken as -27C 30% RH and 35C 85% RH as assumed in previous study by Dr. Milnes. [1]. The first test conducted within the environmental chamber was done on 1U air cooled server. Type-T thermocouples are connected to the different components inside the server i.e hard disc, fan, heat sink and memory as shown in figure 4, which is connected to the Agilent DAQ system to measure the temperature change through time. The server is first cooled down to -27C where its kept for 6 hours to make sure that all the components inside reach the initial condition of -27C, after which the chamber is set to 30C with a ramp time of 10 minutes, where it is again kept for almost 12 hours to study the time taken for all the components to reach the final condition of 30C.

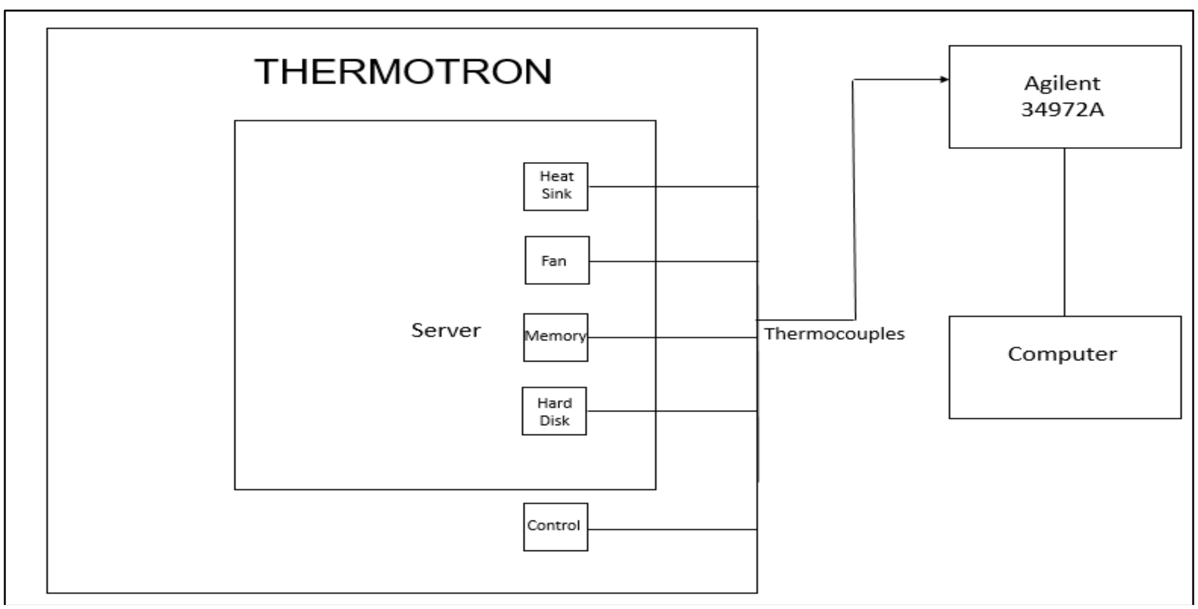

Figure 12. Test 2 setup diagram

The temperature profile set in the environmental chamber is shown below. The experiment is run for approximately 18 hours, so there is enough time for all the components to acclimate.

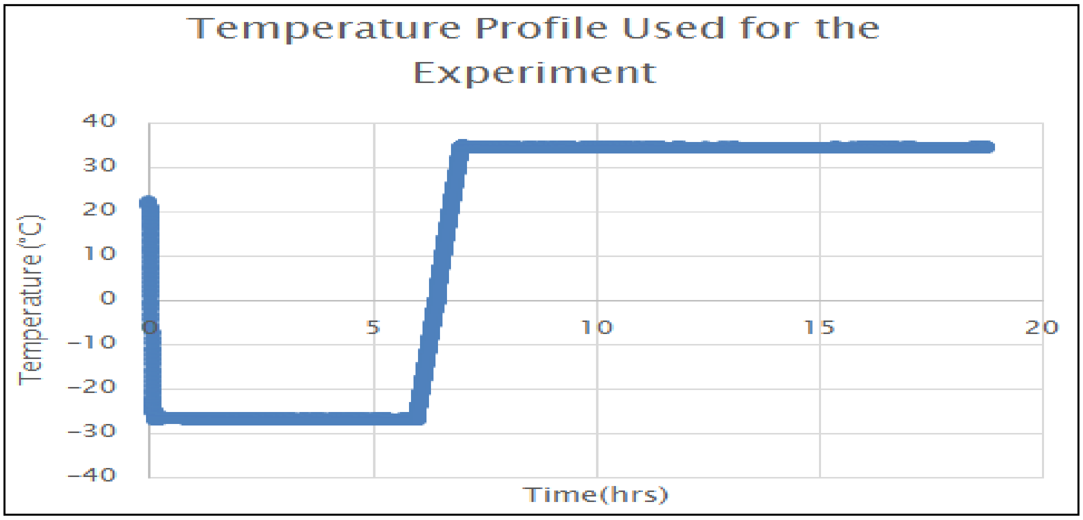

Figure 13. Temperature profile

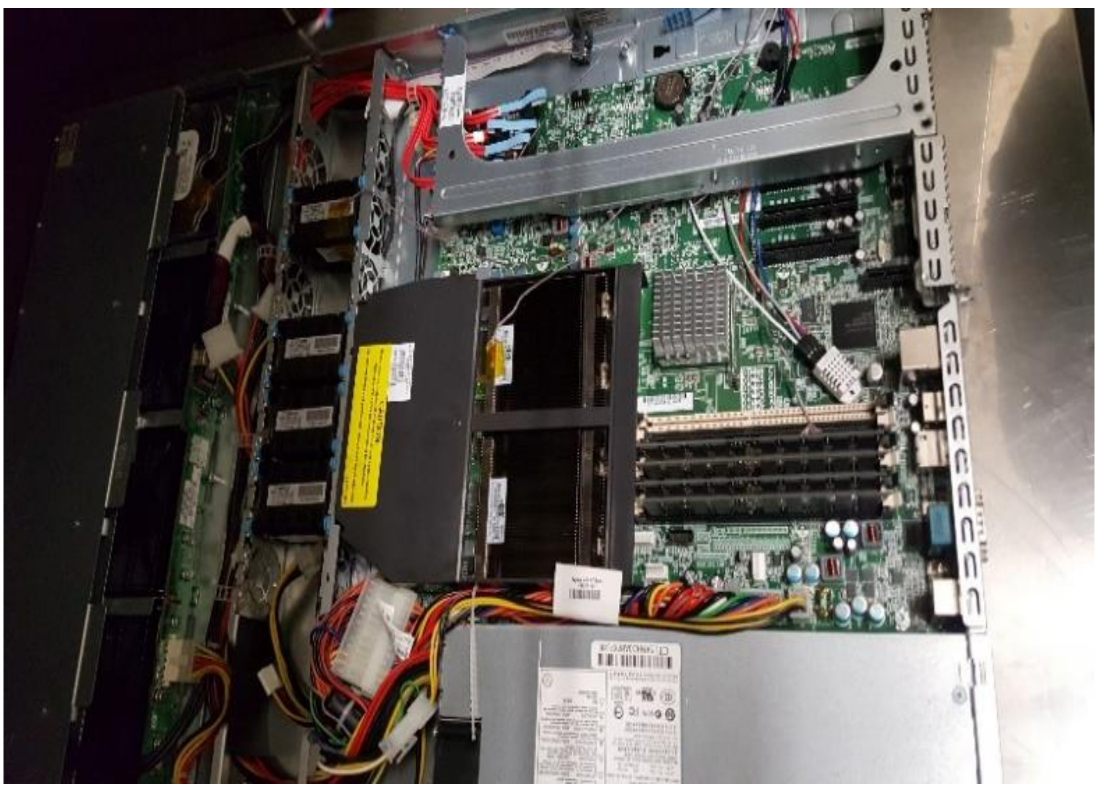

Figure 14. 1U HP server internal components connected with thermocouples.

2.2.3 Test 3 Identification of Factors affecting acclimation time

The next couple of tests were done on 2 different servers, i.e. 1U air cooled server and 2U open compute server as shown in figure 5. and the humidity channel was activated as well in the environmental chamber, to simulate the extreme shipping conditions of -27C an 30% RH and the destination condition of 35C and 85% RH which is well outside the ASHRAE condition but can be used to get results for extreme condition. A humidity and temperature sensor (DHT22) was used instead of thermocouples. 5 DHT 22 sensors were attached at different places, 2 attached inside the 1U server and 2 inside the 2U server. Sensor 1 in the 2U OC server between fan and RAM, sensor 4 in the 2U OC server on the hard disc drive, sensor 2 and 5 inside the 1U server in front of the hard disc drive and the PSU respectively whereas sensor 3 was used as a control which is kept in the middle of the THERMOTRON. The sensors were connected to an ARDUINO board which is connected to the computer to get the readings using a simple Arduino code. These experiments were done by varying the conditions in which the servers were kept.

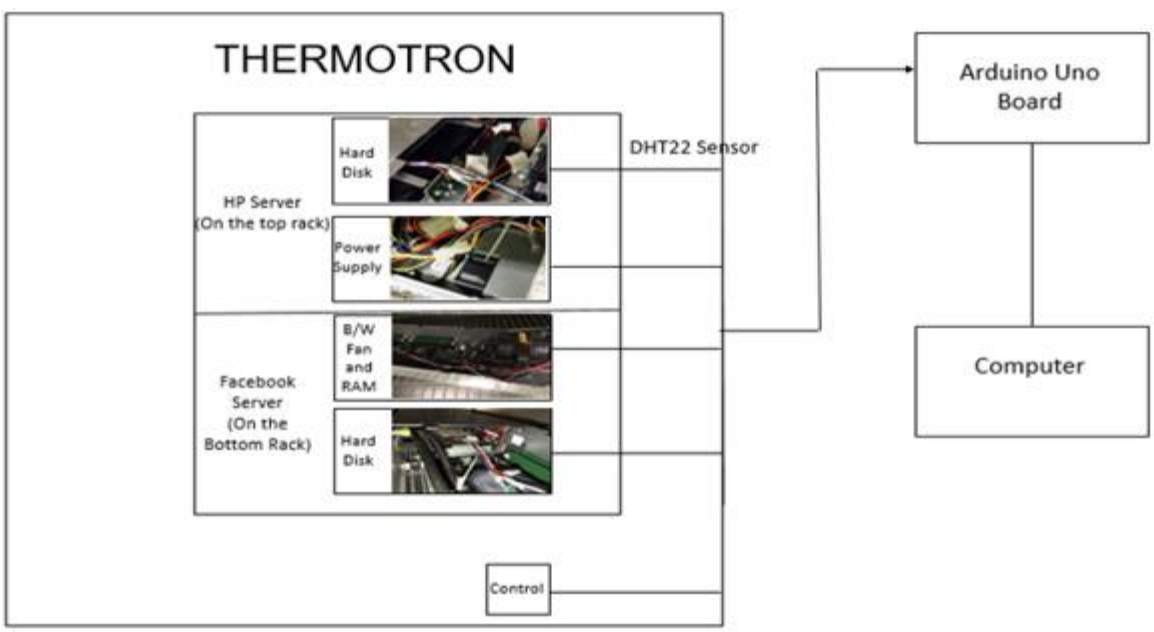

Figure 15. Schematic of the experimental setup for test 3

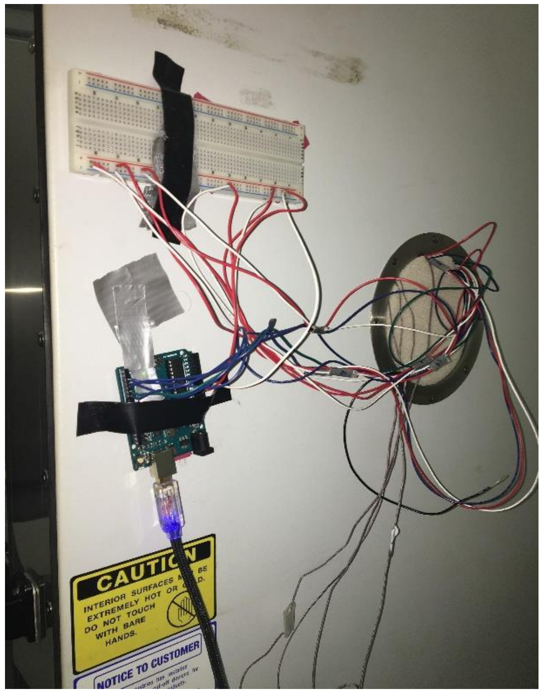

Figure 16. DHT22 sensors attached to the Arduino board through breadboard.

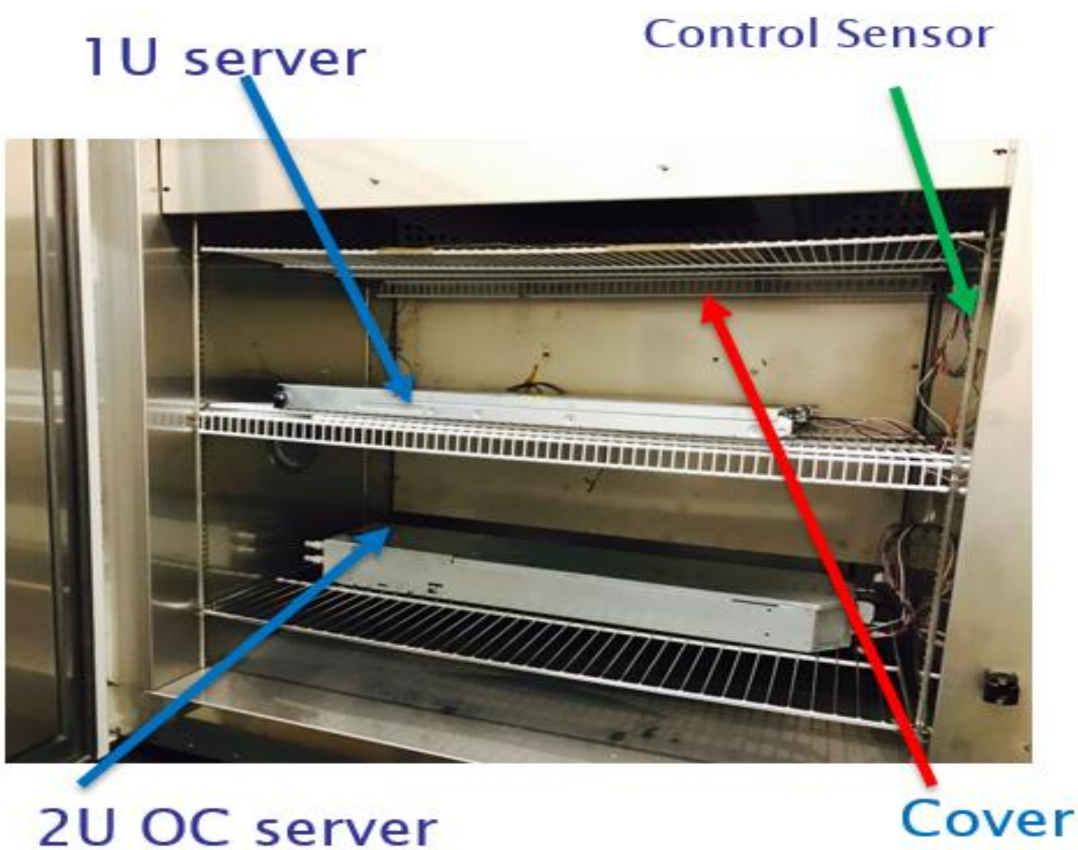

Figure 17. 2 servers inside the environmental chamber

The Setup shown above has the 2 servers inside the environmental chamber, inside the servers are the DHT-22 sensors which read the temperature and humidity change inside the servers. The DHT-22 sensors are connected to the Arduino board trough a breadboard as there are 5 sensors used, which via USB is connected to the computer. A simple Arduino code is written in order to get the temperature and humidity readings.

The different conditions that were tested are:

Condition 1) To test the effect of forced air convection on the acclimation time of the servers.

Condition 2) To test the effect of packaging on the acclimation time.

Condition 3) To test the acclimation of 2 different geometries (1U and 2U servers) when subjected to 3 different destination conditions

CHAPTER 3

Results and discussions

3.1 Experimental results

3.1.1 Spatial variation

The 5 different DHT22 sensors inside the THERMOTRON reacts very close to each other as shown in figure below, giving us the spatial variation inside the chamber. Since they are all reacting close to the set point within the accuracy range it is safe to assume that we have a uniform spatial variation within the chamber.

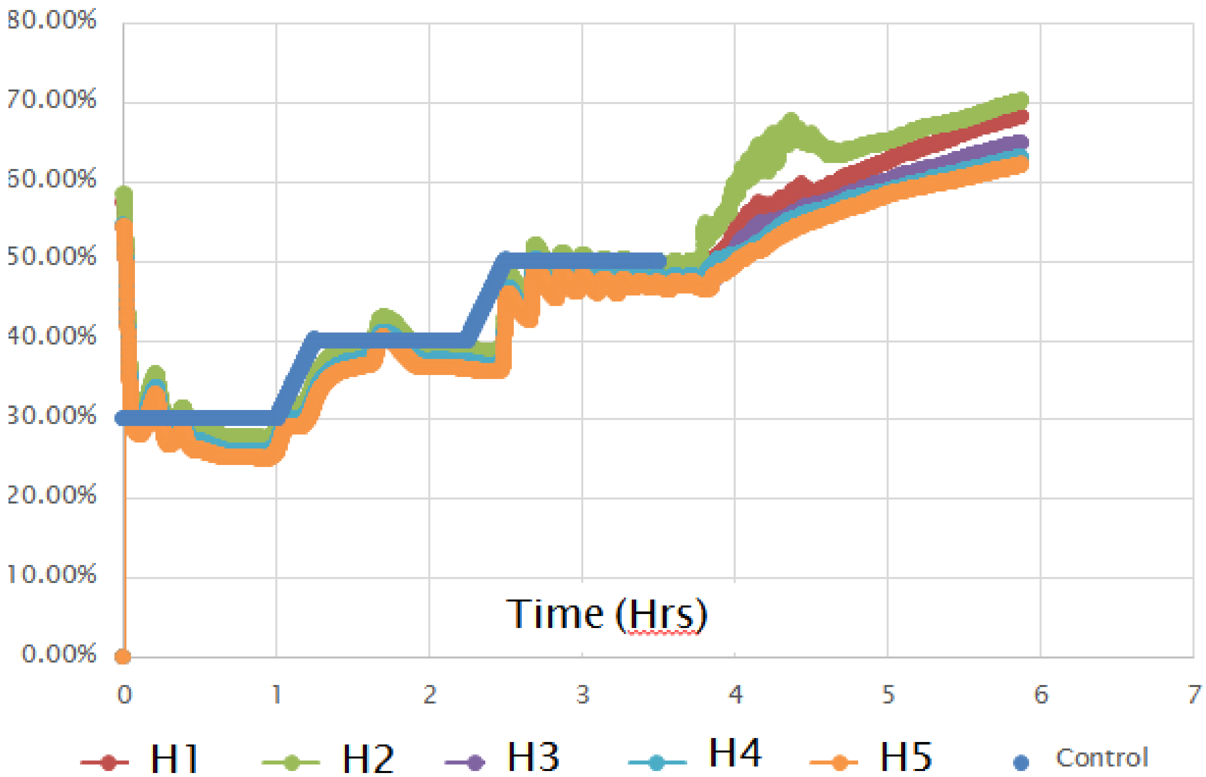

Figure 18. Humidity readings from the DHT22 sensors

3.1.2 Thermal time constants of different components inside the server

The first test where we attach Type-T thermocouples to the different components inside the chamber gives us the total time it takes for all the different components to reach steady state temperature of the environment which is 35C in our case. The readings obtained from the thermocouples are then exported to EXCEL to get the graphs as shown below.

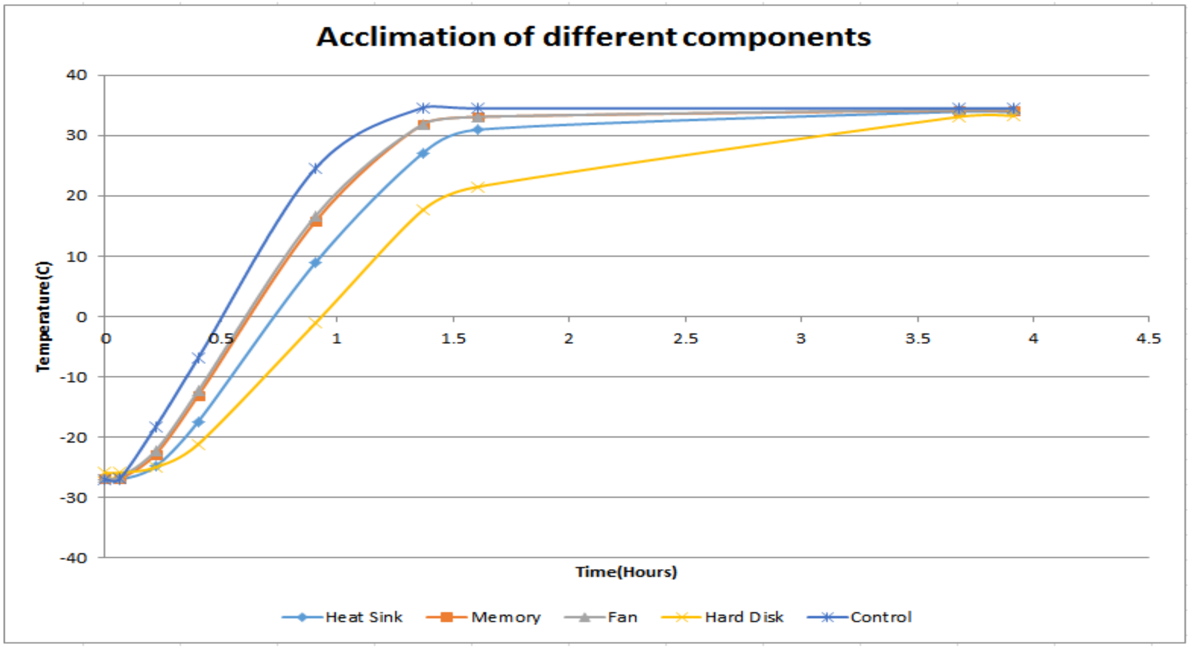

Figure 19. Acclimation time of different component

All component temperatures follow a lumped thermal capacitance model as shown below where t_{hrs} is the time in hours, t_c is the time constant and T is the temperature at different points in time in degree Celsius. A commercially available data analysis software, OriginPro, was used to curve-fit the above obtained data to the lumped capacitance model. From the curve-fitting the time constants for the various components was obtained and is tabulated below. The model used is as shown below.

$$\frac{T-T_f}{T_i-T_f}=e^{-t_{hrs}/t_c}$$

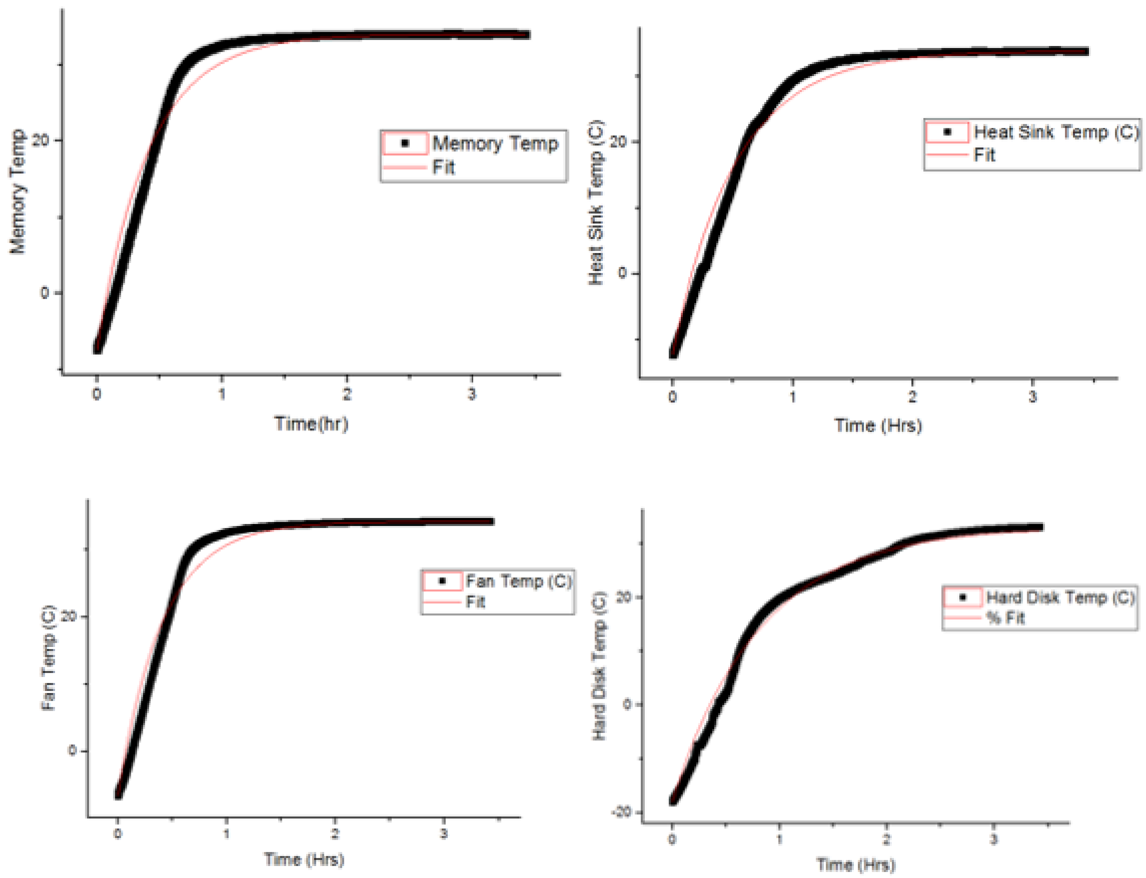

Figure 20. Curve fitting on the different components to get the time constant.

Components	Time constant(hrs)	Standard Error	Reduced Chi-Sqr	Adj. R Sqr
Fan	0.4103	0.00204	3.03207	0.9687
Heat Sink	0.52398	0.0021	3.19533	0.97747
Memory	0.414	0..0213	3.37264	0.96692
Hard disk	0.82172	0.00204	2.35263	0.988

Table 2. Time constant values of the different components within a server

3.1.3 Factor identification tests

The 8 different test cases on 1U and 2U servers was performed in the THERMOTRON as shown in the table below.

Cases	Conditions	Factors	Intial condition (3 hours)		Ramp Time	Final condition (4 hours)	
			Temperature	RH	(min)	Temperature	Humidity
1	Covered	Without package	-27 C	30%	10	35 C	85%
2	Not covered	Without Package	-27 C	30%	10	35 C	85%
3	Covered	Packaged	-27 C	30%	10	35 C	85%
4	Not covered	Packaged	-27 C	30%	10	35 C	85%
5	Not covered	packaged	-27 C	30%	10	25 C	8%
6	covered	Packaged	-27 C	30%	10	25 C	8%
7	Not covered	Packaged	-27 C	30%	10	20 C	50%
8	covered	Packaged	-27 C	30%	10	20 C	50%

Table 3. Test conditions to identify the factors

The first 2 tests were carried on with both the servers being unpackaged and having the same initial and final conditions.

In the first experiment, there was a cover placed above the 1U server to test the effect of forced air convection on the acclimation time of servers, which is compared to the second test where there was no cover used.

The temperature and humidity reading of all the sensors inside both the servers were taken and used to plot a graph as shown in figure below. From the graph for sensor 2 which was placed near the hard disk we see that there is no change in the temperature acclimation time for both the conditions but there is about 10% more relative humidity in the 2^{nd} case. Also, the 5^{th} sensor that is placed near the power supply of the server seems to acclimate faster without cover, both of which tells us that even though the difference isn't significant between the 2 tests, there is some noticeable effect of the cover placed above that stops the 1U server to be directly exposed to the forced air of the chamber. But in the case of 2U server which was placed below the 1U server the graph shows us that there isn't any effect of the cover since it is far away from forced air convection as shown in figure below.

This leads us to a conclusion that when acclimation is required, forced convection is a factor that will play a part in the acclimation time.

Below you'll see the graphs plotted where in both the figures, the top 2 graphs are the humidity readings and the bottom 2 graphs are the temperature readings.

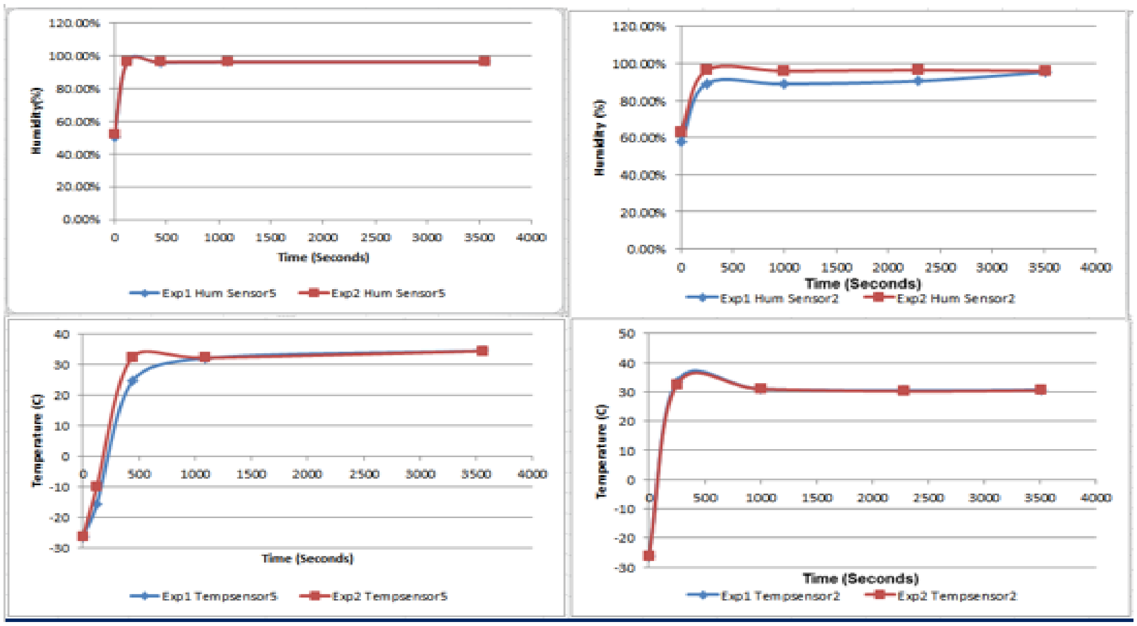

Figure 21. Temperature and humidity reading of 2 sensors inside 1U server

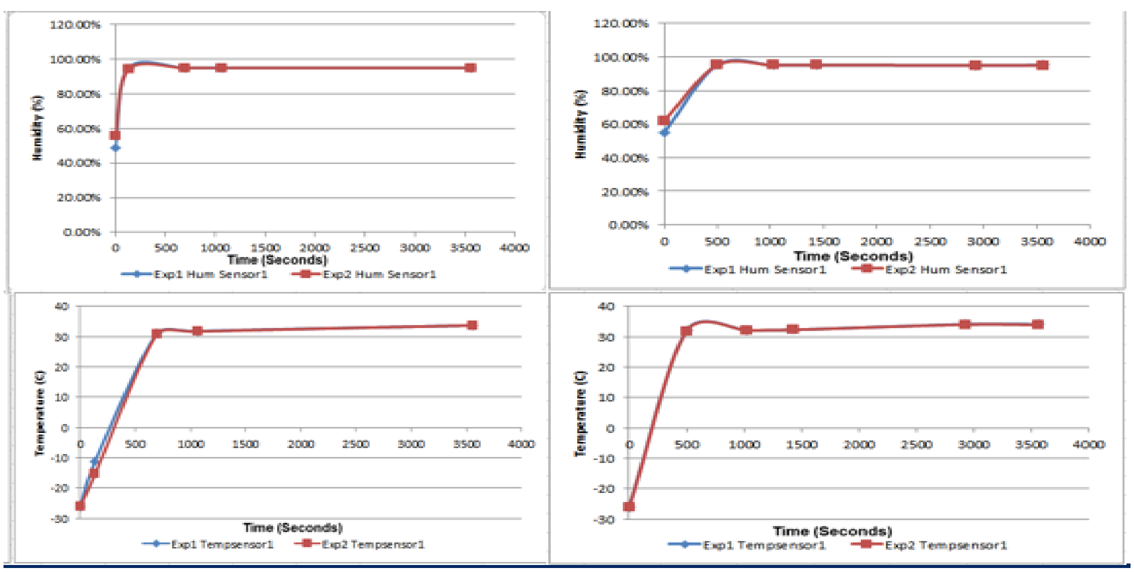

Figure 22. Temperature and humidity reading of 2 sensors inside 2U OC server

The next test comparison was between the servers when packaged and when unpackaged, in both experiments no cover is used and the temperature and humidity profile used for both the tests are the same. Through the graphs, we see the variation in humidity readings for the one with the package on. Packaging is an important step to be considered when calculating acclimation time.

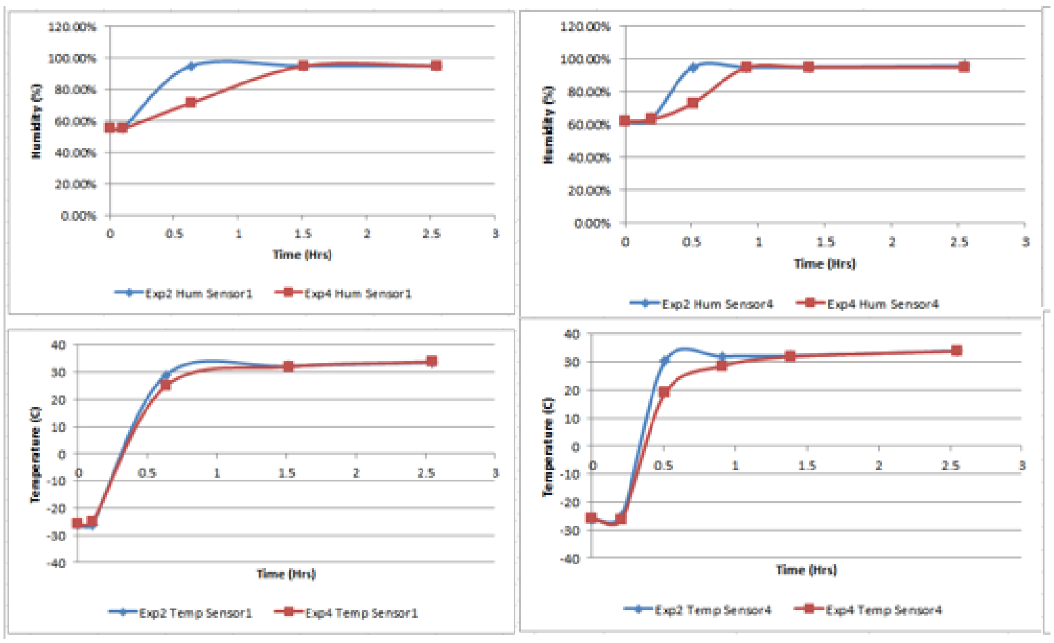

Figure 23. Temperature and humidity reading of 2 sensors inside 1U server

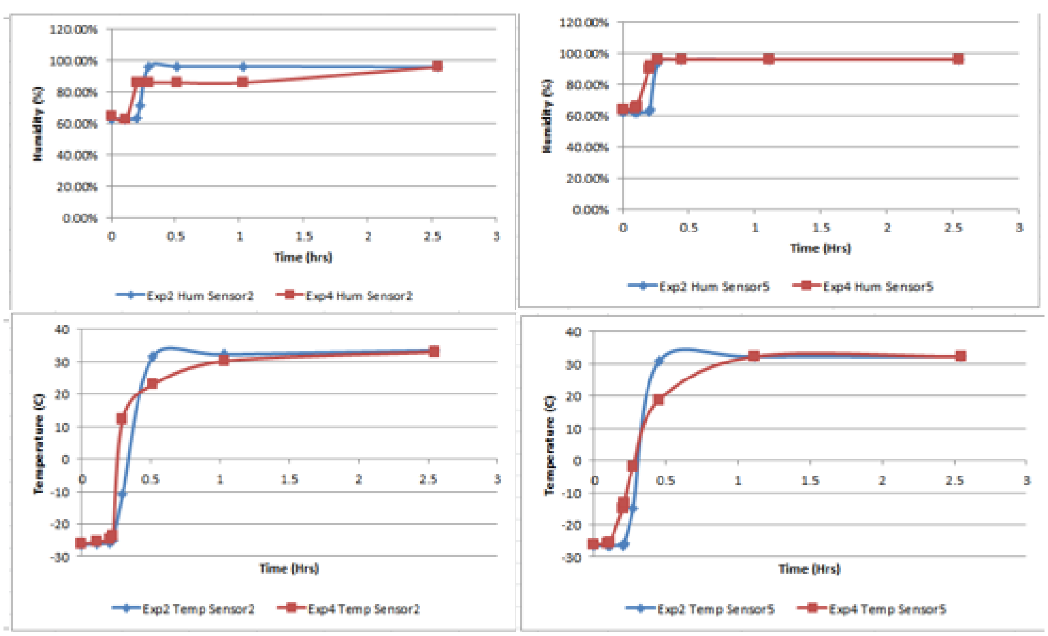

Figure 24. Temperature and humidity reading of 2 sensors inside 2U OC server

The last few tests were conducted to compare the way 2 different geometry based servers react to 3 different destination conditions. The initial condition being same i.e. -27C and 30% RH, the final conditions were changed from 35C & 85% RH to 25C & 8% RH and then 20C & 50% RH. The graphs below show us how the humidity profile of both the servers changes with time. since these tests were conducted with the package on the servers we see that the Facebook server which is a 2U server does not go down to the set humidity condition which means that the packaging plays an important role when it comes to humidity. On the other hand, HP server being a 1U server acclimated to the final humidity conditions with time. The possible explanation to this is that the 1U server may not have been properly packed and since the server have holes it easily reacted to the humidity of the room. Also, the geometry could have played a part in getting the results shown.

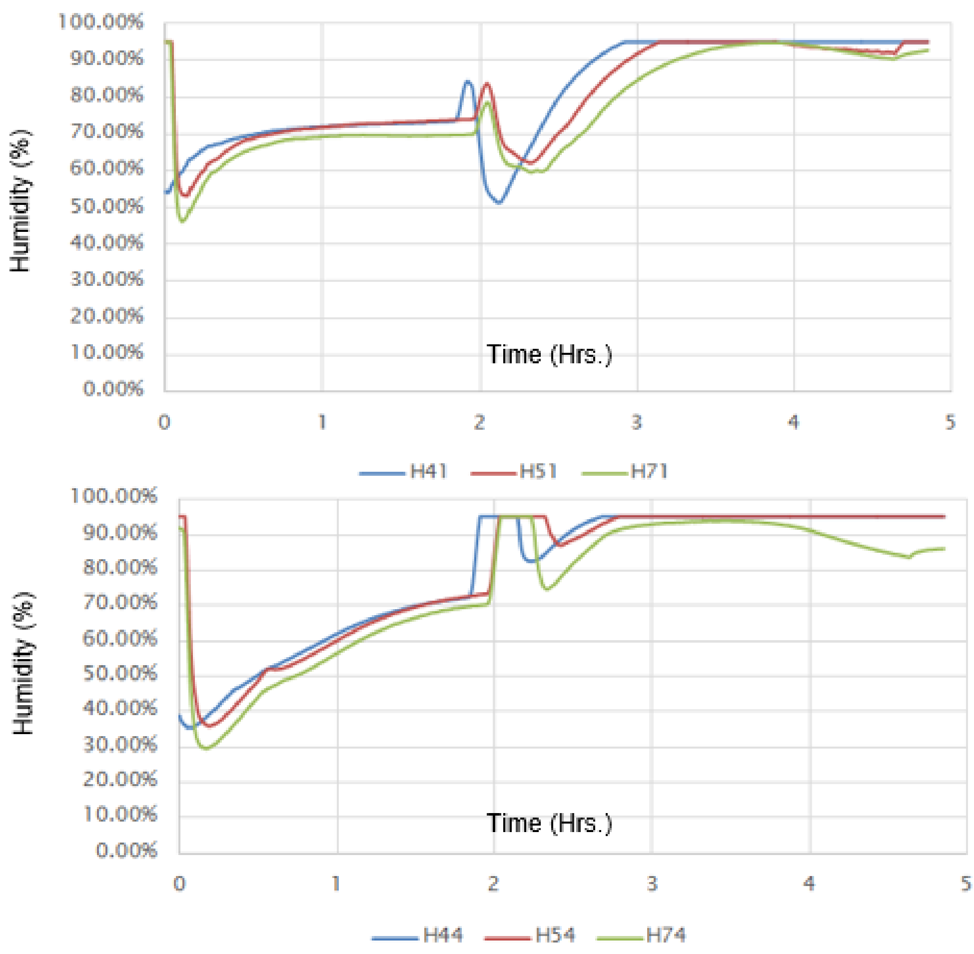

Figure 25. Humidity readings of sensor 1 and sensor 4 inside 1U server

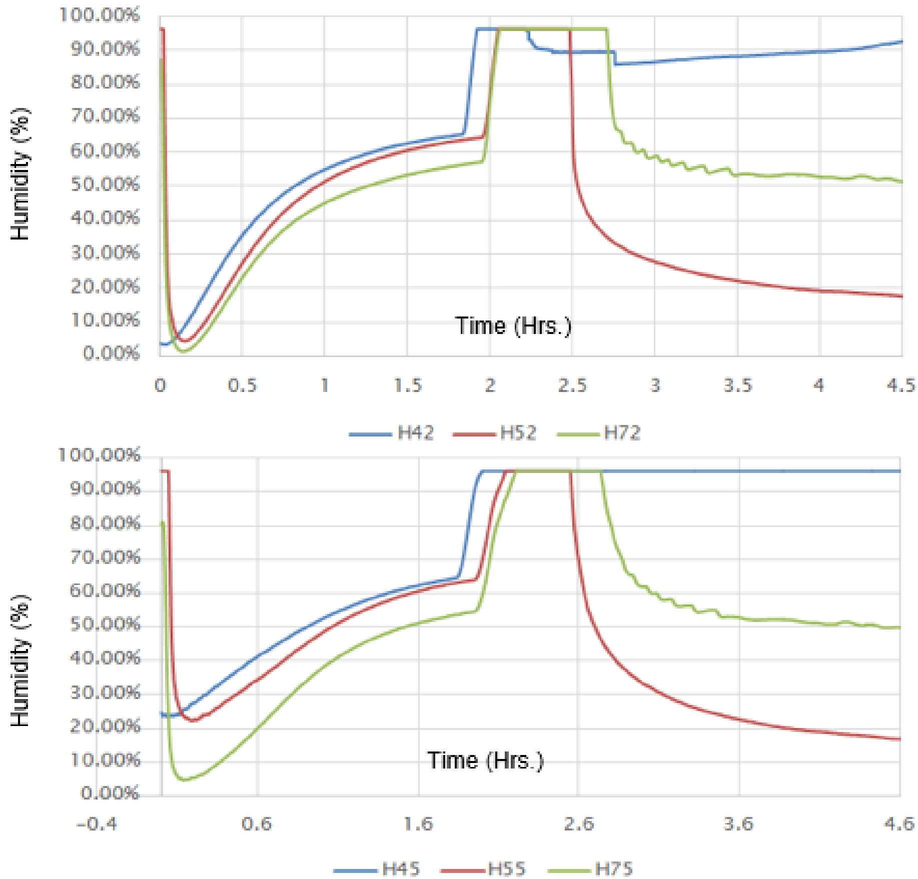

Figure 26. Humidity readings of sensor 2 and sensor 5 inside 2U OC server

3.2 Experimental conclusion

From the table shown previously we saw that the calculated thermal time constant for hard disk is the maximum followed my heat sink, whereas the fan and memory having almost the same time constant. This result is going to be used ahead in the validating the simulation.

These experimental works helped us identify some of the important factors that affect the acclimation time of I.T. Equipment's. The factors being 1) Mass of the component, 2) Packaging, 3) Direct Exposure to sources of forced air, 4) Geometry and build of the server

CHAPTER 4

TRANSIENT MODELING USING COMPUTATIONAL FLUID DYNAMICS

4.1 Introduction

To find out an estimate wait time was the main goal of this project and in this paper we tried to get an estimate time for a single server kept in a room with natural and forced convection.

The transient model simulating the shipping and destination conditions were made using the CFD tool ,6SigmaRoom. In 6SigmaRoom, the room is set to conditions replicating the data center and a solid block is used to replicate the server with shipping temperature. A temperature sensor is kept at the center of the solid block to record the temperature change through time.

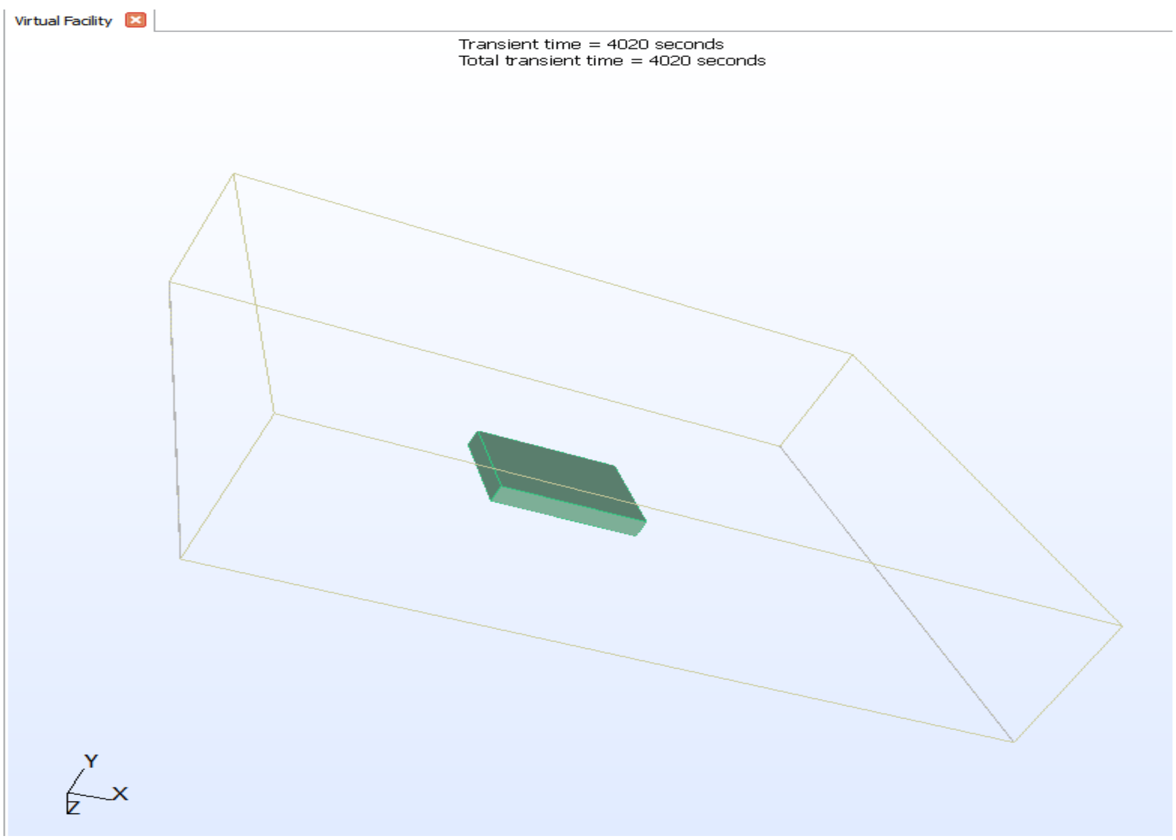

Figure 27 Model used to simulate in CFD

Since a detailed server model is not used in this simulation study, the thermal mass of the 1U IBM server from the below table [4] is used as the thermal mass of the block used in the simulation study.

Server	Mass, kg (lb)	Billerica, MA Lab C_s, J/°C (Btu/°F)	ε, Numerical Method	τ, min	Poughkeepsie, NY Lab C_s, J/°C (Btu/°F)	ε, Analytical Method	τ, min
IBM x3550M3 1 U	14.9 (32.8)	11,900 (6.27)	0.91	6.8	11,100 (5.86)	0.87	6.4
Dell 2850 2 U	24.2 (53.4)	14,500 (7.64)	0.91	8.2	17,500 (9.22)	0.94	9.3

Table 4. Thermal capacitance for 2 different server [4]

4.2 Grid Independence

Grid independence analysis is done on the preliminary model with initial temperature of solid as -27C. Simulation is run for 500 seconds and we see that in 70000 cells we achieve the optimum value of -26.88 C. Since the model does not have complex geometry the optimum value is reached in fewer cells.

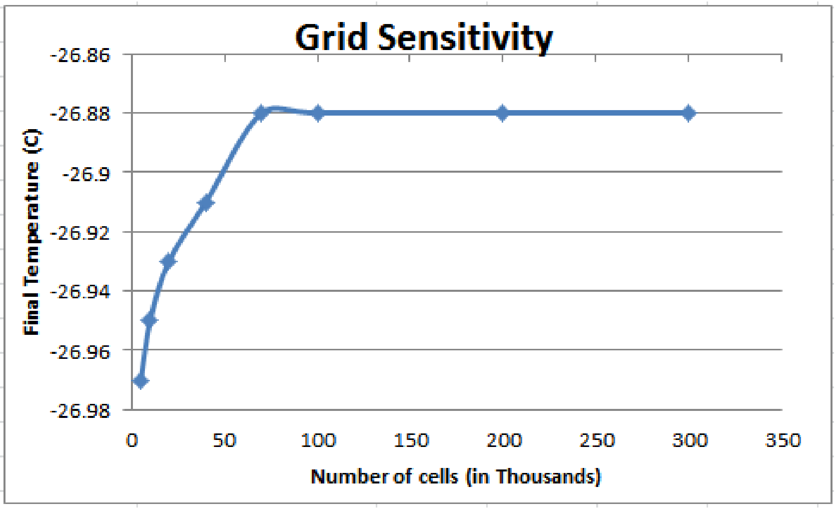

Figure 28. Grid sensitivity analysis

4.3 Validation

4.3.1 Analytical Validation

Since there aren't any papers published that gives us or estimates a wait time for any IT equipment through simulations that can be referred, the simulation results were first validated using an analytical model. The simulation conditions were slightly modified and initial temperature of solid block was kept at 10C with assumed density, specific heat and thermal conductivity, whereas the room temperature was kept at 30C. The dew point of the room is found out to be 27C [2]. The transient model is run and the time it takes for the block to reach the 27C is found out to be 30,240 seconds as shown below.

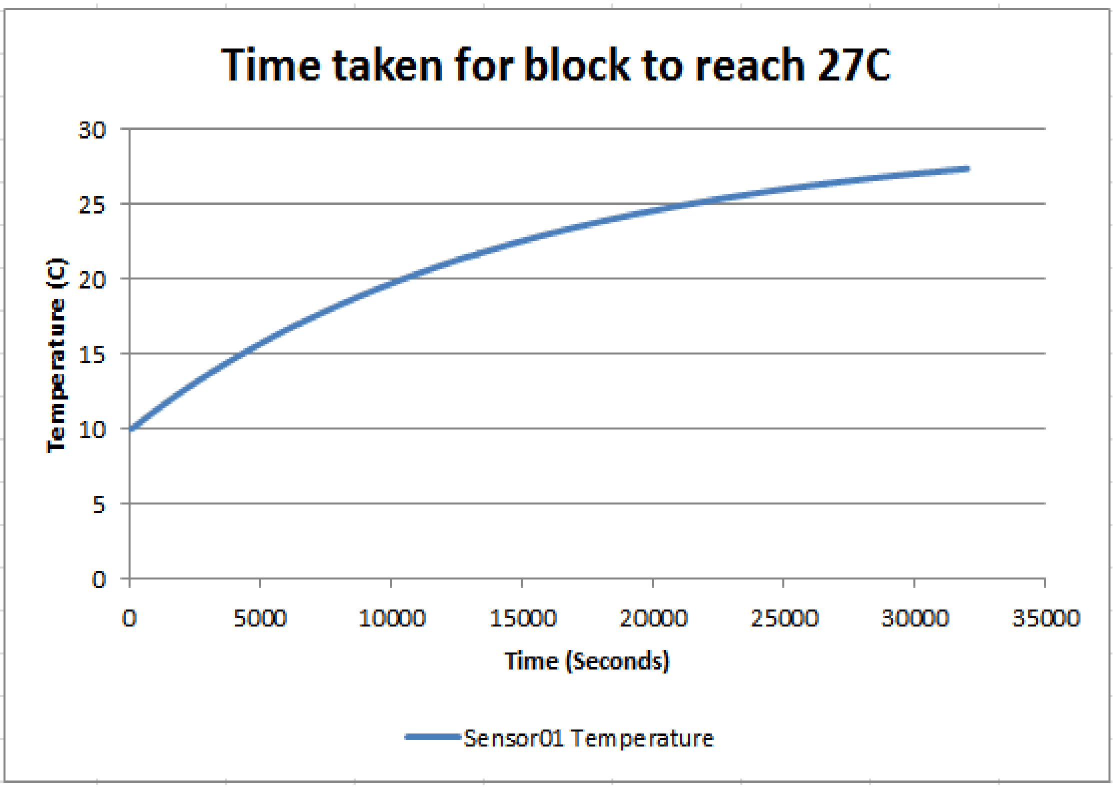

Figure 29. Simulation result 1

In order to validate these results Heisler charts [3] were used. Heisler charts are a graphical analysis tool for the evaluation of heat transfer in thermal engineering. We need to keep in mind that Heisler charts are a faster and simpler alternative to the exact solutions of these problems, there are some limitations. First, the body must be at uniform temperature initially. Additionally, the temperature of the surroundings and the convective heat transfer coefficient must remain constant and uniform. Also, there must be no heat generation from the body itself . Since the limitations are exactly what our problem statement is, Heisler charts can be used to validate the simulation results analytically.

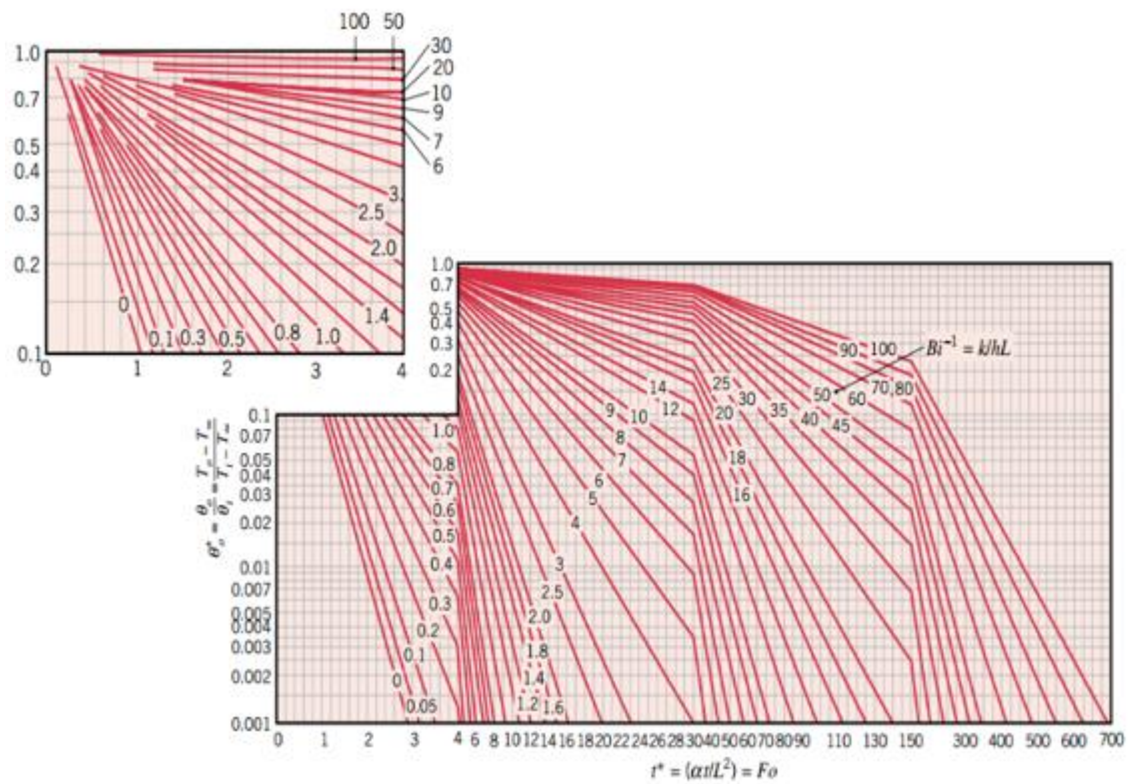

Figure 30. Heisler charts [3]

Heisler charts for a plane wall of thickness 2L is plotted using 3 different variables. Plotted along the vertical axis of the chart is dimensionless temperature at the midplane, plotted along the horizontal axis is the Fourier Number, $Fo=\alpha t/L^2$. The curves within the graph are a selection of values for the inverse of the Biot Number where "$Bi = hL/k$. k is the thermal conductivity of the solid assumed a value same as simulation along with thermal diffusivity and thickness and h is the heat transfer coefficient taken in the range of 5-10 W/m^2K. Knowing all the values except the time taken for the solid to reach 27C. We get $Bi^{-1} \approx 50$ using which we get the Fourier number as 90 with which we calculate the time as 28,928 seconds, which shows that the model used in simulation is accurate enough to be used to estimate the time. Only a difference of **4.6%**

Model	CFD	Analytical
Time taken (Seconds)	30,240	28,928

Table 5. Comparison of CFD and Analytical solution.

4.3.2 Thermal mass validation

To get an estimate acclimation time for a single server, it is necessary to validate the thermal mass of the solid experimentally.we have taken a value of thermal mass as 11.9 kJ/K as found out experimentally for a 1U server [4]. Since thermal mass range is in the range of 9 kJ/K (for a server constructed mainly of copper) and 22 kJ/K (for a server constructed mainly of aluminum) [5], this value is taken. A 1U server is kept in an environmental chamber with a thermocouple attached to the hard disk, since we saw earlier that it takes the maximum time in a server to acclimate and is read by the monitor through DAQ. The room in the model is simulated to replicate the environmental chamber with a flow rate of 1000 CFM by adding vents. It is then compared graphically.

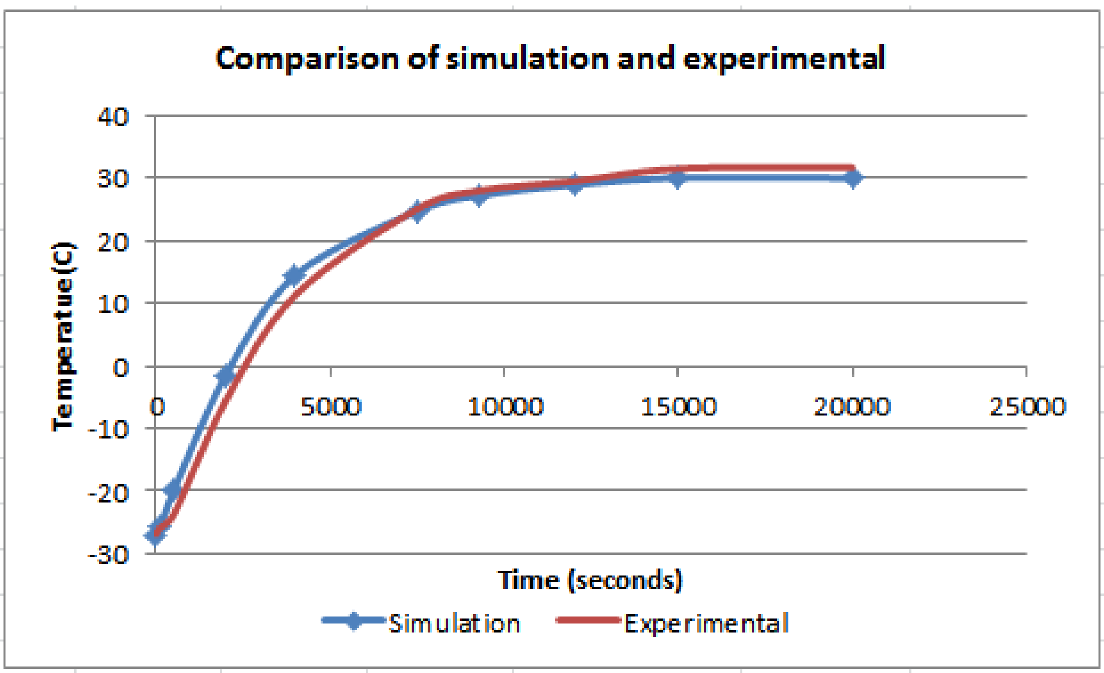

Figure 31. Comparison of simulation and experimental solution

Through the graph we see that the thermal mass assumed matches close enough with the experimental result, hence be used in the simulation to get an estimate acclimation time for a single server.

4.4 Simulation of a single 1U server in different data center condition

The solid (1U*600mm*600mm) is kept at -27C whereas the environment is kept at 30C and 85%RH. The walls of the room are kept open to study the effect of natural convection. The simulation is run for about 50000 seconds and the acclimation time for the server is studied and recorded using the temperature sensor.

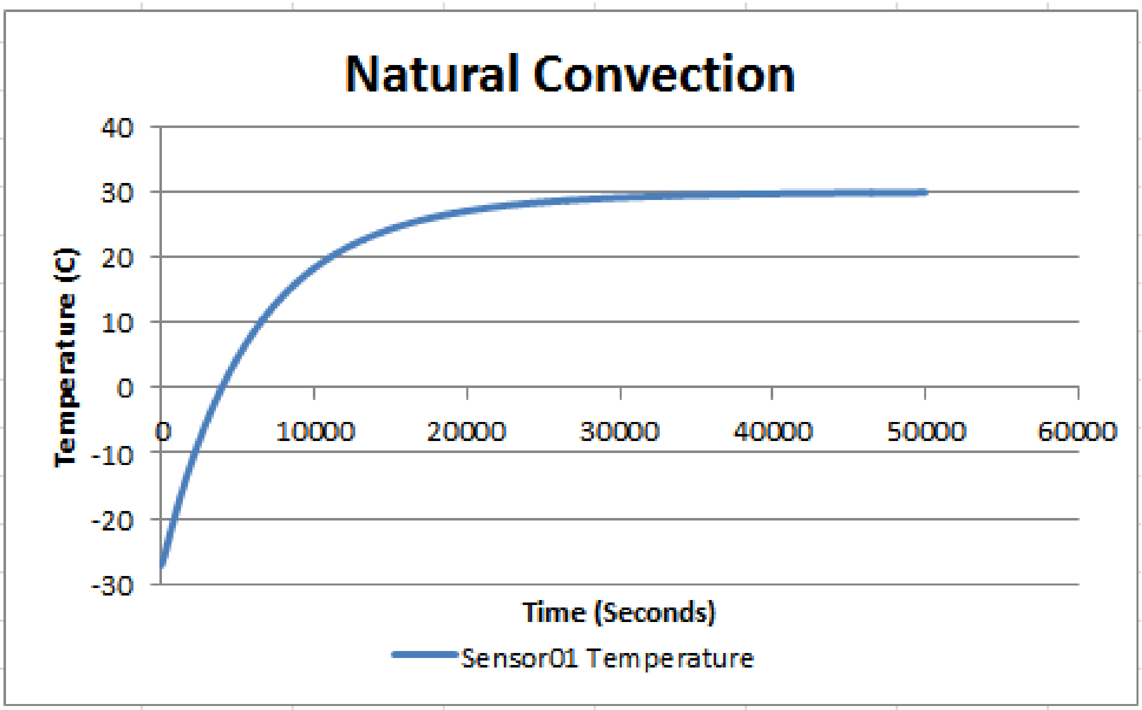

Figure 32. Simulation result 2 Acclimation time under natural convection condition

The walls of the room are then kept closed and vents are added in order to facilitate forced air convection and the server temperature is recorded as shown below.

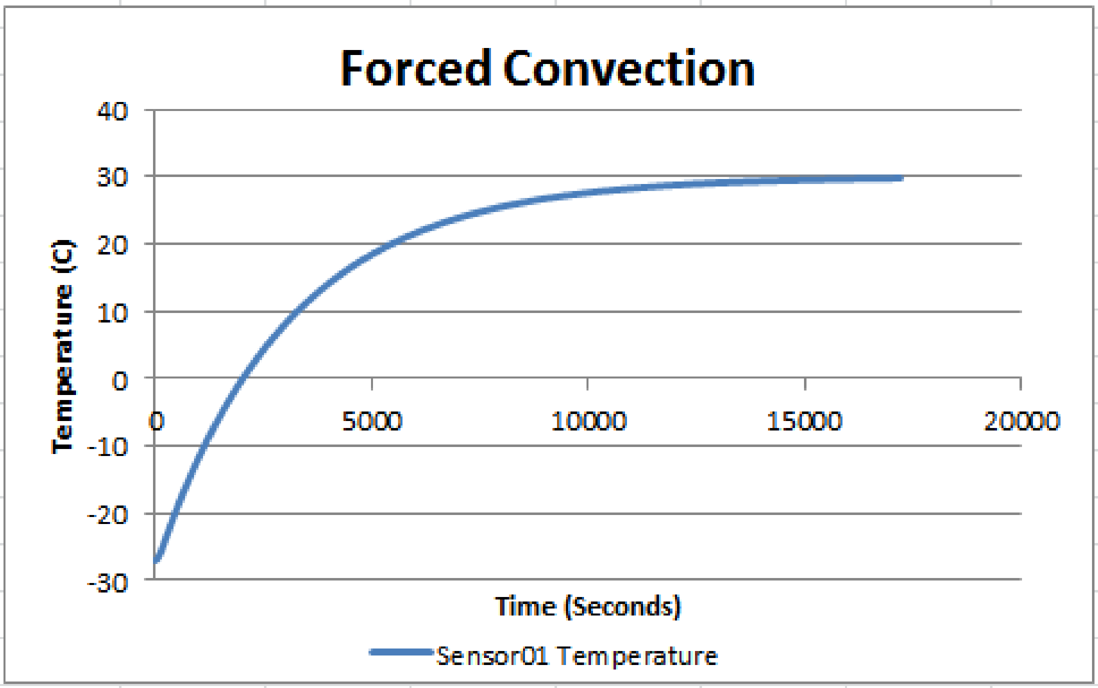

Figure 33. Simulation result 3 Acclimation time under forced convection condition

From the graph we see the time it takes for the server to reach the dew point of the room in 5.5 when it is subjected to natural convection whereas it takes 2.5 hours in forced which is tabulated below.

Condition	Time Taken for temperature of server	
	Dew Point of 27C (Hrs.)	Data center Temperature of 30C (Hrs.)
Natural	5.55	9.5
Forced	2.5	4

Table 6. Time taken for the 1U server under 2 different conditions.

CHAPTER 5

CONCLUSION AND FUTURE WORK

5.1 Conclusion

In all there were 3 parts to this paper, first being the study of acclimation testing of the different components within a server experimentally where we assumed all component temperatures follow a lumped thermal capacitance model, and we obtained the thermal time constants of the main components. The Hard Drive Disks had the max time constant of 0.82 Hours. Second we identified a few different factors that affect the acclimation time of the server. We ran experiments on a 1U server and a 2U OC server in the environmental chamber. The key factors affecting acclimation time are mass of the component, Packaging, Direct Exposure to Sources of Forced Air Convection, Geometry and build of the server. Third and the most important part of this paper tries to justify the main objective by developing a method to estimate the acclimation time of IT equipment. A CFD (6SigmaRoom) tool was used to design and simulate the shipping and destination conditions for a single server whose thermal mass assumption is validated. We found out the estimate time it takes to switch on this single server in natural and forced convection as 5.5 hours and 2.5 hours respectively.

5.2 Future Work

More Experimental data can be used to get an accurate value of the factors that affect the acclimation time which can be used to prioritize the factors identified.

Rack level experiments can be conducted

The same modeling approach can be used to find out the estimate time of multiple servers or racks and get a correlation between the thermal mass of the IT equipment to the time it takes to acclimate, which can easily be used by the industry to estimate the wait time before the equipment can be safely turned on.

REFERENCES

[1] “David, Milnes P., et al. "Environmental acclimation of computing systems." Thermal and Thermomechanical Phenomena in Electronic Systems (ITherm), 2016 15th IEEE Intersociety Conference on. IEEE, 2016.

[2] “Dew Point Calculator,” AJ Design. [Online]. Available: http://www.ajdesigner.com/phphumidity/dewpoint_equation_dewpoint_temperature.php. [Accessed: 2017].

[3] “Heisler Chart” ch05_supp_heisler. [Online]. Available: ttp://homepages.wmich.edu/~leehs/ME431/ch05_supp_heisler.pdf. [Accessed: 2017].

[4] Pardey, Zachary M. "Proposal for standard compact server model for transient data center simulations." ASHRAE Transactions 121 (2015): 413.

[5] Ibrahim, Mahmoud, et al. "Thermal mass characterization of a server at different fan speeds." Thermal and Thermomechanical Phenomena in Electronic Systems (ITherm), 2012 13th IEEE Intersociety Conference on. IEEE, 2012.

[6] Data center knowledge: designing PDU Density for Next-Gen Digital Data Centers.

[7] Thermotron Specifications:http://thermotron.com/pdf/product-page-images/se-series/thermotron-se-series-test-chamber-brochure.pdf

[8] DHT22 sensor specs:https://www.adafruit.com/product/385

[9] Arduino UNO: https://www.arduino.cc/en/main/arduinoBoardUno

Biographical Information

Neil Johnson Vazhappilly (Dec 8th, 1992) is from Mumbai, India. He completed his Bachelors in Mechanical Engineering from Mumbai university in June 2014. Neil then worked as a Quality Engineer at Mazagon Dock Ltd. A ship building company for a year. He was admitted to The University of Texas at Arlington in Fall 2015 for Master of Science program in Mechanical Engineering. He joined EMNSPC team in Fall 2016 and started working on various projects.

His primary research includes Experimental and Computational study the acclimation of new IT equipment. Neil has been involved in a number of projects in UTA and had a constant guidance from industries.

Neil graduated from The University of Texas at Arlington on May 18, 2017.