

# EXPERIMENTAL DESIGN AND CFD ANALYSIS OF HEAT DISTRIBUTION IN SS304 HEAT PIPE WITH COMBINATION OF NANO PARTICLES

Submitted in partial fulfillment of the requirements

for the award of

Bachelor of Engineering degree in Mechanical

By

Vinod kumar.T (37150216)

Vishal.J (37150219)



**DEPARTMENT OF MECHANICAL ENGINEERING**

**SCHOOL OF MECHANICAL ENGINEERING**

**SATHYABAMA**

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

**Accredited with Grade "A" by NAAC | 12B Status by UGC | Approved by AICTE**

**JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119**

**March – 2021`**



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**Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai - 600 119**

[www.sathyabama.ac.in](http://www.sathyabama.ac.in)



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### **DEPARTMENT OF MECHANICAL ENGINEERING**

### **BONAFIDE CERTIFICATE**

This is to certify that this Project Report is the bonafide work of **VINOD KUMAR.T(37150216)**, **VISHAL.J(37150219)** who carried out the project entitled **EXPERIMENTAL DESIGN AND CFD ANALYSIS OF HEAT DISTRIBUTION IN SS304 HEAT PIPE WITH COMBINATION OF NANO PARTICLE** under our supervision from September 2020 to April 2021.

**Internal Guide**

**Mr.V.SRIRAM, M.E., (Ph.D.,)**

**Head of the Department**

**Dr.G. ARUNKUMAR, M.E., Ph.D.,**

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**Submitted for Viva voice Examination held on \_\_\_\_\_**

**Internal Examiner**

**External Examiner**

## DECLARATION

We **VINOD KUMAR.T(37150216), VISHAL.J(37150219)** hereby declare that the Project Report entitled **“EXPERIMENTAL DESIGN AND CFD ANALYSIS OF HEAT DISTRIBUTION IN SS304 HEAT PIPE WITH COMBINATION OF NANO PARTICLES”** done by me under the guidance of **Mr.V.SRIRAM, M.E., (Ph.D.,)** is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Mechanical Engineering.

DATE:

SIGNATURE OF THE CANDIDATE

PLACE:

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## ABSTRACT

Heat pipes are the most promising heat removal devices that are widely used in most of the fields from thermal management of electronic to terrestrial and aerospace applications. The working principle, phase change of a working fluid, makes them the most superior to any other conventional cooling methods available. Nanofluids are used as the working medium for the conventional cylindrical of heat pipe. The working fluids are involved in this study are DI-water and Nano-particles suspension (mixture of copper nano particle and DI-water). The overall heat transfer coefficient of the heat pipe are calculated based on lumped thermal resistance and then compared with heat transfer coefficient of the base fluid filled heat pipe. The main aim of the experiment is to study the thermal expansion. Thermal expansion is known as the tendency of a matter to change its volume, area, shape, and density in response to the change in temperature, usually without including the phase transitions. When the substance is heated, molecules begin to vibrate and it cause to move more, usually creating more distance among themselves. Substances which make contract with increasing temperature are unusual, and it can only occur within limited temperature ranges. Using anaoparticles as the working fluid we conduct the experiment at different time and along with the help of CFD we can prove that conducted experiment is properly provide a analysed result

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## CHAPTER 1

### INTRODUCTION

Thermal stress and thermal strain are the two most major reason for a material lifespan so to identify we use a heat pipe which provide a proper information. The heat pipe is a heat transfer device that combines by the principles of both the thermal conductivity and the phase transition which makes a effective heat transfer between the both two solid interfaces. At the hot interface of the heat pipe, where a liquid in a contact with the thermally conductive of a solid surface turns into a vapor by absorbing of the heat from the surface. The vapor travels along the heat pipe to cold interface and the condenses back into the liquid, by releasing the latent heat. The liquid is then returned to hot interface through either the capillary action, centrifugal force or gravity and the is cycle repeated. Due to very high heat transfer coefficients for both the boiling and the condensation, heat pipes are the highly effective thermal conductors. And the effective thermal conductivity varies with heat pipe length and can approach

#### 1.1 HEAT PIPE

A heat pipe is are the two-phase heat transfer device which has a very high effective thermal conductivity. In a vacuum-tight device which consist of an envelope, wick structure and a working fluid. The heat input get vaporizes until the liquid working fluid that is present in the wick in the evaporator section. As the saturated vapor which is carrying the latent heat of vaporization, flows though the colder condenser section. In the condenser the vapor condenses and which gives up its latent heat. The condensed liquid get back to the evaporator through t wick structure by the capillary action. This phase changing process and the two-phase flow circulation keep on continue

until till the temperature gradient between evaporator and the condenser are kept maintained.

- High Thermal Conductivity (10,000 to 100,000 W/m K)
- Isothermal
- Low Cost
- Shock/Vibration tolerant
- Freeze/thaw tolerant

Heat pipe is known as self-heat recovery device which is used to transfer the heat from the one end point to the another end point with the minimum temperature differences and to circulate the heat across the internal surface. The most important terms you have to take into the notice while choosing the pipe for the application on industrial devices. They are made in different types of shapes like round or flat shapes. By the use of these liquid and vapor phases, the heat transport mechanism has become the extremely easy to fluent and efficient. As the heat pipes are made in closed loop design, heat pipes are made to works continuously and passively which gains a reliable and passive part in the thermal management system Steel is an alloy which is a metal that is made by blending so called alloying elements into the base metal and it provides a quite literal work as the backbone for the modern industry today. Steel are composed of primarily iron and carbon, which also include other trace elements that gives steels a unique properties each other. One class of steels is classified as stainless steels, it use chromium to reduce usual corrosion experienced by making use of most iron-based materials. Here we will explore the most commonly used stainless steel which is 304 steel, and we will explore mechanical, physical, and working properties. So we will also gain a better knowledge of this material is works, and where the 304 steel is used in the industry so that we can potentially choose the material for use in our own projects.

Stainless steels got the names from the Society of Automotive Engineers (SAE) and the American Iron & Steel Institute (AISI), which had separately made their own naming for the steel alloys based on their uses, alloying elements, and other factors. Steel names mostly get confusing due to the same alloy which can have

different identifiers based on which the system is used; however, by understanding that the chemical composition of the most alloy blends which remains the same across all the classification systems. In these cases of stainless steels, they are mostly composed of 10 to 30% chromium and they are made to withstand the varying degrees of the corrosion exposure.

These type 304 steel are the most commonly used stainless steel, which is naturally chosen for its corrosion resistance. It can also resist the rusting in many different kinds of environments, only majorly are attacked by the chlorides. It also has the experiences to increase the pitting in warm temperatures (above 60 degrees Celsius), it also reaches though the higher carbon grades of (304H) mitigate this is considered as the effect considerably. This shows that 304 steel mainly rusts but not in high temperatures, but in the aqueous solutions it keeps a continuous contact with the corrosive materials can wear down the alloy. The 304 steels are not mostly readily hardened by thermal treatment, but it can be annealed to increase its workability and the cold worked to increase its strength. If corrosion resistance is the major priority to a project, 304L is the better choice as it decreased the carbon content reduces intergranular corrosion.

304 steel are often considered as “food-grade” stainless steel because it is unreactive with the most of the organic acids and it is used in the food processing industry. Its excellent in most of the cases because of its machinability, weldability and its workability suits these stainless steels which require a level of corrosion resistance as well as complexity. The 304 has found many uses, such as:

- Kitchen equipment (sinks, cutlery, splashbacks)
- Tubing of various types
- Food equipment (brewers, pasteurizers, mixers, etc.)
- Pharmaceutical processing equipment
- Hypodermic needles
- Pots and pans
- Dyeing equipment

## 1.2 THERMAL STRESS

Thermal stress in mechanics and thermodynamics, thermal stress is a mechanical stress which is caused by any changes in temperature of the material. This stress can lead to the fracture or any deformation of plastics based on the other variables of the heat, which is included as material types and their constraints. Temperature gradients, thermal shocks and thermal expansion or contraction are things that can lead to thermal the stress. These stresses are highly dependent on thermal expansion coefficient of which varies from the material to material. The greater the temperature changes, the higher the stress that can occur. Thermal shocks are mostly resulted from the rapid change in the temperature, resulting in shattering or cracking.

When the material is undergoing rapid heat or cool, the surface and the internal temperature will also have a difference in temperature. A quick heating or cooling a thermal expansion or the contraction, which cause localized movement of material causes the thermal stresses. Consider heating a cylinder, first it is going to do is the surface rises in temperature and the center will remains the same temperature. After few time the center of the cylinder may reach the temperature same as the surface temperature. During this heat up of the surface is relatively hot and it will lead to expand more than the center. Consider a case of example a dental filling which can cause a thermal stress in a person's mouth. Certain times the dentists uses a dental fillings which is more different than thermal expansion coefficients than tooth enamel, this fillings can expand faster than enamel which cause pain in a person's mouth.

Material will contract or expand which depending only on the material's thermal expansion coefficient is known as temperature gradient. As the material is totally free to move, the material can freely expand or contract without generating any stresses. When this material is attached to the rigid body at many locations a thermal stresses can be formed in a geometrically constrained region. These stress are calculated by multiplying the temperature change, material's thermal expansion coefficient and the material's Young's modulus. Thermal shock is a combination of a large temperature gradient which is due to low the thermal conductivity, in addition to the rapid change in temperature on the brittle material.

The change in the temperature which causes the stresses on the surface that are in tension, which cause building of crack formation and propagation. The Ceramic materials are mostly susceptible to the thermal shock. For example consider when the glass is heated up to its high temperature and then moving quickly to the quenched in cold water. As soon as the temperature of glass falls rapidly, the stresses are induced and which causes fractures in body of the glass which can be easily be visible as the cracks or even shattering in some cases.

Some of the applications of Thermal Stress are

The thermostats are the most commonly known application of Thermal stress. The word “Thermo” means temperature and the word “stat” means static. The thermostat is a device which is used to maintain a constant temperature. They are mostly used in the construction of electronic devices, ranging from iron box to the air conditioners.

Iron box: Bimetallic strips the thermostat are used in an iron box which contains a “*bimetallic strip*”. As the name called, bimetallic strips which mean, “*a metallic strip*” which is made up of another coefficient of the thermal expansion bonded together.

### 1.3 NANOFUIDS

A variety of industrial methods are involved in the transfer of the heat energy. Throughout the any industrial facility most of the requirements of heat are, heat must be added, moved or removed from one process stream to another. And it has become a industrial necessity. Most of these processes provide a proper source for energy recovery and process fluid cooling or heating.

The heating or cooling in an industrial process mostly creates a saving in energy and also in process to reduce process time, also to raise thermal rating and to increase the working life of the equipment. Some of these processes are even affected qualitatively by the action of enhanced heat transfer. As the development of the high performance thermal systems for heat transfer has become more popular today. As the number of work done to gain a proper understanding about

the heat transfer performance. For their practical application to heat transfer enhancement. This is the advent of high heat

flow processes which has created been significant demand for the new technologies to enhance the heat transfer

There are more methods to improve the performance of the heat transfer efficiency. Some of these methods are used in extended surfaces, usage of micro channels and application of vibration to the heat transfer surfaces. Heat transfer of the efficiency can be improved by the increase of thermal conductivity of working fluid. The most Commonly used heat transfer fluids are ethylene glycol, water and engine oil have the relatively lower thermal conductivities, while compared to thermal conductivity of the solids. High thermal conductivity of the solids also can be used to improve the thermal conductivity of the fluid by adding a small solid particle to the fluid.

Thermo the physical properties of nanofluids are really essential to make a prediction in their heat transfer behavior. It is quite important in the control of the industrial and the energy saving perspectives. There is a great industrial usage interest in nanofluids. Nanoparticles have the great potential to increase the thermal transport properties while comparing to the conventional particles fluids suspension mostly, millimetre and micrometer sized particles. In the last few years, nanofluids have showed greate significant attention because of its enhanced thermal properties. This experimental study has show us that thermal conductivity of the nanofluids depends on the many factors such as particle size, particle shape, base fluid material, particle volume fraction, particle material and temperature. The amount and the types of additives and acidity of the nanofluid are shown to be more effective in the thermal conductivity enhancement.

The advanced concepts of the nanofluids offer us a fascinating heat transfer characteristics while comparing to the conventional heat transfer fluids. They are considerable to the researches on superior heat transfer properties of the nanofluids especially on the thermal conductivity and the convective heat transfer. Applications of the nanofluids in the industry where the heat exchanging devices which are more promising with these characteristic. Nanofluids can be used in following specific areas:

Heat-transfer nanofluids.

Tribological nanofluids.

Surfactant and coating nanofluids.

Chemical nanofluids.

Process/extraction nanofluids.

Environmental (pollution cleaning) nanofluids.

Bio- and pharmaceutical-nanofluids.

Medical nanofluids (drug delivery and functional tissue–cell interaction).

Nanofluids also can be used to cool the automobile engines and the welding equipment and to cool the high heat-flux devices like high power microwave tubes and the high-power laser diode arrays. The nanofluid coolant which flow through a tiny passage in MEMS to improve the efficiency. The measurements of the nanofluids are critical heated flux (CHF) in a forced convection loop which is used for nuclear applications. Nanofluids can be very effectively used for a wide variety of industries, starting from transportation to energy production and in the electronics systems like microprocessors, Micro-Electro-Mechanical Systems (MEMS) and also in the field of the biotechnology. In Recent, the number of the industrial application potential of nanofluids technology and which their focus for the specific industrial applications is increasing.

The increases in the effective thermal conductivity are the most important thing in improving the heat transfer behavior of the fluids. A number of other variables are also plays a import key roles. For example, consider a heat transfer coefficient for the forced convection in the tubes which depends on many other physical quantities related to the fluid or any geometry of the system by which the fluid is flowing. These quantity which include intrinsic properties of fluid which are its thermal conductivity, viscosity ,specific heat and density along with extrinsic system parameters such as the tube diameter and the length and its average fluid velocity. Therefore, it is really essential to the measurement of the heat transfer performance of the nanofluids which directly under flow conditions. Researcher

has shown us that nanofluids have not only the better heat conductivity but also a greater convective of heat transfer capability than the base fluids.

The following section provides us a wide usage and the effective utilization of the nanofluids with the heat exchangers as heat transfer fluids.

## CHAPTER 2

### LITERATURE SURVEY

Dharmapal A. Baitule and Pramod R. Pachghare they have conducted a experiment based on their work on experimental analysis of the closed loop pulsating heat pipe with the variable of filling ratio. This experiment was conducted on vertical orientations for the different heat loads which is varying from 10 W to 100 W in steps of 10 W. The PHP is tested on the Acetone, Ethanol, Methanol and Water as the working fluids. The ratios are from 0% to 100% in steps of 20%. This experimental results shows the heat transfer characteristics, lower thermal resistance and higher the heat transfer coefficient of the PHP are mostly found to be better at the fill ratio of 60% for various heat input. The results from the model experiment are summarized as follows: 1. As there is rise in the heat input the thermal resistance of closed loop pulsating heat pipe get decreased. At lower heat input ( $Q < 60$  W) the thermal resistance is get decreased slowly and at the higher heat input ( $Q > 60$  W) as the difference is smaller. 2. The thermal resistances which has the results of the acetone < methanol < ethanol

Pramod R. Pachghare, Ashish M. Mahalle have conducted a experiment based on the Effect of the pure and the binary fluids on a closed loop pulsating heat pipe thermal Performance, to shown the effect of the working fluid (binary or mixed) on a closed loop pulsating heat pipe. This paper presents shows the proof of the experimental results on thermal performance of a close loop pulsating heat pipe using a copper tube having a internal diameter of– 2.00mm, external diameter- 3.6mm, Material that are used is copper and the working fluid used are Water, Methanol, ethanol, acetone and different binary mixtures. This experiment shows the result that the thermal resistance decreases more rapidly as the increase of heating power which is ranging from 20W to 60W, This provide us a conclu ons from this experiment are 1. Above said working fluids of PHP, thermal resistance which decreases with increasing in heat inputs. The dry-out for the water-ethanol water-methanol and water-acetone PHPs are at 90w, 85W and 80W heat input respectively, which is the approximate algebraic mean values for the boiling point of binary mixture. 2. The high power inputs where the evaporator temperature of the methanol is low as expected in. PHP of a water-methanol binary mixture

shows good thermal performance over the any other working fluids. This experiment result shows us that pure acetone provide us the best thermal performance while comparisons with any other pure and binary mixtures working fluid. . During this experiment no measurable difference has been found recorded during the PHP running with the pure and binary the mixture working fluids, with the overall thermal resistance.

SuchanaAkter Jahan, Mohammad Ali, Md.QuamrulIslamh have conducted a experiment based on the effect of its inclination angle and the working fluid on the heat transfer characteristics and also including the performance of the CLPHP. The performance inspection is done using the two different working fluids of the water and the ethanol. The inclination angles which are of  $0^\circ$  (vertical),  $30^\circ$ ,  $45^\circ$ ,  $60^\circ$ ,  $75^\circ$  and  $90^\circ$  (horizontal). This experiment has conducted on a CLPHP which is made upof copper capillary tube. The length of the copper capillary tube are 148 cm and has 3.0 mm the outer diameter and 2.0 mm the inner diameter which is created a total of 13 turns. The evaporator section has the total length of 39.5 cm and the condenser section which is 31.5 cm; where the rest is assume to adiabatic. The evaporator section are mostly heated by a electrical heat input and condenser section which is cooled by the atmospheric air flow. Since the PHP which is recognized as the two phase heat transfer device which is for the comparative studies it is operated as the double-phase system by using a filling of 70% with working fluid. This result properly demonstrates the effect of its input heat flux, its inclination angle and the physiochemical properties of working fluid based on the thermal performance of the device. This experiment is beings carried out for the water and ethanol and for a different 6 angular orientations of heat pipe, with a similar trend of the thermal characteristics. This research, where the value of thermal resistance is considered as a indication for the efficiency, i.e. The greater value of  $R_{th}$  refers to its greater the difference of the temperature between evaporator and the condenser section and eventually indicates a greater efficiency of system.

D. Manginia , M. Mameli a, A. Georgoulas a, L. Araneo c , S. Filippeschi b , M. Marengo, have conducted a research on heat pipe for the space applications: Ground and microgravity experiments. Based on a novel concept of a hybrid

Thermosyphon/Pulsating Heat Pipe which has a diameter that is bigger than capillary limit on both the ground is tested and in the hyper/micro gravity conditions which are 61st ESA Parabolic Flight Campaign. This device is filled totally with the FC-72 50% vol. filling ratio and it is made up of an aluminum tube with the I.D. 3 mm. The tube which bent into the planar serpentine which has a five curves at evaporator zone, when a transparent section which closes the loop, fluid flow visualizations are in the condenser zone. The five heaters which are mounted alternatively in the branches above the curves at evaporator zone, which provide asymmetrical heating which promoting the fluid flow circulation in a preferential direction. This device is been tested at a different positions (vertical and horizontal) and also in different heat power input levels (from 10 W to 160 W). The Ground test show that the effectively the device works as a thermosyphon while the gravity assisted: in a vertical position which the device can reach an equivalent thermal resistance of the 0.1 K/W with the heat fluxes up to 17 W/cm<sup>2</sup>. In a horizontal position where the fluid motion are absent and where the device works as a pure thermal conductive medium. In a parabolic flight tests points out the PHP working mode: during this micro-gravity period, a sudden absence of the buoyancy force activates an oscillating slug plug flow regime, a typical of the PHP operation, which leads the device to work even in the horizontal position. According to authors' best knowledge, this is the only attempt in literature of a hybrid device is tested.

Mauro Mamelia, Marco Marengo, Sameer Khandekar, has conducted the research based on the Local heat transfer measurement and the thermo-fluid characters of the pulsating heat pipe. When a compact CLPHP is filled with the ethanol with 65% v/v, of adiabatic section made up of four transparent glass tubes which forming and which is connected with the copper U-turns in a evaporator and the condenser sections with respectively, and it is designed to perform a thermal-hydraulic performance investigation. In a Local heat transfer coefficient which estimated by a measurement of the tube wall and the internal liquid temperatures in a evaporator section. At this same time a fluid pressure is oscillated which are recorded together with corresponding flow of patterns. This thermal performances are done for measured for a different heat levels and the global orientation of these device with respect to the gravity. And an exploratory test is also been

conducted with azeotropic mixture of the ethanol and water. The results show a stable device operation is obtained (i.e. evaporator wall temperatures can reach a pseudo-steady-state) when an circulating flow mode is obtained superimposed on a local pulsating flow. This heat transfer performance strongly depends on heat level and inclination angle but in turn, it affects the flow of pattern. The analysis of which the pressure signal reveals that also during a stable performance regimes, the characteristic fluid oscillation frequencies are not easily recognizable. A Equivalent thermal conductivities are the order of  $10^{15}$  times that are made up of pure copper which is achieved. Due to a few number of turns horizontal mode is not feasible. Preliminary result which indicates the filling of azeotropic mixture of the ethanol and the water as fluid does not adjust the thermal performance while comparing it to pure ethanol case. The input heat power which is provided to the evaporator zone is one of the major element of the experimental which controls the parameters. Khandekar shows us the CLPHP which may work in any other different modes (oscillation/ circulation) based on the heat input level and with the different flow of patterns may occur when an heat input rises. To characterize a response to startup a heat flux, a set of experiments are been made and a common form has been formed : for any low level initial heat input levels and the device behavior is very unstable and it will not reach a pseudo steady-state although the heat input is increased during this experiment. For higher level heat input levels the device shows a behavior which is much stable.

V. K. Karthikeyan, K. Ramachandran, B. C. Pillai, A. Brusly Solom, has conducted a experiment based on the Understanding of the thermo-fluidic characteristics of glass tube in a closed loop heat pipe. In flow patterns and the fluid oscillations. A experimental program is carried out for understanding the thermo-fluidic character of deionized (DI) water which is charged in a closed loop pulsating heat pipe (CLPHP) with a flow patterns and fluid oscillations. In a CLPHP is examined under the vertical and horizontal heating modes with the varying heat power. In flow pattern along with the fluid oscillations which is been correlated with the thermal performance of CLPHP. The CLPHP is build on Pyrex glass capillary tube with a total height of 200 mm, width of 140 mm with 5 turns. In a inner and outer diameters of glass tubes with 2.5 and 6 mm respectively. The heights of a evaporator and the condenser were 50 and 150 mm respectively. The height of

condenser is equal to 3 times the evaporator due to the small heat transfer coefficient on a outer wall surface of its glass tube. Where the filling ratio are 50 % of total volume of tube. The visual experimental was carried out to understand a thermalfluid behaviour of a CLPHP. Thus the effect of heat power, heating mode and fluid on the thermal performance of the device are analysed. This flow patterns and the fluid oscillations are captured in an operation. The effective thermal conductivity and the thermal resistance are measured in a CLPHP.

HarshalGamit, VinayakMore, has conducted a experiment based on the investigation of heat pipe. Pulsating heat pipes are new to family of heat pipes used for greater heat removal. And various experiments has carried out to check the effect of the filling ratio and the input of the heat flux for the performance of (CLPHP). The Working fluid which is used in this experiment was water. The inner diameter of copper tube is 2.15mm. Filling ratio are 40%, 50% and 60%. The heat input ranging from 10W, 20W, 30W, 40W and 50W. This result indicates a better system which performance with a small level of filling ratio and at high input.

Roshan D Bhagat, K.M. Watt, have done a experiment based on the Performance of closed loop heat pipe with the acetone as the working fluid. Copper is chosen as the material for the heat pipe which is due to the compatibility of the copper with the acetone as the working fluid. The ratio of the working fluid which effects the performance of closed loop heat pipe. Filling ratio is 30-75 % which provides the proper result so 60 % filling ratio is been selected has the filling ratio of the thermal performance of a closed loop heat pipe with the acetone as the fluid is investigated. This experiment conclude the thermal resistance of closed heat pipe which decreases with increase in heat input for a both methanol and the acetone hence thermal performance of the closed heat pipe increases with increase in the heat input.

Xiaoyu cui,ZiqianQiu,JianhuaWenge, Zhihua Li,In this experiment is presented on the thermal resistance characteristics of closed heat pipes with methanol-based binary mixtures. The working fluids used here are methanol mixed with the deionised water, ethanol and acetone. The volume of ratio mixed here is 2:1, 7:1 and 4:1, and the heating power which ranges from 10W to 100W with filling ratios of 45%, 62%, 70% and 90%. The results prove that the adding other working fluids

to the methanol could change the thermal resistance characteristics of PHP. In a low filling ratio (45%), by adding water to the methanol could prevent a dry-out at the high heating power; when the ethanol which is added to the methanol, the thermal resistance of was between that with the pure methanol and the ethanol; when a acetone was been added, the thermal resistance which is slightly lower while comparing the pure methanol and acetone. At the high filling ratio (62%, 70%, 90%), which can be inferred the heat transfer performances the with methanol-based binary mixtures which are related to thermal-physical properties of a working fluids, molecular interactions, , vapor–liquid phase transition properties and the additional resistance to mass transfer.

Pramod R. Pachghare, Ashish M. Mahalle have done a experiment on Thermo-hydrodynamics of closed heat pipe for a experimental study. In this experimental result on the thermal performance of a closed heat pipe is presented. This made up of copper capillary tubes, which is having a inner and the outer diameters of 2.0 mm and 3.6 mm respectively. The working fluids used here for the experiment are water, ethanol, methanol and the acetone also binary mixture (1:1 by volume) of water-acetone and water-ethanol, water-methanol. For all this experimentations the filling ratio was (FR) 50%, two-turns and vertical bottom heat mode position which is properly maintained. The lengths was selected based on evaporator 42 mm, condenser 50 mm and adiabatic 170 mm. This experimental study conclusion is summarized: Thermal performance are the main quantitatively contributing for the boiling point and for the latent heat of the vaporization of working fluid. In addition to which dynamic viscosity and the surface tension will play a major important role to drive liquid slug against all the gravity in vertical position for circulation.

## CHAPTER 3

### AIM AND SCOPE

The thermal expansion is the kind of tendency to change its volume, shape, area and density which response to the change in temperature, usually without including the phase transitions. When a substance is under heat their molecules begin to vibrate and move more often, usually which create more distance among themselves. Substances which make contract it will increase the temperature than unusual, and only happen within the limited temperature ranges. Heat pipes are one of the most promising way to remove heat in a devices that are widely seen in most of the fields from thermal management of electronic to terrestrial and aerospace applications. The working principle, phase change of a working fluid, makes them the most superior to any other conventional cooling methods available. Nanofluids are used as the working medium for the conventional cylindrical of heat pipe. The working fluids are involved in this study are DI-water and Nano-particles suspension (mixture of copper nano particle and DI-water). By the use of Computational Fluid Dynamics (CFD) in the field of the heat exchangers. The CFD has been employed in the following study for heat exchangers: fouling, pressure drop, the fluid flow, and thermal analysis in the design and optimization phase. The CFD is a effective tool for the prediction of the performance and behavior of a wide variety of heat exchangers.

So with the help of the heat pipe we are able to understand the thermal expansion. By this experiment we can properly determine the suitable nanoparticle and its thermal properties.

## CHAPTER 4

### MATERIALS AND EXPERIMENTAL METHOD

The major aim of this project was to understand the thermal stress using a heat pipe and using nanoparticles which are the affordable method to experiment the thermal strain. By making use of the CFD which shows us a proper working of the heat pipe in a visual manner.

#### MATERIALS

##### 4.1 GALVANOZED STEEL

Galvanization or galvanizing can also be spelled as galvanization or galvanising is a process of applying a layer of protective zinc coating to iron or steel, for preventing rusting. The most commonly used method is hot-dip galvanizing, in this process where the parts are submerged in a bath of molten hot zinc. Hot dip galvanizing deposits which are thick, it contains a robust layer of zinc iron alloys which is present on the surface of the steel item. Consider in case of automobile bodies, where there is an additional coating of paint which will be applied, a kind of thinner form of galvanizing is been applied by the electroplating. This hot-dip process is generally which does not reduce the strength on a measurable scale, the exception of the high-strength steels ( $>1100$  MPa) where the hydrogen embrittlement can cause a problem. This is a consideration that affects the manufacture of wire rope and any other highly stress products.

The protection which is provided by a hot-dip galvanizing is mostly insufficient for the products because that will be constantly exposed to certain corrosive materials such as acids, including acid rain in outdoor. Most of these applications are more expensive stainless steel which is preferred. Most of these nails made today are mostly galvanized. In electroplating which uses on its own for many outdoor purposes because it is cheaper than the hot-dip zinc coating and it looks good while they are new. A reason not to use hot-dip zinc coating is that for nuts and bolts of sizes or smaller, where the thick hot-dipped coating fills almost too much of the threads, which often reduce its strength because of the dimension of steel prior to which coating must be reduced for fasteners to get fit together. This

shows that for, bicycles, bike, car and many other light weight mechanical products, this practical alternative to the electroplating bolts and nuts which are not hot-dip zinc coating, but mostly making it fasteners from stainless steel or titanium. The size of the crystallite present in galvanized coating are visible and aesthetic which is known as "spangle". By different number of particles that are added for heterogeneous nucleation and the rate for cooling in hot-dip process, the spangle also can adjusted from an apparently a uniform surface to grain several cm wide. Mostly the visible crystallites are very rare in any engineering material, even they are usually present.

The term thermal diffusion galvanizing or the sherardizing. Which provides a zinc diffusion coating for iron- or copper-based materials. The parts and the zinc powder are mostly tumbled in sealed rotating drum. Which is around 300 °C (572 °F). Zinc which will diffuse into substrate to create a zinc alloy. The surface preparation of goods also can be carried out by shot blasting. This process is called as "dry galvanizing", because of no liquids involved; this could avoid the most possible problems caused by any hydrogen embrittlement. The dull-grey crystal structure which is zinc diffusion coating with a good adhesion to rubber, paint, powder coatings. This is a preferred method for, complex-shaped metals, coating small and for smoothing the rough surfaces on items which is formed from sintered metal.



Fig:4.1:GALVANIZED STEEL

During the early 20th century, galvanized piping was replaced previously-used cast iron and lead in water plumbing. Typically, when a galvanized pipe rusts from the inside out, building up a layer of plaque which is on the inside of piping, which will eventually cause both water pressure problems and eventual pipe failure. These plaques also can flake off, which leads to the visible impurities in the water and also a slight metallic taste. Mostly the life expectancy of a galvanized piping is almost about 40–50 years, but it is always dependent on how well the pipes were built and installed. Pipe life also depends on the thickness of zinc in the original galvanizing. It ranges on a scale of G01 to G360, and the pipe was galvanized both on the inside and also the outside, or just the outside.

During World War 2, plastic and copper piping have replaced most of the galvanized piping on interior drinking water service, but the galvanized steel pipes are also still used in many outdoor applications which require steel's superior mechanical strength. Use of galvanized pipes which lend some of the truth to the myth that water purity in the outdoor water faucets is always lower, but the actual impurities such as iron, zinc, calcium those are harmless.

Presence of galvanizing piping detracts from appraised value to the housing stock because the piping can lead to failure, by increasing the risk of water damage. Galvanized pipe which will eventually lead to be replaced if the housing stock is to be serving almost 50 to 70-year life expectancy, and some jurisdictions needed for galvanized piping to be replaced before sale. One better way to extend the life expectancy of the existing galvanized piping is to line it with an epoxy resin. This is the common use of galvanized metal and were the hundreds of tons of steel products are galvanized yearly worldwide. In most of the developed countries, the most large cities have their own several galvanizing factories, and many items of the steel-based manufacture are galvanized for protection purpose. Some of these include: verandahs, staircases, ladders, walkways, street furniture, building frameworks, balconies and more. Hot dip galvanized steel is used for making any steel-based frames as a construction material for steel frame buildings.

Low initial cost while comparing to most of the treated steels. In addition, to which galvanized steel is immediately used to deliver. It also does not require any

additional preparation of, painting/coatings, surface, inspections etc. sparing companies are mostly costs on their end.

Longer life. With galvanization, any piece of industrial steel are expected to last any were more than 50 years in an average environments, and also can last more than 20 years with more water exposure. Where their is no maintenance required. It will increase the durability of steel's finished product and increases the product's reliability.

The sacrificial anode which ensures any damaged steel will be protected by surrounding zinc coating. It is totally fine even if the steel section is completely exposed; the zinc which will still corrode first. The coating which will corrode preferentially to steel, By creating a sacrificial protection to areas which are damaged.

Rust resistance from the zinc coating. Where the iron elements in the steel that are incredibly prone to the rusting, but making use of the zinc which acts as a protective buffer between steel and any other moisture or oxygen. Galvanized steel are very protective, including the sharp corners and the recesses which cannot be protected with any other coatings, making it resistant to damage.

## 4.2 COPPER TUBE

Heat exchangers are devices which are used to transfer heat for achieving the desired heating or cooling process. In an important design aspect of the heat exchanger technology is to selection of appropriate materials that are used to conduct and transfer the heat fast and efficiently.

Copper has all the many properties for the thermally efficient and durable heat exchangers. The first and the most important thing is copper its an excellent conductor of the heat. This shows us that copper is a high thermal conductivity which allows the heat to pass through it quickly. The other desirable properties of the copper in heat exchangers which include its boifouling resistance, corrosion resistance internal pressure and maximum allowable stress, creep rupture strength, specific heat, thermal expansion ,hardness, ,fatigue strength, antimicrobial properties, yield strength ,tensile strength ,high melting

point, alloyability, ease of fabrication and joining.

Combination of these properties are mostly enable copper to specified for the heat exchangers in the industrial, radiators, HVAC systems, vehicular coolers, and as heat sinks to cool the computers, disk drivers, computer monitors, televisions and other electronic equipment. Copper is considered as incorporated to the bottoms of the high-quality cookware because of its metal conducts the heat quickly and which distributes it evenly.

Non-copper heat exchanger which are available. Some of the alternative materials which include aluminium, titanium, stainless steel, carbon steel and nickel alloys.

Based on the focuses of beneficial properties and the common applications of the copper in a heat exchangers. Some of the new copper heat exchanger technologies for the specific applications which introduces.

### 1. Thermal conductivity

Thermal conductivity is a measurement of material's ability which to conduct heat. The heat transfer across the materials of the higher thermal conductivity occurs mostly at a high rate than across the materials of the low conductivity. In the SI unit, thermal conductivity it is measured in watts per meter Kelvin. In a Imperial System the Measurement of the thermal conductivity is measured in Btu/(hr•ft•F).

Copper has a thermal conductivity of 231 Btu/(hr-ft-F). This is higher than all other metals except silver, a precious metal. Copper has almost a 60% better thermal conductivity than the aluminium and almost a 3,000% rating than stainless steel.

### 2. Corrosion resistance

Corrosion resistance is considered as the essential in a heat transfer applications where the fluids which are involved, such as in, radiators, hot water tanks etc. The most practically affordable that are similar corrosion resistance to the copper is only stainless steel. However, the thermal conductivity of the stainless steel which is 1/30<sup>th</sup> of copper. The Aluminium tubes which are not very suitable for the potable or the untreated water applications because of it corrodes at pH<7.0 and it releases hydrogen gas.

The protective film which can be applied to inner surface of the copper alloy tubes to increase its consisting of an inner titanium layer with outer copper-nickel alloys are employed. This enables use of the copper's beneficial chemical corrosion resistance and mechanical. In a certain applications, the film it is composed of iron. In a power plant condensers, duplex tubes properties along with the titanium's corrosion resistance. A duplex tube which consists of inner aluminium brass or the copper-nickel and outer mild steel or stainless can be used for the cooling in a oil refining and the petrochemical industries.

### 3. Biofouling resistance

Copper and copper-nickel alloys has the highest natural resistance to biofouling with relative to alternative materials. Any metals used in a heat exchangers, such as titanium, steel and aluminium, foul readily. Protection against the biofouling, mainly in marine structures, it can accomplish over a long periods of time with the copper metals.

Copper-nickel alloys has been consider over many years in sea water pipework and any other marine applications. Where these alloys can resist biofouling in the open seas where they don't allow any microbial slime to build up and to support macrofouling.

Researchers attribute towards the copper's resistance is biofouling, even in the temperate of waters, where two possible mechanisms first one is a retarding sequence of colonization through which slow release of copper ions during corrosion process, thereby inhibiting the attachment of the microbial layers a marine surfaces;and second one is separating the layers which contain the corrosive products and also the larvae of macro-encrusting organisms. The latter mechanism it deters the settlement of the pelagic stages on a metal surface, rather than destroying the organisms.

### 4. Antimicrobial properties

Due to which the copper is the strongest antimicrobial property, copper fins which can inhibit bacterial, fungal and growths that commonly build up the air conditioning systems. The surfaces of the copper-based heat exchangers that can be cleaner for the longest periods of time than the heat exchangers which is made from other metals. This benefit offers the greatest expanded of heat exchanger

service life and the contributes to improve the air quality. Heat exchangers which fabricate separately from antimicrobial copper and the aluminium in a full-scale of HVAC system have been evaluated for their ability to maintain a limit microbial growth under the controlled conditions of normal flow rates using the single-pass outside air. The commonly used aluminium component that develop stable biofilms the of bacteria and the fungi within four weeks of operation. During this time period, antimicrobial copper are able to limits bacterial load which are associated with copper heat exchanger fins by 99.99% and fungal loads by 99.74%.

In Copper fin where the air conditioners has been deployed on the bus in Shanghai to the rapidly and completely destroys the bacteria, fungi and viruses that were previously in thriving on non-copper fins and permitted to circulate around the systems. The decision to replace aluminium with copper followed antimicrobial tests by the Shanghai Municipal Center for Disease Control and to Prevention from 2010 to 2012. The study found that microbial levels on copper fin surfaces were significantly lower than the aluminium, which is helping to protect the health of bus passengers.

#### 5. Ease of inner grooving

Newly grooved copper tube which are of smaller diameters which is more thermally efficient, materially efficient, and easier to bend and flare and otherwise work with. It is generally easier to create a inner grooved tubes out of the copper, a very soft metal.

### Applications for copper heat exchanger

#### Direct Exchange (DX) Geothermal Heating/Cooling

Geothermal heat pump technology, which is known as the "ground source," "earth-coupled," or "direct exchange," relies on the circulating the refrigerant through the buried copper tubing for the heat exchange purpose. These units, which are considerably the most efficient than the air-source counter parts, which rely on the constancy of the ground temperatures that are below the frost zone for the heat transfer. The best efficient ground source that heat pumps are using the ACR, Type L or special-size copper tubing buried into the ground to transfer heat to or from the conditioned space. Flexible copper tube (typically 1/4-inch to 5/8-inch)

can be buried in deep vertical holes, that are horizontally in the relatively shallow grid pattern, in the vertical fence-like arrangement in the medium-depth trenches, or the custom configurations. Further information is available.

### Internally Grooved

The benefits of the small-diameter which are internally grooved the copper tube for heat transfer are well documented.

Smaller the diameter coils has the better rates of the heat transfer which are conventional sized to the coils and they are withstand the highest pressure that requires the new generation for environmentally friendlier for refrigerants.



Fig:4.2:Copper Tube

Smaller the diameter coils also have the low material costs because of the requirement of less refrigerant, fin, and coil materials; and they mostly enable the design of the small and light high-efficiency air conditioners and the refrigerators because they have evaporators and condensers coils which are small and light. The MicroGroove which uses the groove inner surface of tube to increase the surface to the volume ratio and to increase the turbulence to the mix the refrigerant and the homogenize temperature across the tubes.

### 4.3 DISTILLED WATER

**Distilled water** is water which is been boiled in to vapor and the condense back into a liquid in the separated container. The impurities in original water that are to

be boiled below or near the boiling point of water which remain in a original container. Therefore, distilled water is one of the type of purified water.

Drinking water which is been distilled from the sea water at least about AD 200, when this process was clearly described by the Alexander of Aphrodisias. The history predates as a passage in Aristotle *Meteorologica* (II.3, 358b16) refers to distillation the water. Captain Israel Williams of the *Friendship* (1797) improvised a better way to distill water.

In most of the chemical and biological laboratorie, and also in any industry, cheaper alternatives which is deionised water are preferred to distilled water. But the problem with these alternatives are not pure enough, distilled water are used. In exceptionally condition high-purity water is required, double distilled water is used.

In general, mostly a non-purified water could cause or interact with the chemical reactions and also leave mineral deposits after boiling away. One of the best method of removing impurities from water and other fluids is distillation.

For example the best case is ions are commonly found in a tap water which would drastically reduce the lifespans of lead acid batteries used in trucks and cars. Most of these ions are not acceptable in a automotive cooling systems because they get corrode the internal engine components and also deplete typical antifreeze anti-corrosion additives.

Consider any non-volatile or mineral components in water that are left behind when there is water evaporates or a boils away. Water escaping in a form of steam, for example consider a boiler of heating system or any steam engines, left behind any of the dissolved materials leads to its mineral deposits known as boiler scale.

Until the World War II, the method of distilling sea water to produce an fresh water was very time-consuming and very expensive in fuel. It was said: "It almost takes one gallon of fuel to make a one gallon of the fresh water. Before the war, Dr. R. V. Kleinschmidt developed a very compression still, which was later known as the Kleinschmidt still, it was know for extracting fresh water from the sea water or the contaminated water. It was done by compressing the steam produced by boiling water, 175 US gal (660 l; 146 imp gal) of fresh water could be extracted

from sea water for every gallon (3.8 l; 0.83 imp gal) of fuel used. During World War II this equipment became standard on Allied ships and on trailer mounts for armies during the later half of the century. Modern vessels now know as flash type evaporators to boil sea water, heating the water to between 70 and 80 °C (158 and 176 °F) and evaporating the water in a vacuum; this is first collected as condensation before being stored.

Bottled distilled water which are found in pharmacies or supermarkets, and home water distillers are available as well. Water purification, which is called as distillation, is important in a region where there is water resource or tap water is not very suitable for ingesting without the boiling or chemical treatment.

Municipal water supplies mostly always contain a trace of components at the levels which are regulated as safe for consumption. Consider some other components such as the trace levels of aluminium which may result from a treatment process. Fluoride and any other ions are mostly not removed through the conventional water filter treatments. However, distillation eliminates most of the impurities.

Distilled water is used as drinking water in arid seaside areas where there is lacking sufficient freshwater, via desalination of seawater.

Health effects of Distillation it removes all minerals from water. It results in demineralised water, which has proven not to be healthier than the drinking water. The WHO investigated a related health effects of demineralised water in 1982, and its also experiments in humans found that the demineralised water will increased diuresis and also elimination of electrolyte, with the lowering of serum potassium concentration. Magnesium, calcium, and any other nutrients in a water which can help to protect against any nutritional deficiency. Recommending for magnesium has put at a minimum of 10 mg/L with 20–30 mg/L optimum; for calcium a 20 mg/L minimum and a 40–80 mg/L optimum, and a total water hardness (adding magnesium and calcium) of 2–4 mmol/L. Any water hardness above 5 mmol/L, higher the incidence of kidney stone, urinary stones, arthrosis and arthropathies gallstones, have been observed.

Water filtration and any distillation devices has become increasingly common in any households. Municipal water supplies most often have the minerals added or

any trace impurities at the levels which are mostly regulated to be safe for consumption. Much of these additional impurities, such as fluoride, volatile organic compounds, and an estimated >75,000 other chemical compounds are not able to be removed through any conventional filtration; however, reverse osmosis and distillation eliminate nearly all of these impurities.

The drinking distilled water as a replacement for the drinking water has both advocated and discouraged for the based health reasons. Distilled water which lack minerals and certain ions such as calcium that play a major role in the biological functions such as in nervous system homeostasis, and also normally found in any potable water. The lack of naturally occurring minerals such as distilled water has raised some concerns. The Journal of General Internal Medicine published a paper based on the mineral contents of different waters available in the US. This study found that drinking water available to North Americans may contain high levels of sodium, magnesium, and calcium and may provide certain clinically important portions of recommended dietary intake of these minerals. It also encourages the people to check mineral content of their water, whether it is a tap or bottled, and choose water most appropriate based on their needs. Since the distilled water is devoid of the minerals, mineral intake through the diet is needed to be maintain a good health. The use of "hard" water (water with minerals) is associated with many beneficial cardiovascular effects. As noted in American Journal of Epidemiology, consumption of hard drinking water which contain negatively it is correlated with the atherosclerotic for heart disease.



Fig:4.3:Distilled Water

## 4.4 THERMINOL 55

Therminol 55 is a synthetic heat transfer fluid which is mostly used in a moderate-temperature applications. Therminol 55 fluids is designed purpose for the use in non pressurized or low-pressure, indirect heat systems. It delivers its efficient based on, uniform process heat with no need for high pressures. Some of the Performance Benefits are Long Life you will get many years of reliable and a cost-effective performance, even if you are operating your system continuously around at 300°C (570°F). This shows that you do not have to overspecify your fluid.

It act as a excellent resistance to the fouling because of the Therminol 55 which is a synthetic fluid, it can resists the effects of a oxidation which is 10 times better than the mineral oils, which means less oxidation and more solids formation. For any systems without any nitrogen inerting, the advantages are more significant. It act as an excellent Low-Temperature pumpability Therminol 55 is still more pumpable around –28°C (–18°F), compared to other mineral oils that will not be able to pump at the temperatures below –7°C (20°F). With the therminol 55, your heat transfer fluid system which can start up easily and quickly

### Applications

- Asphalt
- Asphalt storage
- Biomass - orc
- Cement - waste heat recovery + orc
- Desalination
- Gas to liquid (gtl)
- HTF - production of bioalcohol
- HTF - production of biodiesel
- Hot mix asphalt
- Natural gas purification
- Oil or gas processing
- Polymer & plastic

- Waste heat recover + orc

#### Key attributes

- Excellent Low Temperature Pumpability
- Excellent resistance to fouling
- Long Life

Therminol 55 heat transfer fluid is a quite unique, synthetic fluid which is designed to provide the reliable, consistent heat transfer performance which is over a long period life at the maximum huge temperatures up to 290°C (550°F). It provides an excellent cost performance which provide over the fluid life while comparing to the normal mineral oil-base heat transfer fluids, even at a normal operating temperatures which can obtain its maximum use temperature around 315°C (600°F). It has more readily pumpable at very low temperatures than the most of the other mineral oil-based heat transfer fluids. Savings in capital, maintenance costs and operations are often achieved during the application that traditionally use steam as a heating medium.

#### Physical and chemical characteristics

Therminol 55 fluid which is designed for use the purpose of nonpressurized and lowpressure , with an indirect heating systems. It also delivers a efficient, dependable, uniform process heat which has no need for the high pressures. The high pressure boiling point of the Therminol 55 helps to reduce the volatility and the fluid leakage problems which is associated with any other fluids. The recommended huge maximum and the film temperatures for the Therminol 55 are mostly based on the industry-standard thermal studies. If the Operation is conducted at or below these temperature maximums can also provide the long service life under most of the operating conditions. The actual fluid life is totally dependents on the total system of design and operating and can also vary by the heat transferring fluid chemistry. At the fluid ages, formation for the low- and most high-boiling compounds may result. In a low-boiling compound it should be very well vented from all these system as it is necessary for a safe location away from the personnel and the sources for ignition and in the compliance it with the

applicable which the regulations and laws. The high-boiling compounds which may vary very much soluble in a fluid. The significant overheating or the fluid contamination will also be accelerated decomposition and also may result in increase in highboiler and the solids concentrations. Excess solids it can be removed typically be filtered.

Therminol 55 which seems to be significantly kind of less sensitive than the mineral oils to the negative consequences (sludging, fouling) of the thermal oxidation. Eastman recommends that the systems which utilizes Therminol 55 fluid it must be blanketed with an significant atmosphere of inert gas to be protected against effects of the fluid oxidation which performance and increase life expectancy. The pressure relief device(s) which must be installed where required. Therminol 55 is a non corrosive to the metals common uses in construction of the heat transfer systems. While the therminol 55 which has a relatively high flash point, which is not to be classified as the fire-resistant heat transfer fluid. Its consequently use of the protective devices which may be required to reduce the fire risk and users of Therminol 55 must be checked with the safety and risk management experts for specific instructions.



Fig:4.4:Therminol 55

Precaution for safe handling of therminol 55 are to avoid contact with clothing, eyes and skin. And avoid breathing vapors or mists. It must be used in very well ventilated areas. While carrying the equipment mostly individual protection. Do not drink, eat, or smoke during use. Handle it accordance with a proper industrial practice safety and health. The product which is not named as transfer fluid heat

fire resistant. Should take a proper precautions to avoid any ignition sources. The conditions for any safe storage Keep container which is tightly closed in a cool, dry, and well-ventilated place. It should be Kept away any of the direct sunlight. Keep away from its contact with is oxidizing materials. Keep it in a properly labeled container. Using a appropriate containment to avoid any environmental contamination. The containers which have been opened must be carefully resealed and kept upright to prevent any kind of leakage. These are some of the safest way to handle therminol 55.

#### 4.5 CFD ANALYSIS

Mainly the gas and liquid flow behavior are quantified by the partial differential equations which representing the conservation laws for momentum, mass and energy. In a computational fluid dynamics which is a branch of the fluid mechanics that make use of the numerical analysis and also algorithms to solve fluid flows situations. In an High-performing computer which are used for conducting the calculation requires to simulate a interaction for gases and liquids with surfaces defined by both boundary conditions.

As we know that CFD basics which is based on the Navier stokes equations. Arising from the apply Newton's second law to fluid motion, which is together with any assumption of the stress in a fluid is the sum of diffusing viscous term and the pressure term, these equations are more describe how the temperature, velocity, pressure and density of a moving fluid are correlated.

The development in CFD and also the increase in CFD software applications which has been closely associated with evolution of an high-speed computers. A brief history of the CFD in 1922 was the basis of modern CFD was made and numerical meteorology made by Lewis Fry Richardson which was done for weather forecasting scheme using many differential equations and finite differences. In 1933 where the earliest numerical solution was done for flow past a cylinder developed by A. Thom. Also in 1950 in first 24-hour weather forecast was performed by the ENIAC modern computer. In the year 1955 the particle-in-cell simulation method which was for transient a 2D fluid flow which was developed

by Los Alamos National Lab. Also in 1963 where the vorticity-stream-function method which was done for 2D, transient, incompressible flow in 1965 also the Marker-and-cell method for the time-dependent viscous flow which was developed by Los Alamos National Lab. In 1966 where the Fluid-in-cell method was developed for the unsteady compressible flow problems. In 1967 the first 3D model was based on the panels discretization which was published by the Douglas Aircraft. In 1968 where the first lifting Panel Code which was described by the Boeing Aircraft. In 1970 the first description of a Full Potential equations was published by the Boeing. In the year 1981 – 3D FLO57 code was based on the Euler equations for the use of transonic flows. After the year 1981 many fundamental pieces of research which contributed to CFD 2D and 3D methods which were focused mostly on airfoil design and the analysis. In NASA research which dedicates to the Navier–Stokes equations which was developed using the 2D codes ARC2D and 3D codes. These also includes codes like ARC3D. With a proper CFD analysis, we can always understand the flow and the heat transfer throughout which the design is processed. The common methodology for any of the engineering CFD software analysis is common base on the few procedures:

Clear Understanding the flow model which includes Flow separations, transient effect, physical interactions;

showing the Prove for the assumed model it includes experimental results validation, , structural simulations and parametric studies

In a model optimizing which reduces the pressure drops, improving laminar, flow homogenization, and turbulent mixing.

Without a proper numerical simulations of fluid flow it is always very difficult to imagine how:

- Meteorologists which can forecast the warn of natural disasters and weather
- It helps the vehicle designers to improve the aerodynamic characteristics;  
It helps the architects which can design the energy-saving and also the safe-living environments;
- The gas and oil engineers also can design and to maintain a optimal pipes networks;
- It also helps the doctors in preventing and curing the arterial diseases by any computational hemodynamic.

One good examples for CFD analysis is a formula one car which is carried out in a web browser with simcale

In relation to the mechanical fluid simulation, the fluid dynamics is the major key for analyses methods used for the SimScale platform together with solid mechanics and thermodynamics. In a SimScale which offers a wide variety of CFD software analysis capabilities which including:

- In a multiple laminar and the turbulence models, that are mostly based on the Reynolds number for any fluid flow;
- For any Steady-state applications and anyother transient solvers setup;
- CFD software also analysis mass transport within the fluid flows;
- It can access to any multiple incompressible and also any compressible fluids solvers;
- It can also analysis the Single- and multiphase flows simulation;
- In a advanced modeling concepts, it includes such as porous media or any kind of rigid body movement for fluid domains



Fig:4:5:CFD Analysis

#### 4.6 EXPERIMENTAL METHOD

Initially, we have done the research using the heat pipe, which is a heat-transfer device it is a combination of the principles of both the thermal conductivity and phase transition to effectively transfer heat between any two solid interfaces. As

we know that heat is the main reason for thermal strain it is later analysed visually using the CFD software. which representing the conservation laws for momentum, mass and energy in a computational fluid dynamics that make use of the numerical analysis and also algorithms to solve fluid flows situations.

In this experiment the CFD methodology is done here is totally based on the flow fluid and the heat transfer into a heat pipe is a process which is very complex. In this consequence, the efficiency of the thermal CFD where the simulation depends on many factors. Creation a proper model geometry and it should integrate in a physical domain, where the grid generation and its choice of suitable numerical computing scheme that are some of the significant factors which can be determined by the level of success of the simulation process

With this calculations and reading from both the heat pipe and the CFD we are able to develop and design an effective method to determine the proper reliability and the affordability of the material in a heating or cooling process

## CHAPTER 5

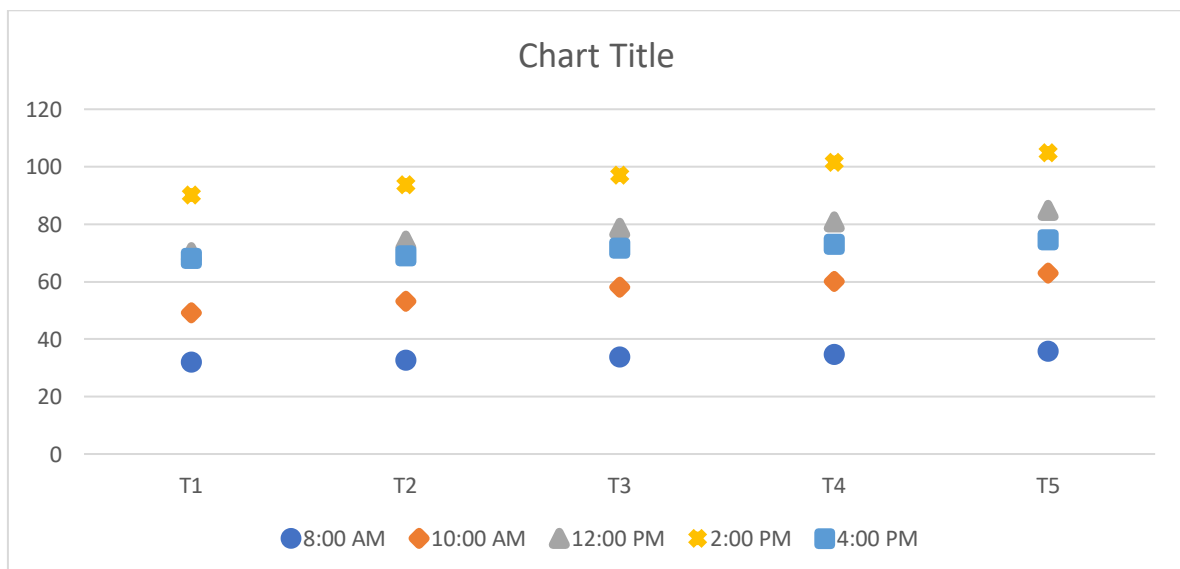
### RESULTS AND DISCUSSIONS

The calculations and the readings which are obtained from a heat pipe are represented in a graph for a better understanding. As shown in the tabular column the reading are taken during five different time in a day and also we gain five different temperature at each points.

The below readings given in the tabular column and in the graph which represent the reading of the distilled water

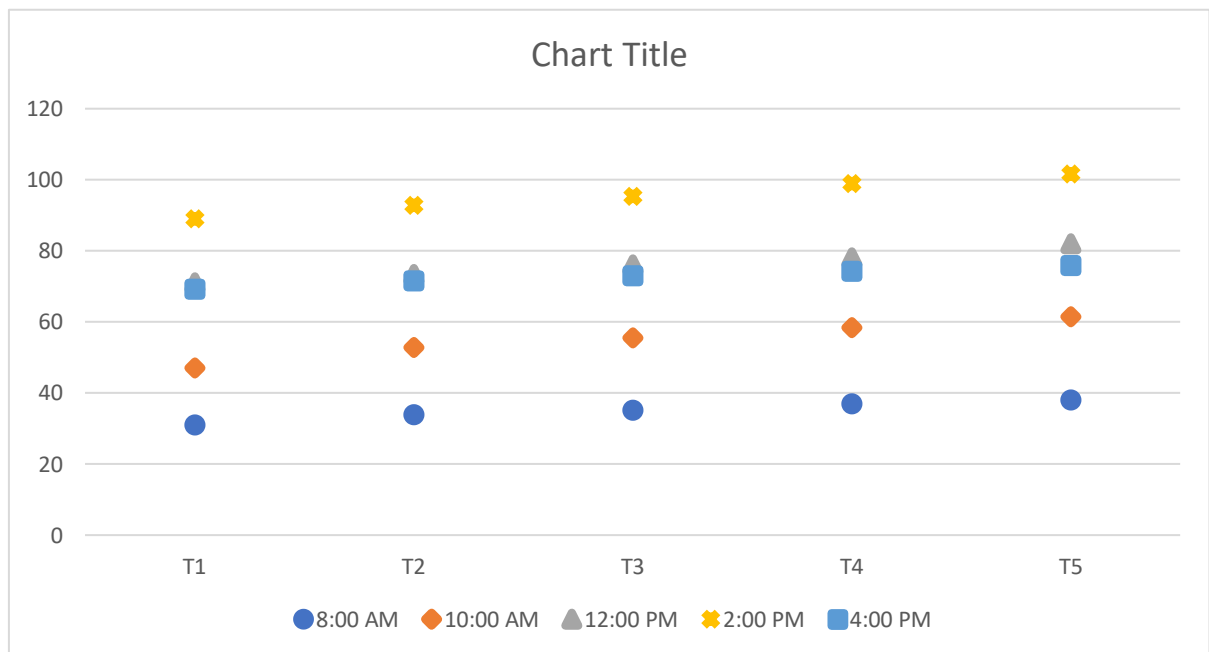
This tabular column represents the reading which is taken on the Day 1

|    | 8:00 AM | 10:00 AM | 12:00 PM | 2:00 PM | 4:00 PM |
|----|---------|----------|----------|---------|---------|
| T1 | 32      | 49       | 70       | 90      | 68      |
| T2 | 32.6    | 53.2     | 74.1     | 93.7    | 68.9    |
| T3 | 33.8    | 57.9     | 78.5     | 97      | 71.5    |
| T4 | 34.7    | 60       | 80.8     | 101.5   | 73      |
| T5 | 35.8    | 62.8     | 84.8     | 104.7   | 74.5    |



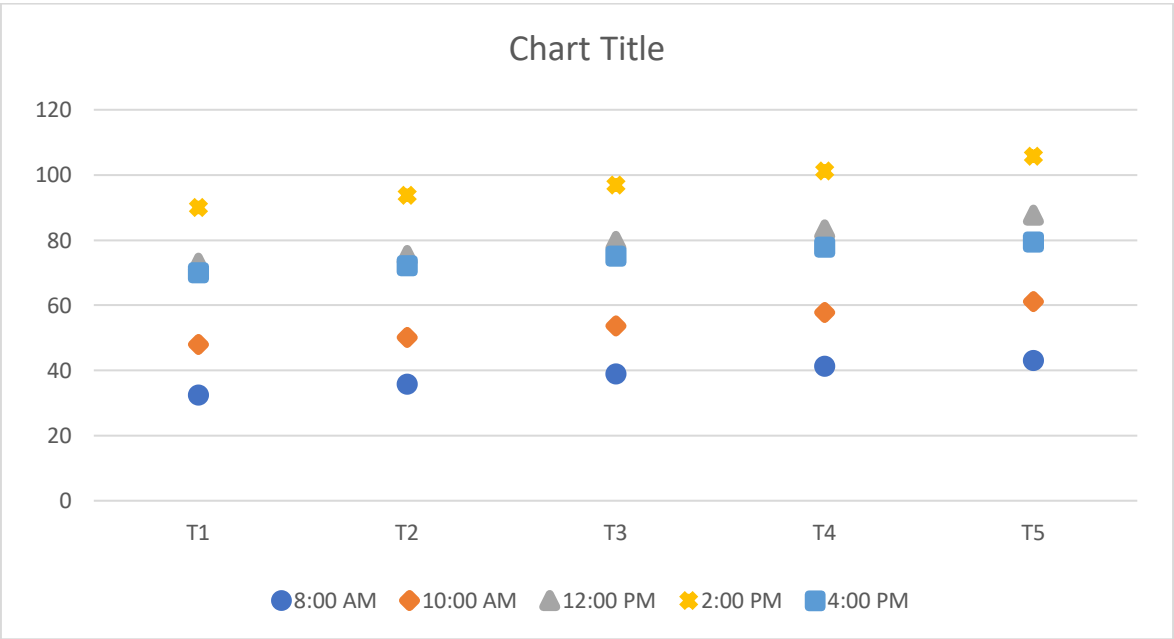
This tabular column represents the reading which is taken on the Day 05

|    | 8:00 AM | 10:00 AM | 12:00 PM | 2:00 PM | 4:00 PM |
|----|---------|----------|----------|---------|---------|
| T1 | 31      | 47       | 71       | 89      | 69.2    |
| T2 | 33.9    | 52.8     | 73.2     | 92.7    | 71.5    |
| T3 | 35      | 55.5     | 75.9     | 95.3    | 73      |
| T4 | 36.8    | 58.4     | 78       | 98.9    | 74.2    |
| T5 | 38      | 61.3     | 81.9     | 101.6   | 75.8    |



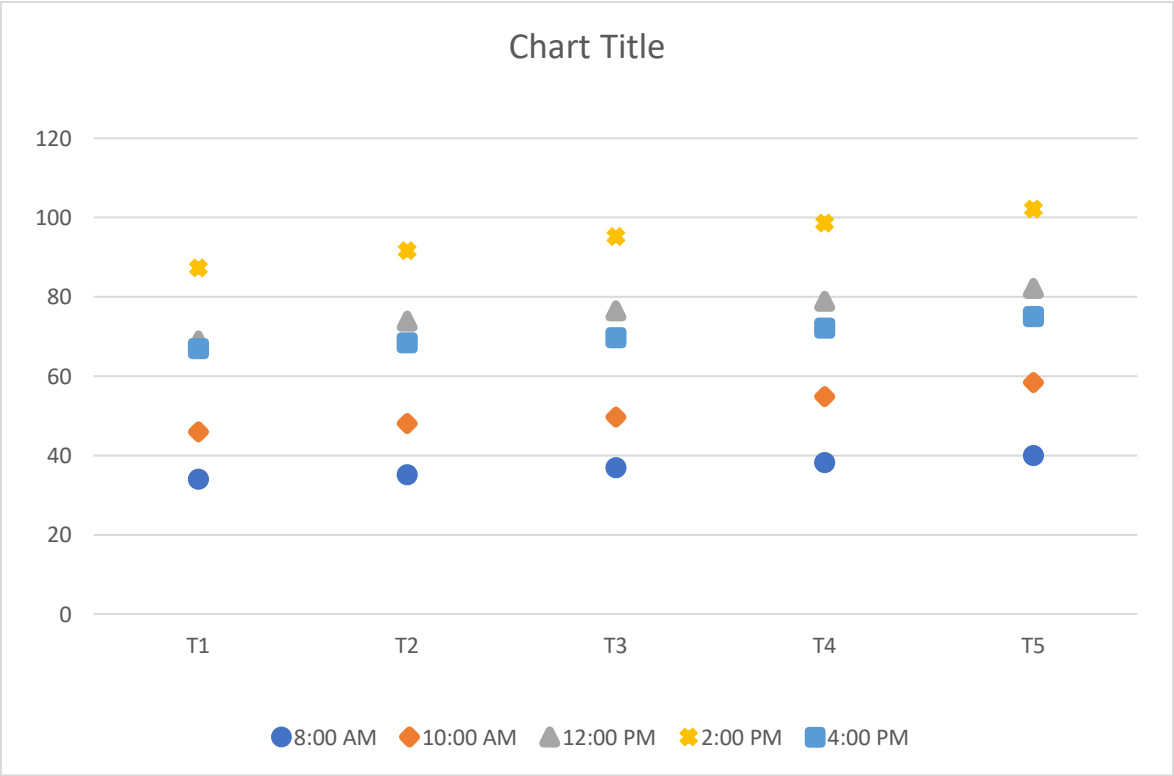
This tabular column represents the reading which is taken on the Day 10

|    | 8:00 AM | 10:00 AM | 12:00 PM | 2:00 PM | 4:00 PM |
|----|---------|----------|----------|---------|---------|
| T1 | 32.5    | 48       | 73       | 90      | 70      |
| T2 | 35.8    | 50.1     | 75.3     | 93.8    | 72.2    |
| T3 | 39      | 53.6     | 79.7     | 97      | 75.1    |
| T4 | 41.2    | 57.8     | 83.1     | 101.2   | 77.8    |
| T5 | 43      | 61.2     | 87.6     | 105.8   | 79.4    |



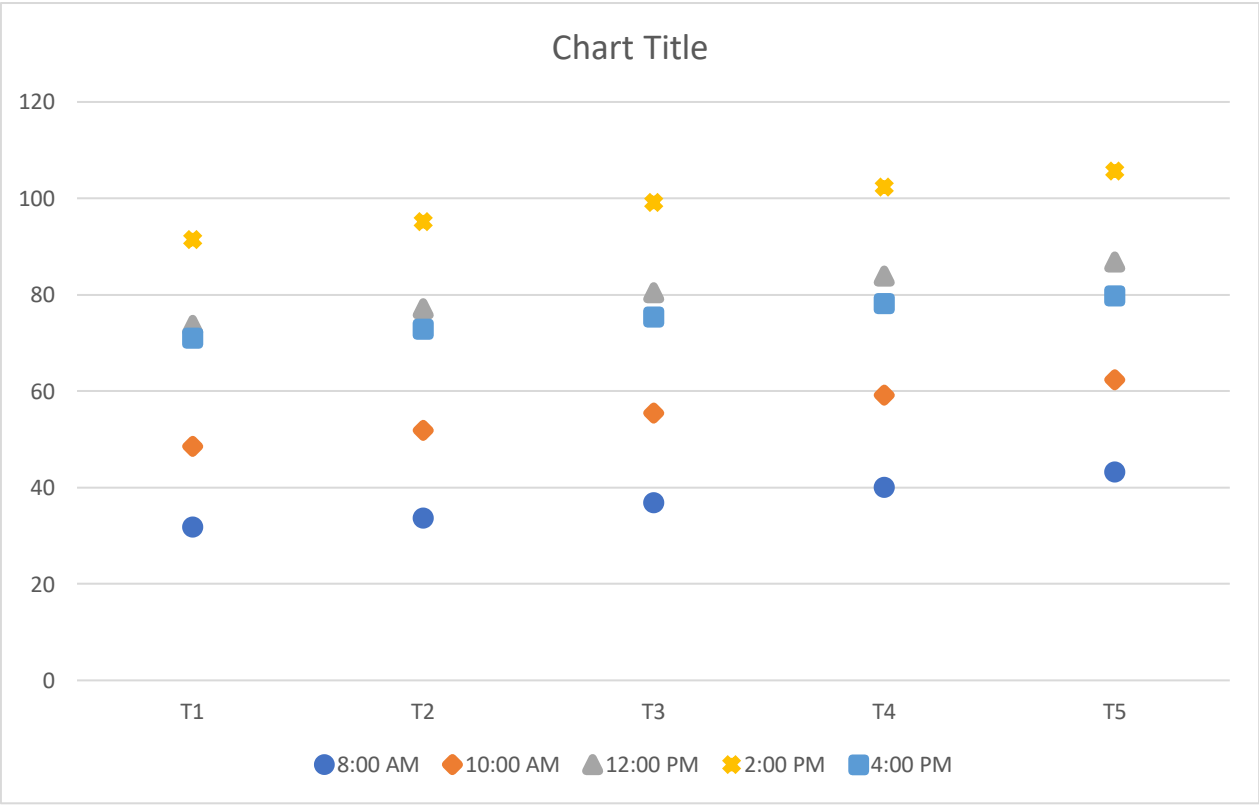
This tabular column represents the reading which is taken on the Day 15

|    | 8:00 AM | 10:00 AM | 12:00 PM | 2:00 PM | 4:00 PM |
|----|---------|----------|----------|---------|---------|
| T1 | 34      | 46       | 69       | 87.4    | 67      |
| T2 | 35.2    | 48.2     | 73.9     | 91.8    | 68.4    |
| T3 | 37      | 49.8     | 76.5     | 95.3    | 69.8    |
| T4 | 38.3    | 54.9     | 79       | 98.6    | 72.2    |
| T5 | 40.1    | 58.4     | 82.2     | 102.3   | 75.1    |



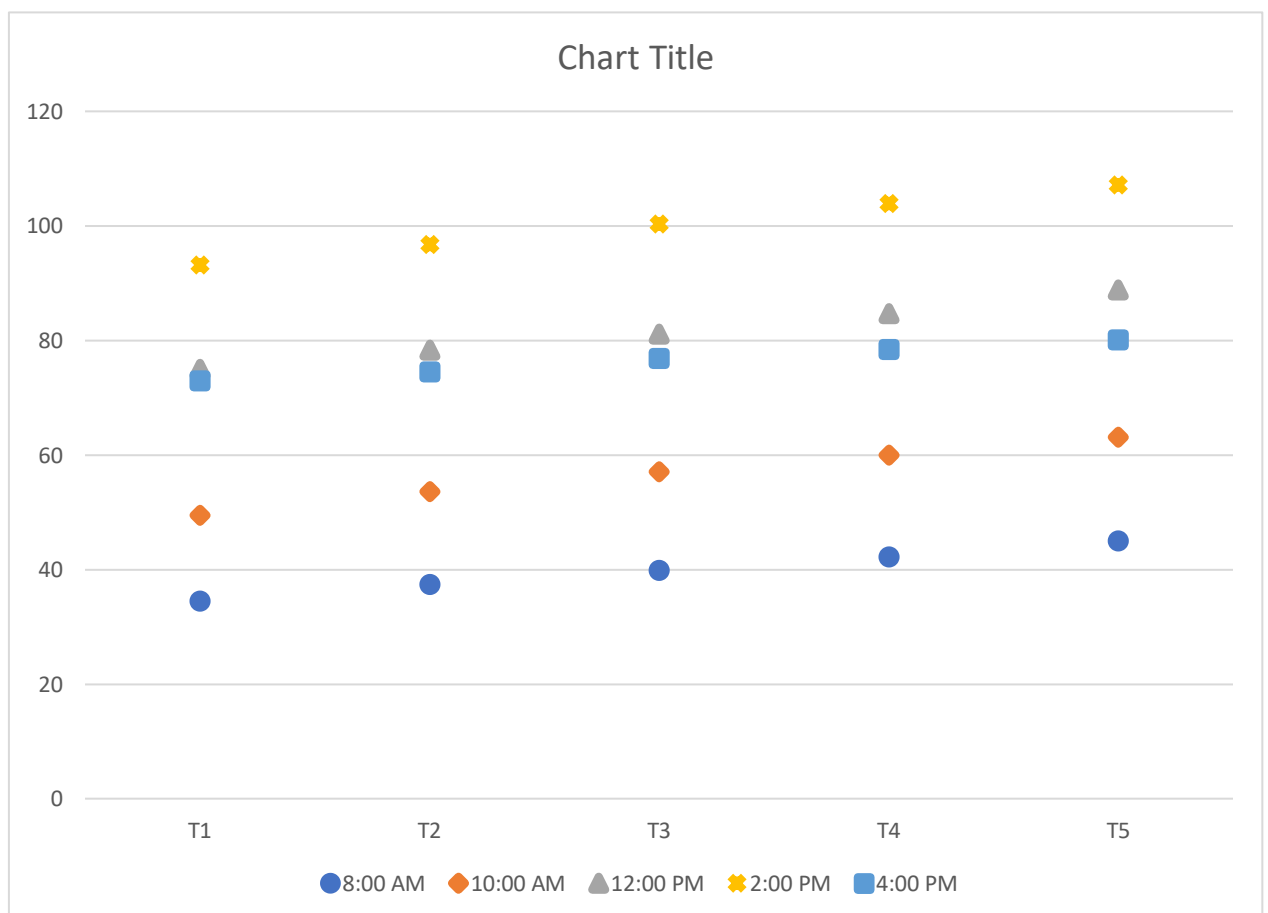
This tabular column represents the reading which is taken on the Day 20

|    | 8:00 AM | 10:00 AM | 12:00 PM | 2:00 PM | 4:00 PM |
|----|---------|----------|----------|---------|---------|
| T1 | 31.8    | 48.5     | 73.6     | 91.4    | 71      |
| T2 | 33.7    | 51.9     | 77.1     | 95.2    | 72.8    |
| T3 | 36.9    | 55.4     | 80.4     | 99.1    | 75.4    |
| T4 | 40.1    | 59.2     | 83.9     | 102.3   | 78.1    |
| T5 | 43.2    | 62.4     | 86.8     | 105.6   | 79.8    |



This tabular column represents the reading which is taken on the Day 25

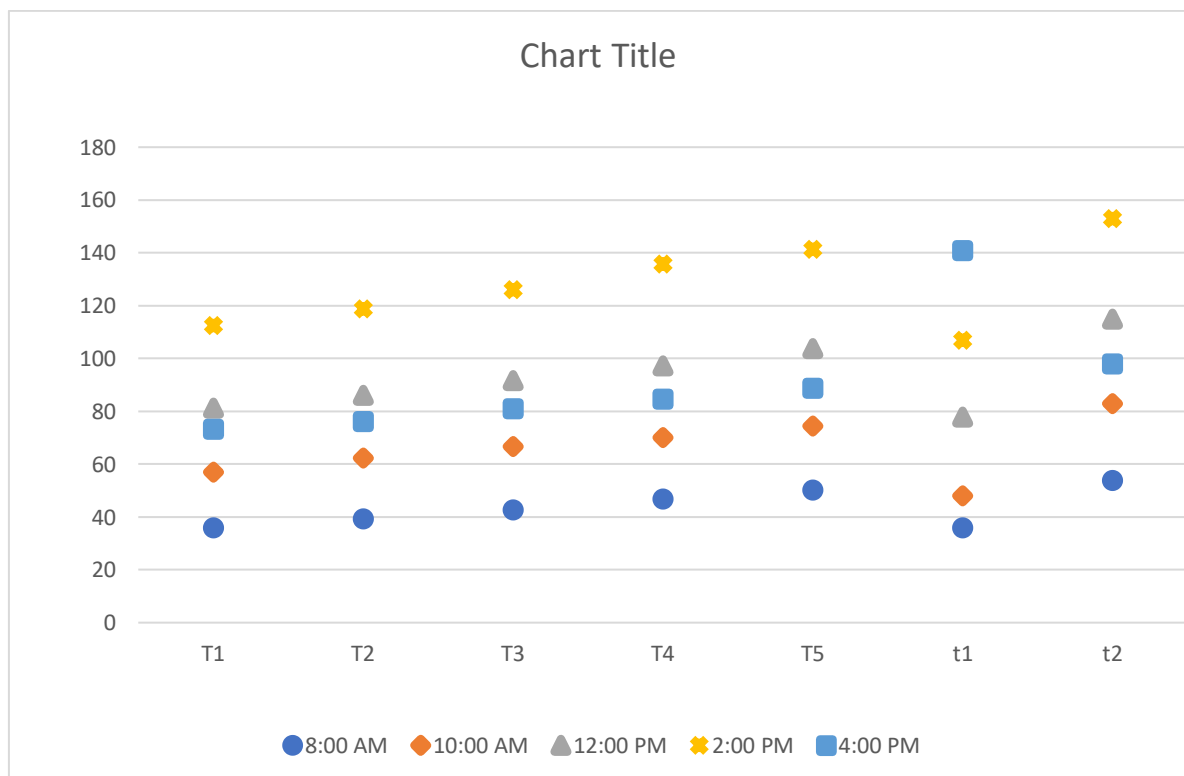
|    | 8:00 AM | 10:00 AM | 12:00 PM | 2:00 PM | 4:00 PM |
|----|---------|----------|----------|---------|---------|
| T1 | 34.5    | 49.5     | 75       | 93.2    | 73      |
| T2 | 37.4    | 53.6     | 78.3     | 96.8    | 74.6    |
| T3 | 39.9    | 57.1     | 81.1     | 100.4   | 76.9    |
| T4 | 42.3    | 60       | 84.7     | 103.9   | 78.5    |
| T5 | 45      | 63.1     | 88.9     | 107.2   | 80.1    |



The below readings given in the tabular column and in the graph which represent the reading of the distilled water which is shown in T1,T2,T3,T4 and T5. And the thermometer which is passing through the copper tube is shown in t1 and t2

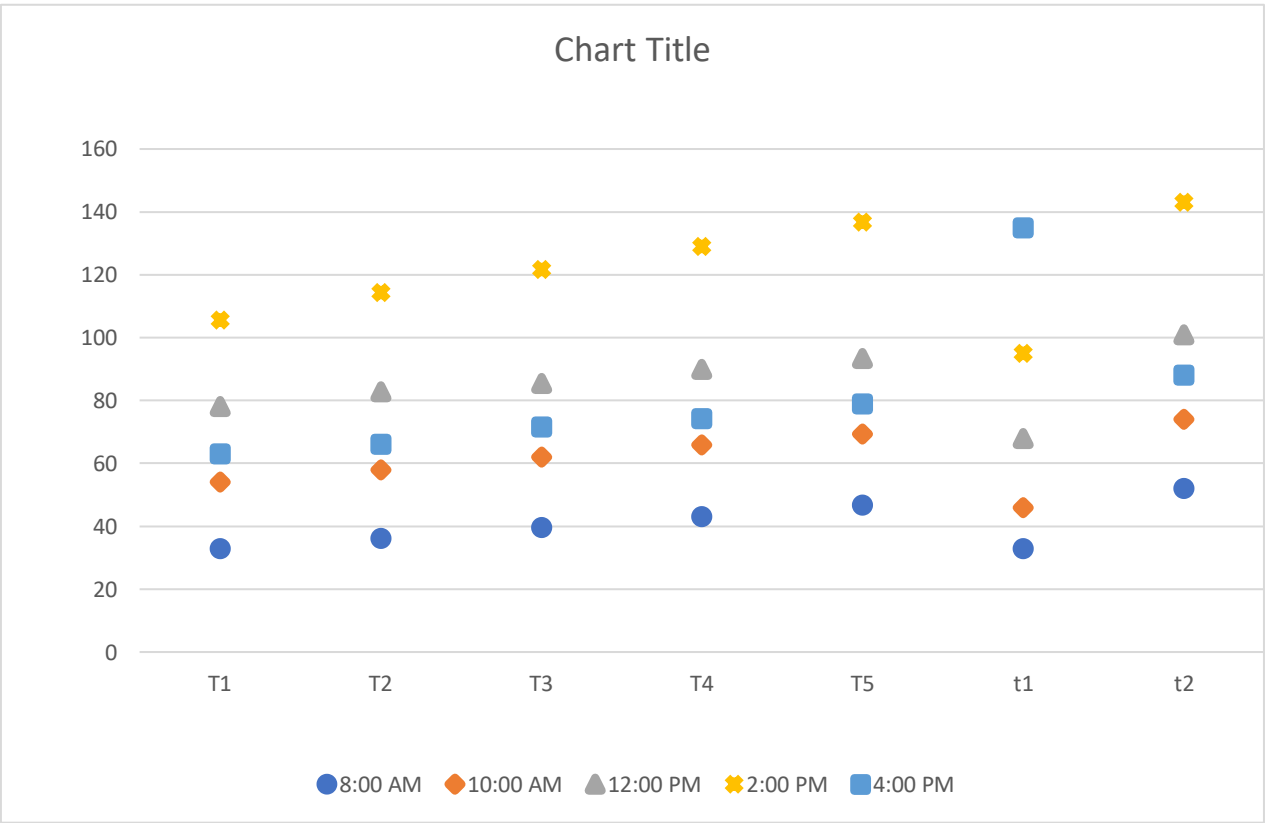
This tabular column represents the reading which is taken on the Day 01

|    | 8:00 AM | 10:00 AM | 12:00 PM | 2:00 PM | 4:00 PM |
|----|---------|----------|----------|---------|---------|
| T1 | 36      | 57       | 81.3     | 112.5   | 73.4    |
| T2 | 39.3    | 62.4     | 86.2     | 118.9   | 76.2    |
| T3 | 42.7    | 66.7     | 91.6     | 126.1   | 81.1    |
| T4 | 46.9    | 70.1     | 97.3     | 135.8   | 84.7    |
| T5 | 50.2    | 74.5     | 103.8    | 141.3   | 88.9    |
| t1 | 36      | 48       | 78       | 107     | 141     |
| t2 | 54      | 83       | 115      | 153     | 98      |



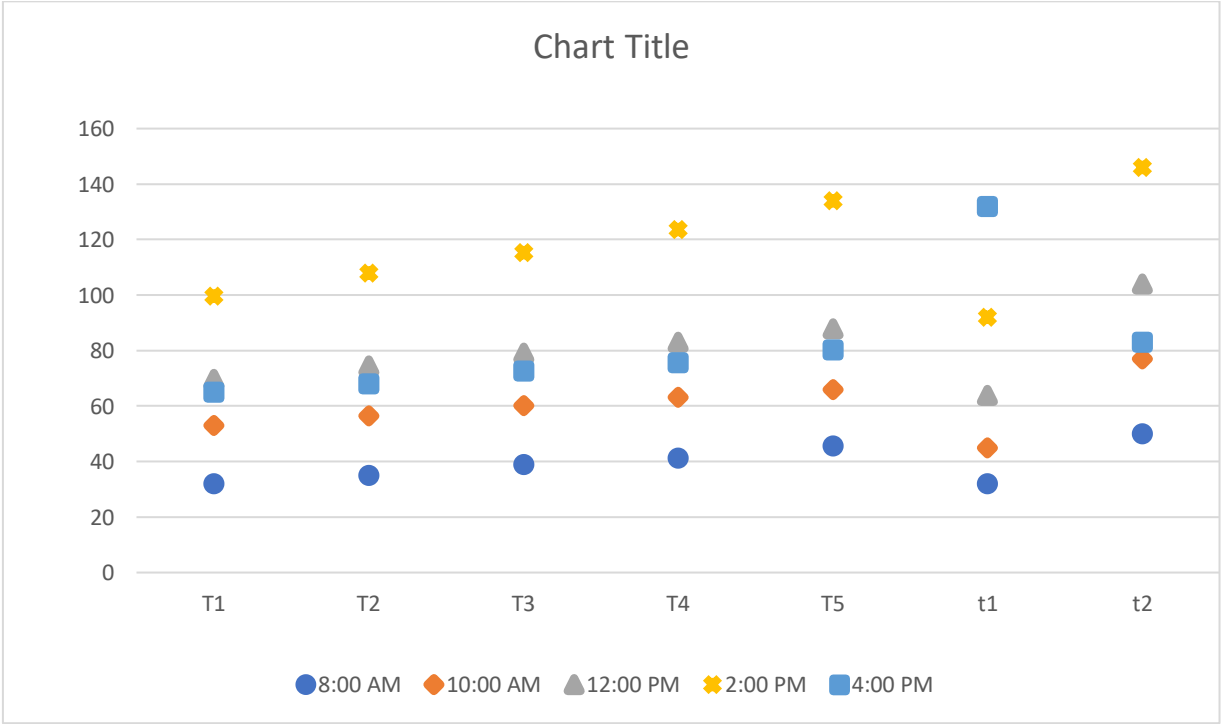
This tabular column represents the reading which is taken on the Day 05

|    | 8:00 AM | 10:00 AM | 12:00 PM | 2:00 PM | 4:00 PM |
|----|---------|----------|----------|---------|---------|
| T1 | 33      | 54       | 78.1     | 105.6   | 63      |
| T2 | 36.2    | 57.9     | 82.7     | 114.3   | 66.1    |
| T3 | 39.7    | 62       | 85.4     | 121.7   | 71.6    |
| T4 | 43.1    | 65.9     | 89.9     | 129     | 74.2    |
| T5 | 46.7    | 69.3     | 93.3     | 136.8   | 79      |
| t1 | 33      | 46       | 68       | 95      | 135     |
| t2 | 52      | 74       | 101      | 143     | 88      |



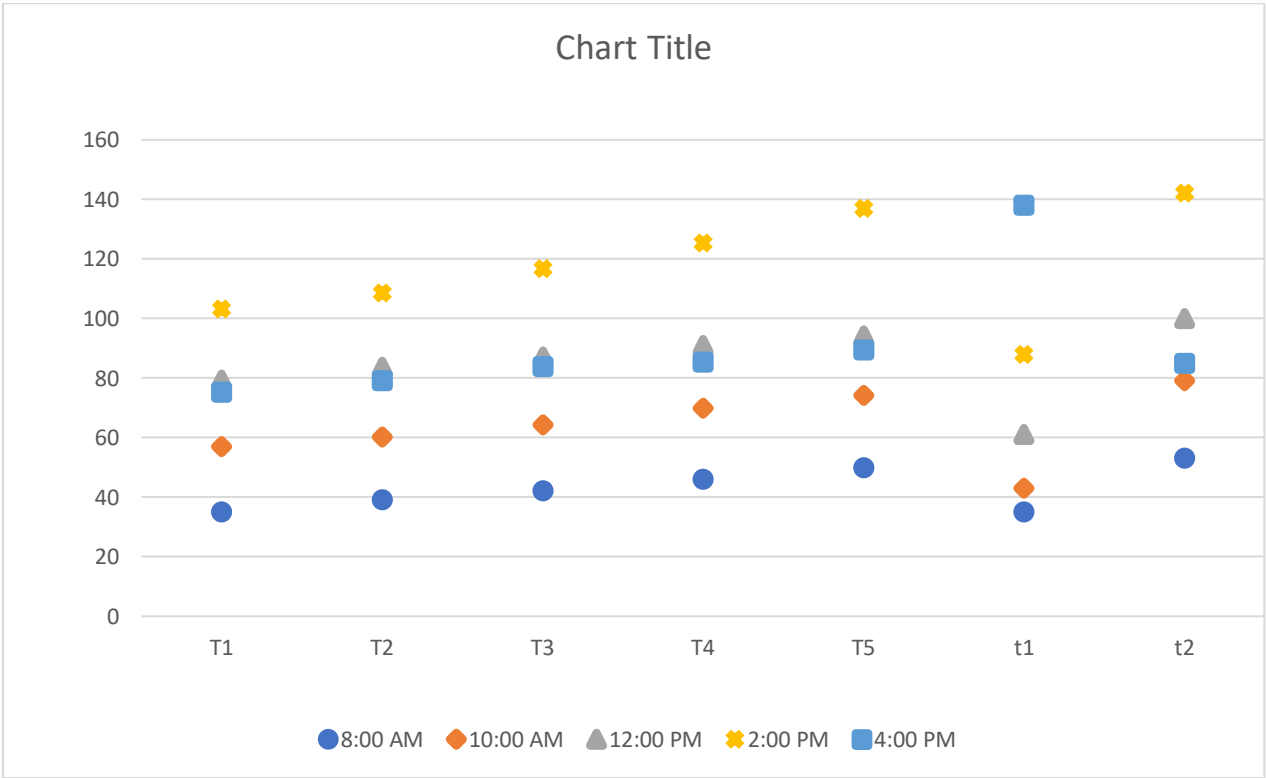
This tabular column represents the reading which is taken on the Day 10

|    | 8:00 AM | 10:00 AM | 12:00 PM | 2:00 PM | 4:00 PM |
|----|---------|----------|----------|---------|---------|
| T1 | 32      | 53       | 69.7     | 99.6    | 65      |
| T2 | 35.1    | 56.5     | 74.6     | 107.9   | 68.1    |
| T3 | 38.9    | 60.3     | 79.1     | 115.4   | 72.7    |
| T4 | 41.4    | 63.2     | 83.1     | 123.7   | 75.8    |
| T5 | 45.8    | 65.9     | 87.9     | 134     | 80.3    |
| t1 | 32      | 45       | 64       | 92      | 132     |
| t2 | 50      | 77       | 104      | 146     | 83      |



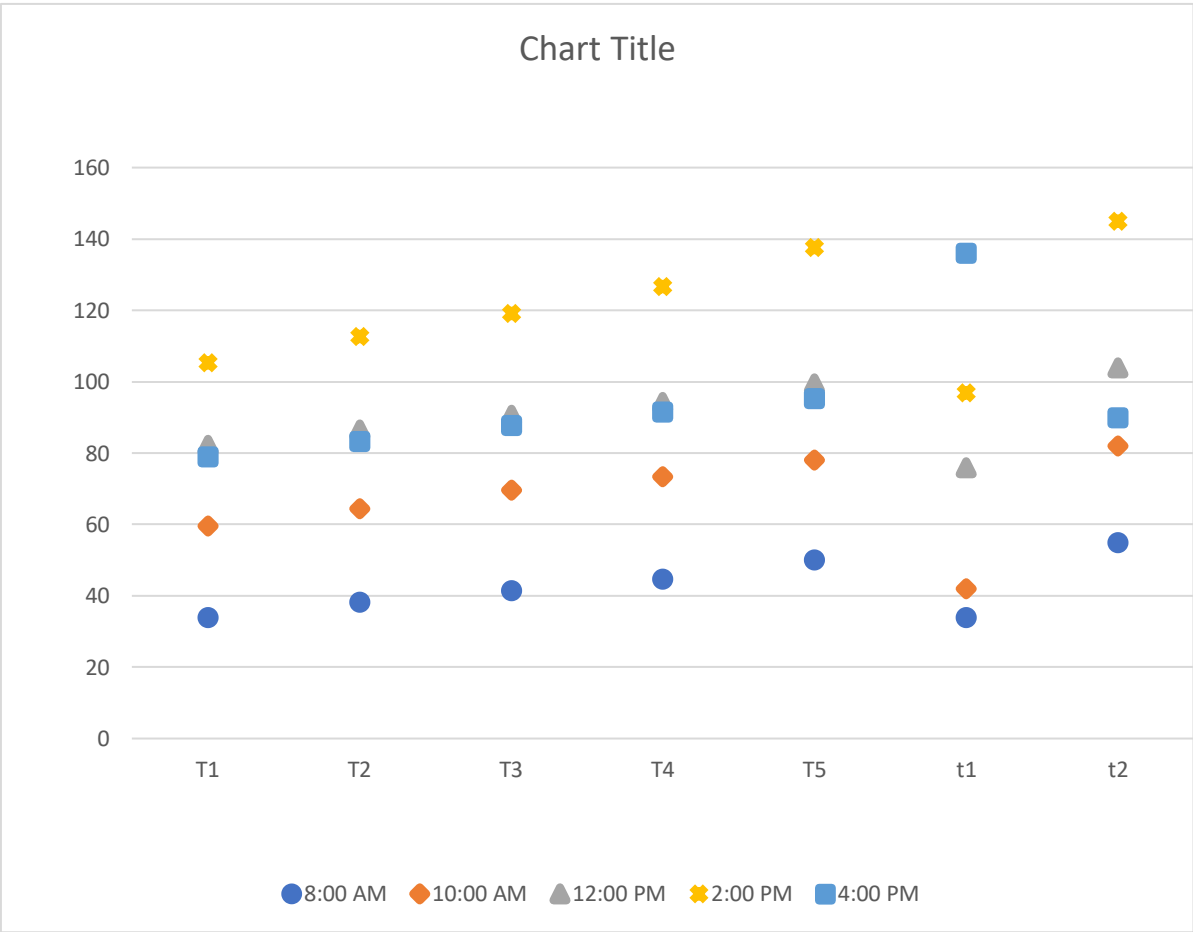
This tabular column represents the reading which is taken on the Day 15

|    | 8:00 AM | 10:00 AM | 12:00 PM | 2:00 PM | 4:00 PM |
|----|---------|----------|----------|---------|---------|
| T1 | 35      | 57       | 79.4     | 103.2   | 75.2    |
| T2 | 39.2    | 60.2     | 83.6     | 108.5   | 79.1    |
| T3 | 42.1    | 64.2     | 87.1     | 116.8   | 83.8    |
| T4 | 45.9    | 69.8     | 90.9     | 125.3   | 85.3    |
| T5 | 49.8    | 74.1     | 94.2     | 136.9   | 89.5    |
| t1 | 35      | 43       | 61       | 88      | 138     |
| t2 | 53      | 79       | 100      | 142     | 85      |



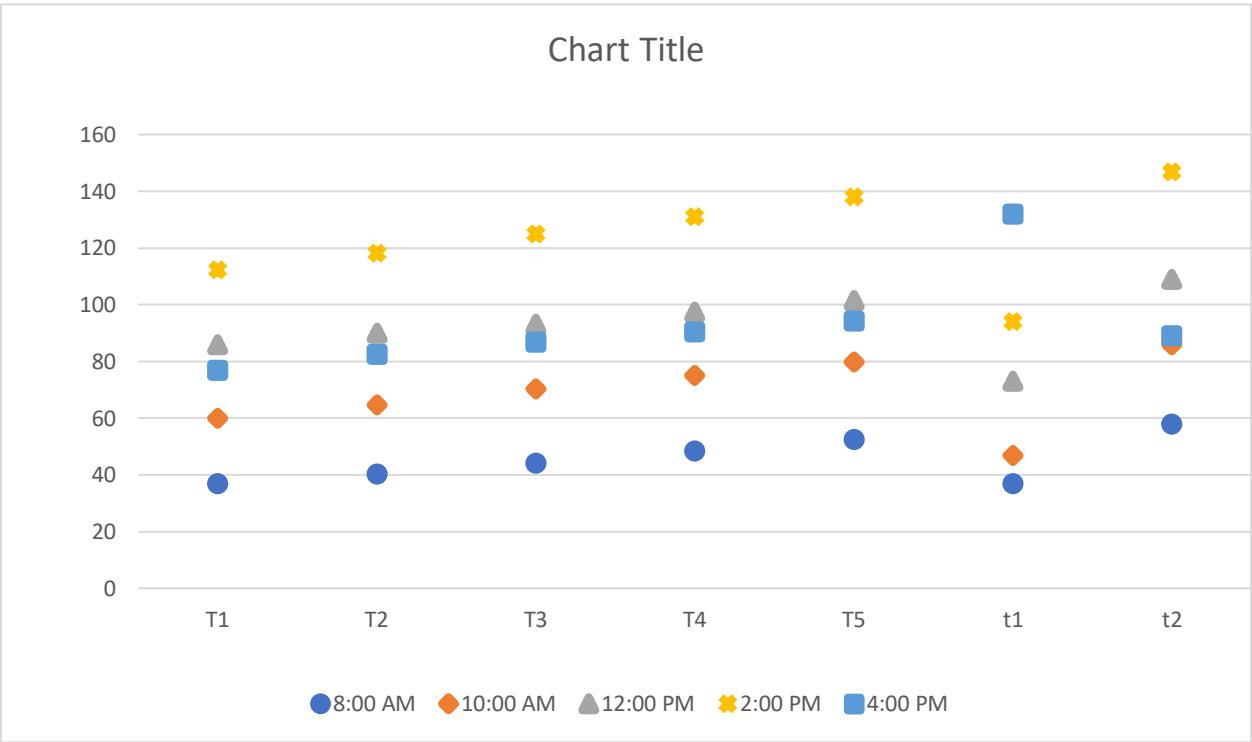
This tabular column represents the reading which is taken on the Day 20

|    | 8:00 AM | 10:00 AM | 12:00 PM | 2:00 PM | 4:00 PM |
|----|---------|----------|----------|---------|---------|
| T1 | 34      | 59.6     | 82.2     | 105.4   | 79      |
| T2 | 38.2    | 64.4     | 86.6     | 112.8   | 83.4    |
| T3 | 41.5    | 69.6     | 90.7     | 119.2   | 87.8    |
| T4 | 44.8    | 73.5     | 94.3     | 126.8   | 91.5    |
| T5 | 50.1    | 78.1     | 99.5     | 137.7   | 95.3    |
| t1 | 34      | 42       | 76       | 97      | 136     |
| t2 | 55      | 82       | 104      | 145     | 90      |



This tabular column represents the reading which is taken on the Day 25

|    | 8:00 AM | 10:00 AM | 12:00 PM | 2:00 PM | 4:00 PM |
|----|---------|----------|----------|---------|---------|
| T1 | 37      | 60       | 86       | 112.4   | 77      |
| T2 | 40.4    | 64.8     | 89.9     | 118.3   | 82.5    |
| T3 | 44.1    | 70.4     | 93.2     | 124.9   | 86.8    |
| T4 | 48.4    | 75.2     | 97.4     | 131.2   | 90.4    |
| T5 | 52.5    | 79.8     | 101.5    | 138.1   | 94.3    |
| t1 | 37      | 47       | 73       | 94      | 132     |
| t2 | 58      | 86       | 109      | 147     | 89      |

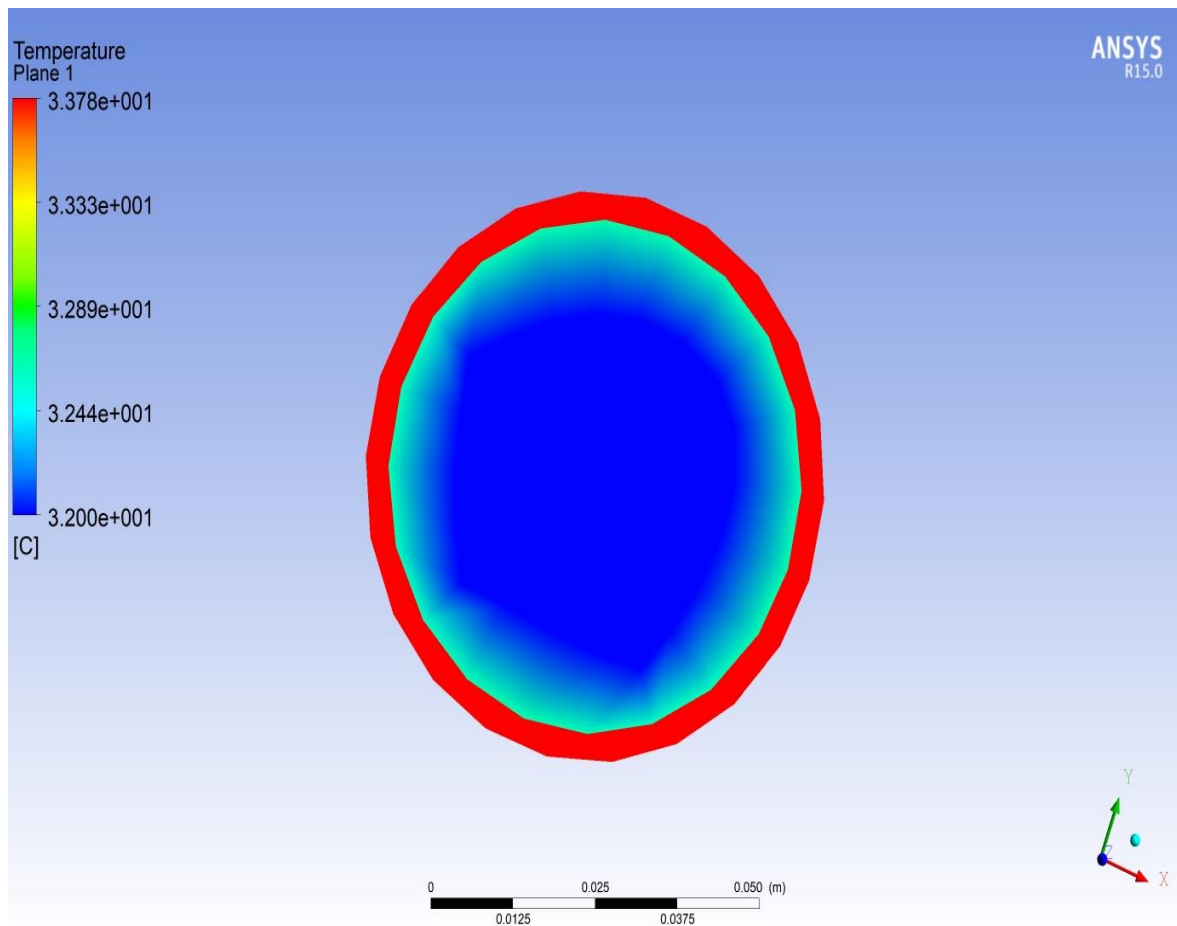


The calculations and readings which are obtained from the heat pipe is later taken for CFD analysis. The figure given below shows the heat distributon in the heat pipe using the CFD analysis.

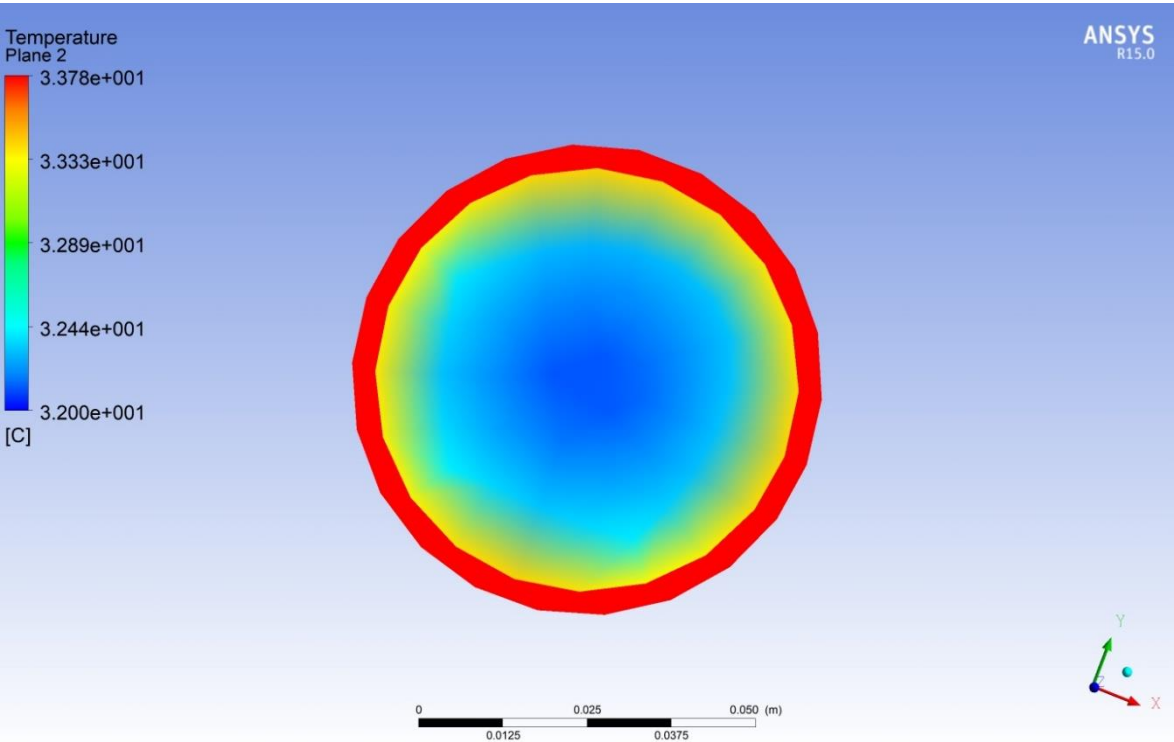
The below CFD analysis represent the Day 01 reading of each points in the pipe at different time

DAY 01

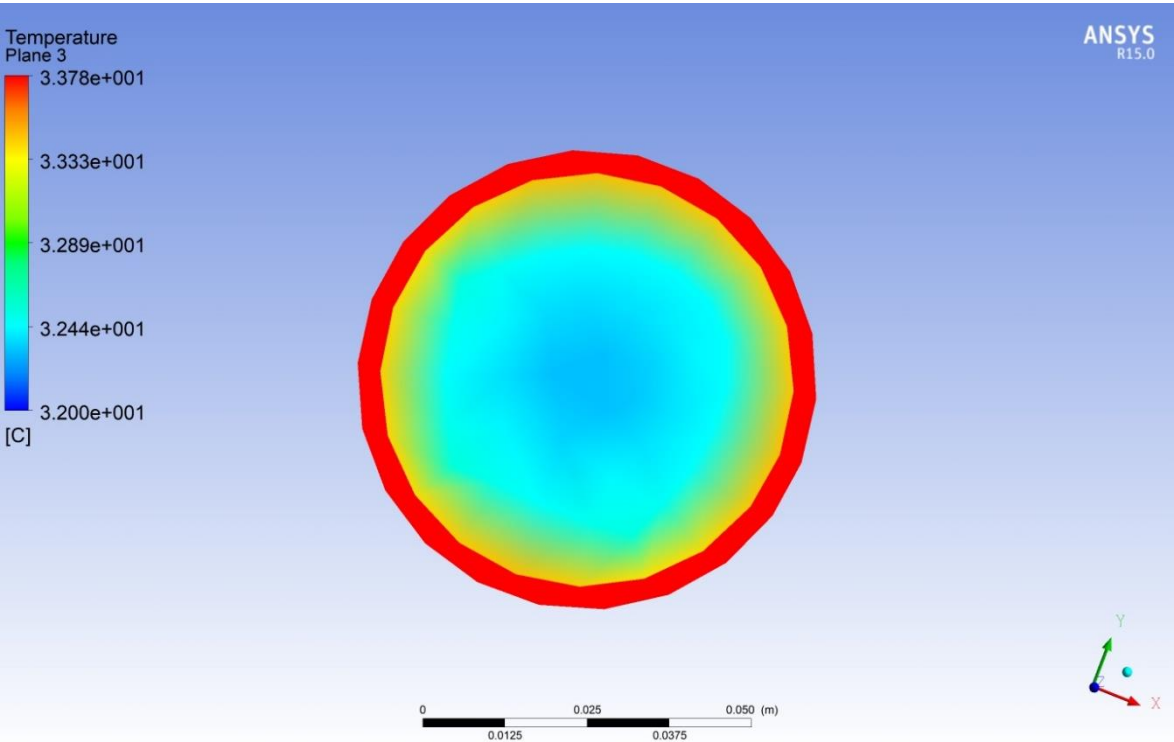
Temperature at 8 am in T1



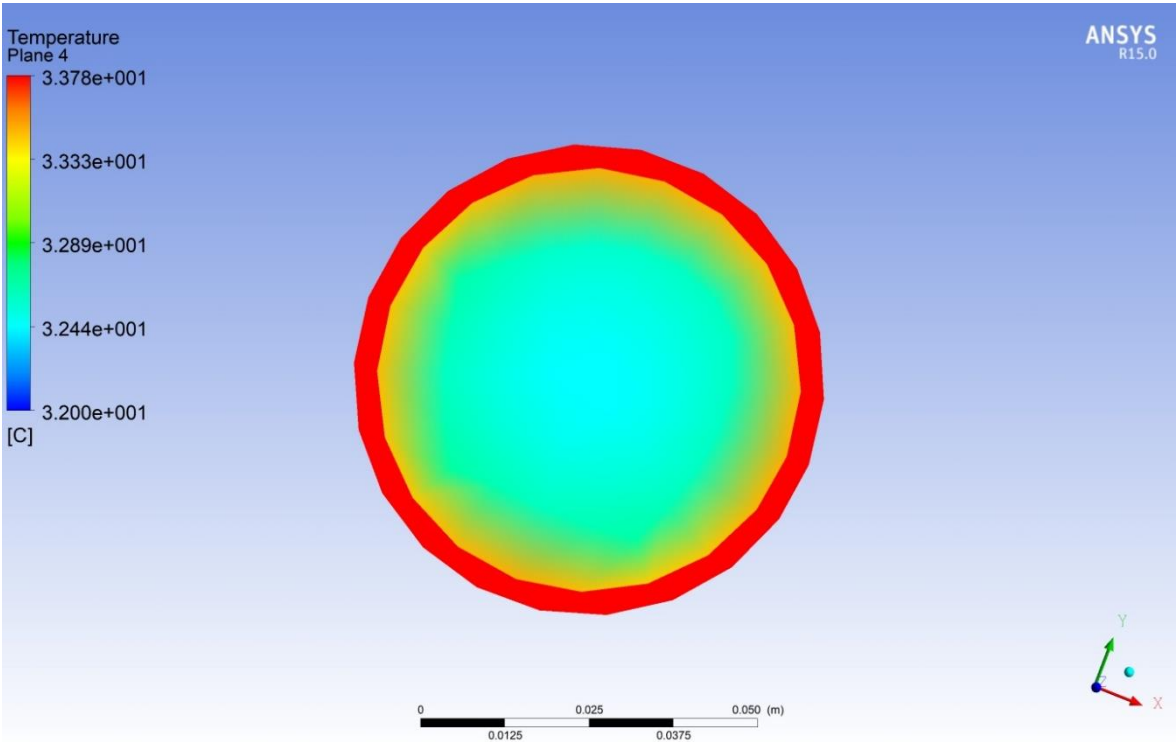
Temperature at 8 am in T2



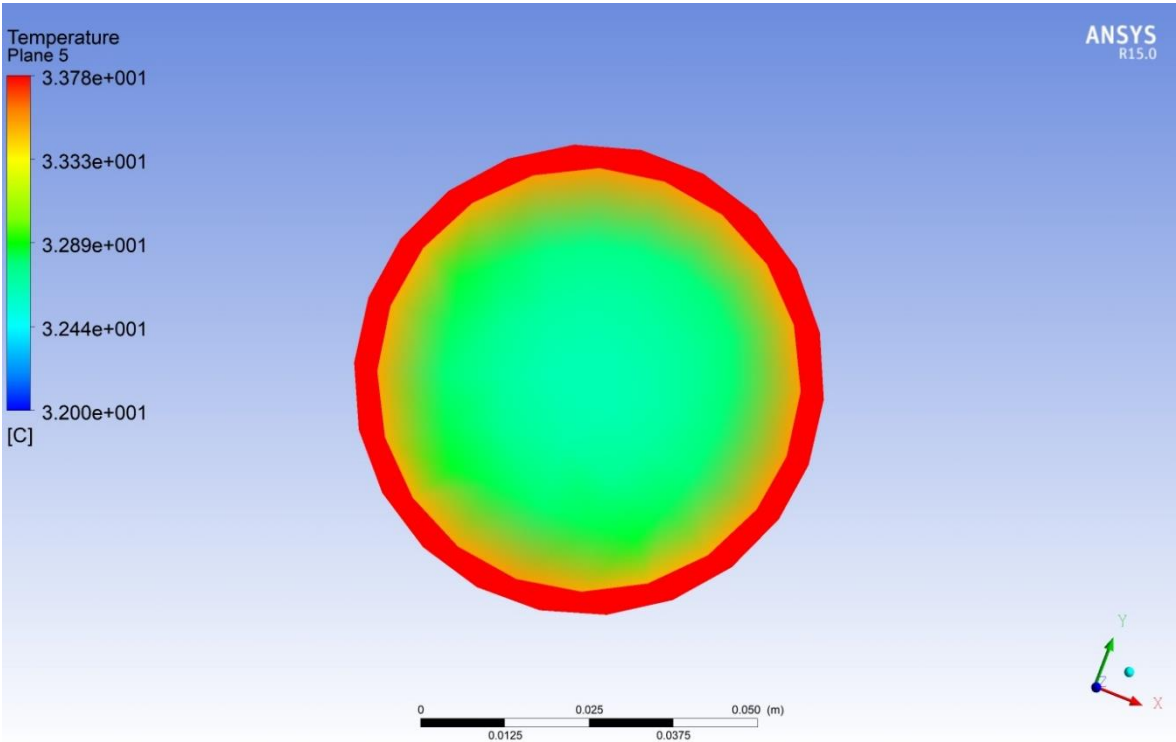
Temperature at 8 am in T3



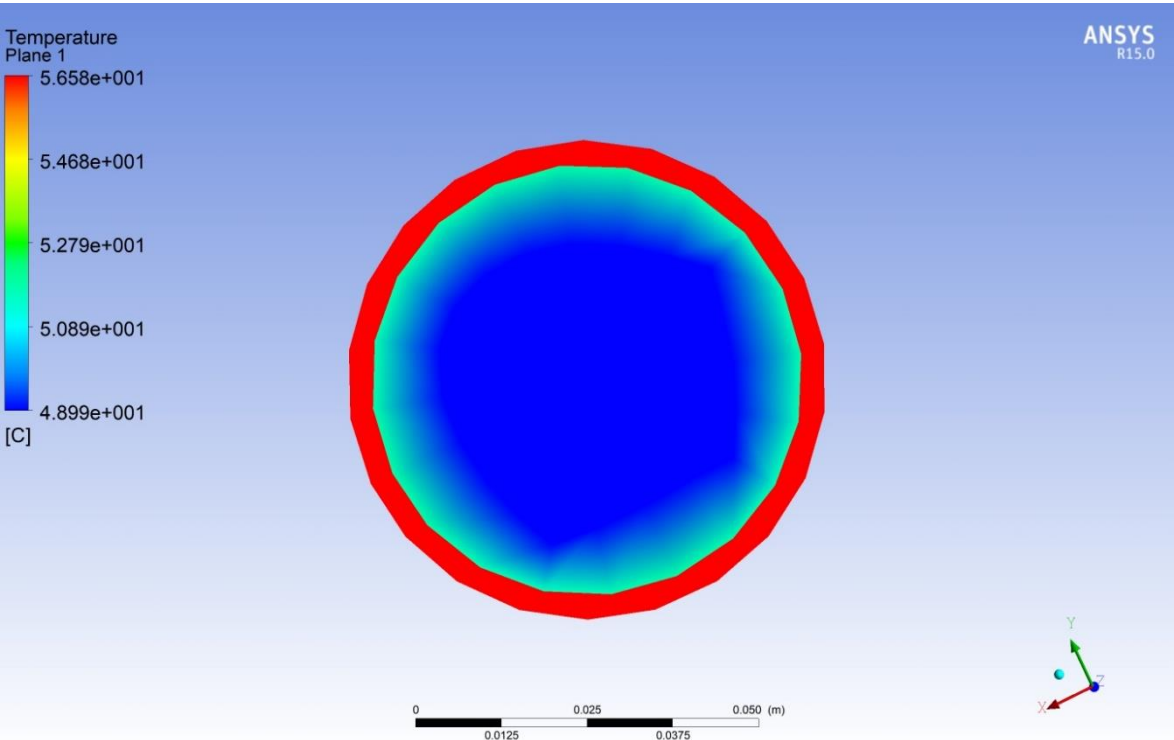
Temperature at 8 am in T4



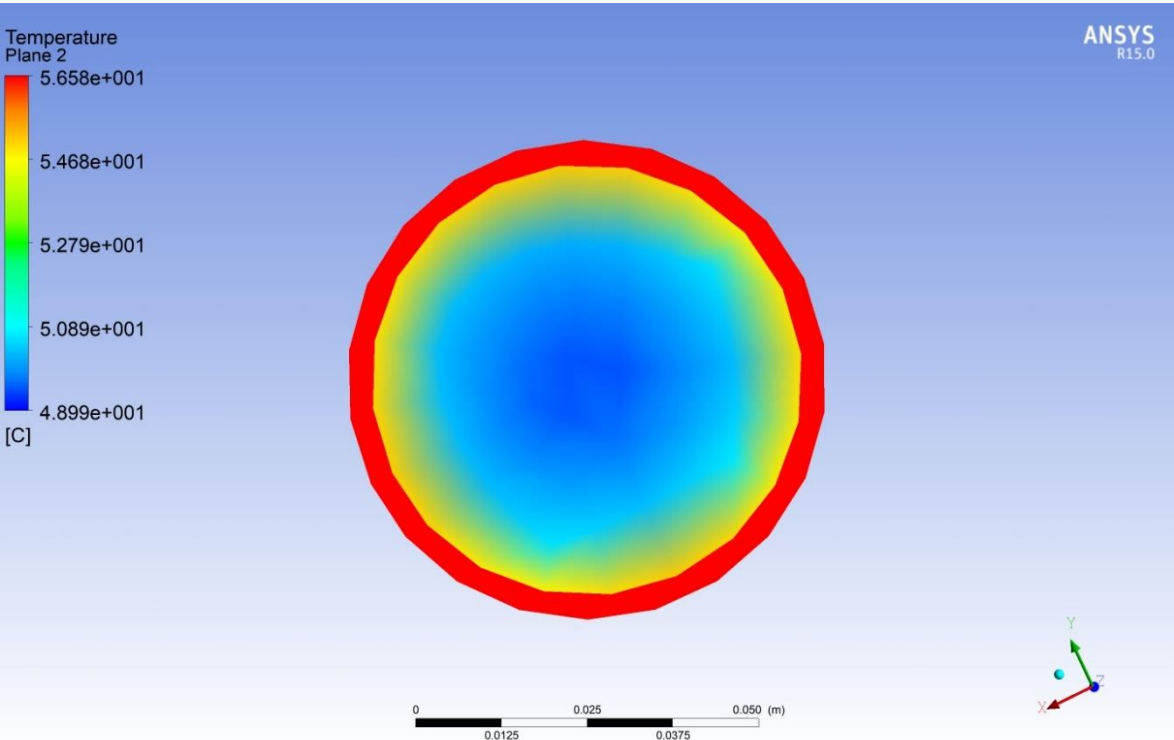
Temperature at 8 am in T5



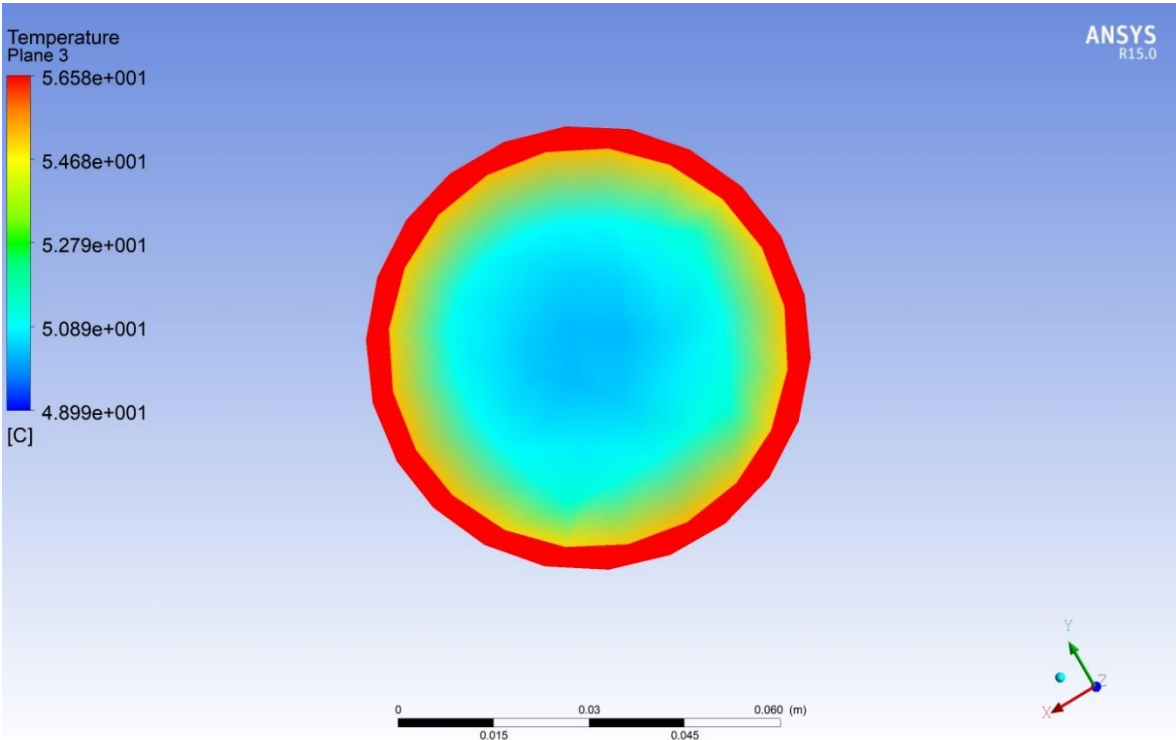
Temperature at 10 am in T1



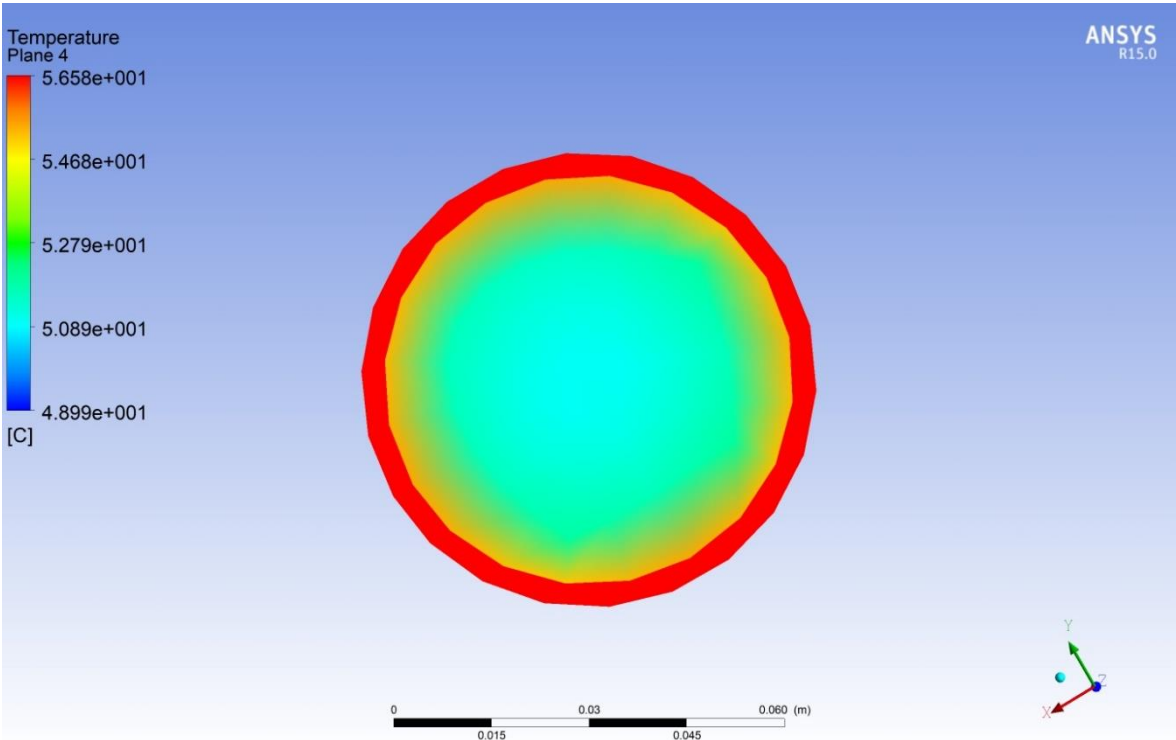
Temperature at 10 am in T2



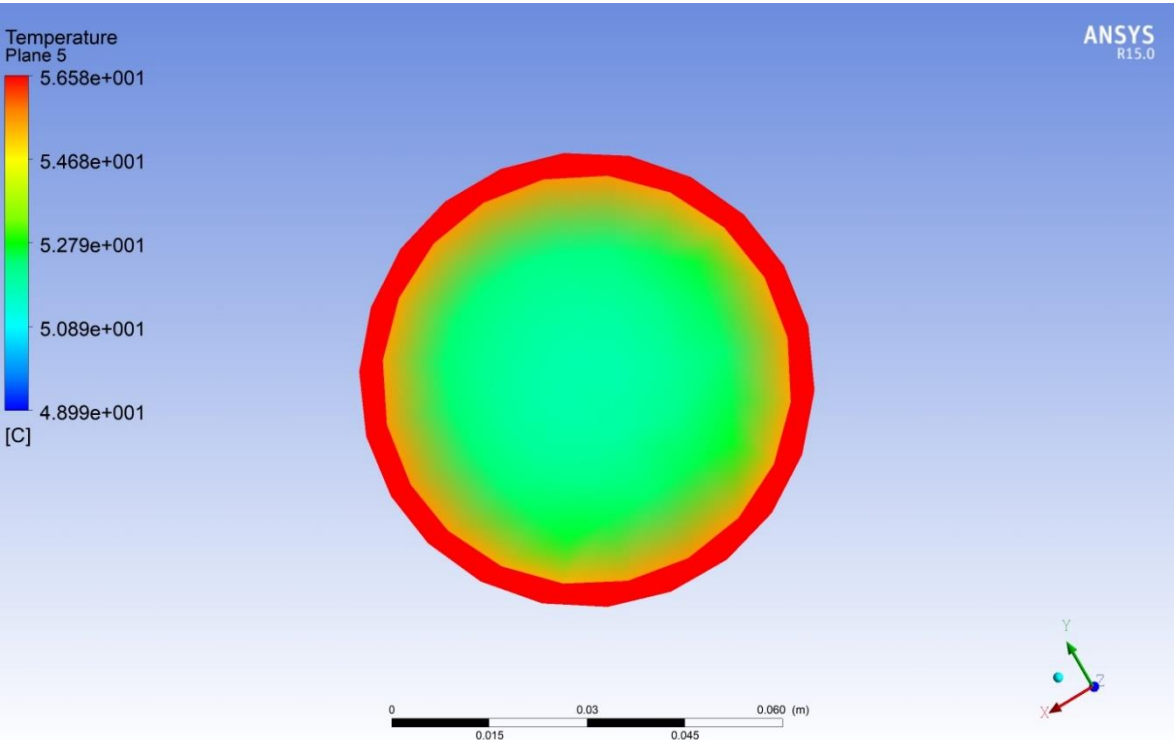
Temperature at 10 am in T3



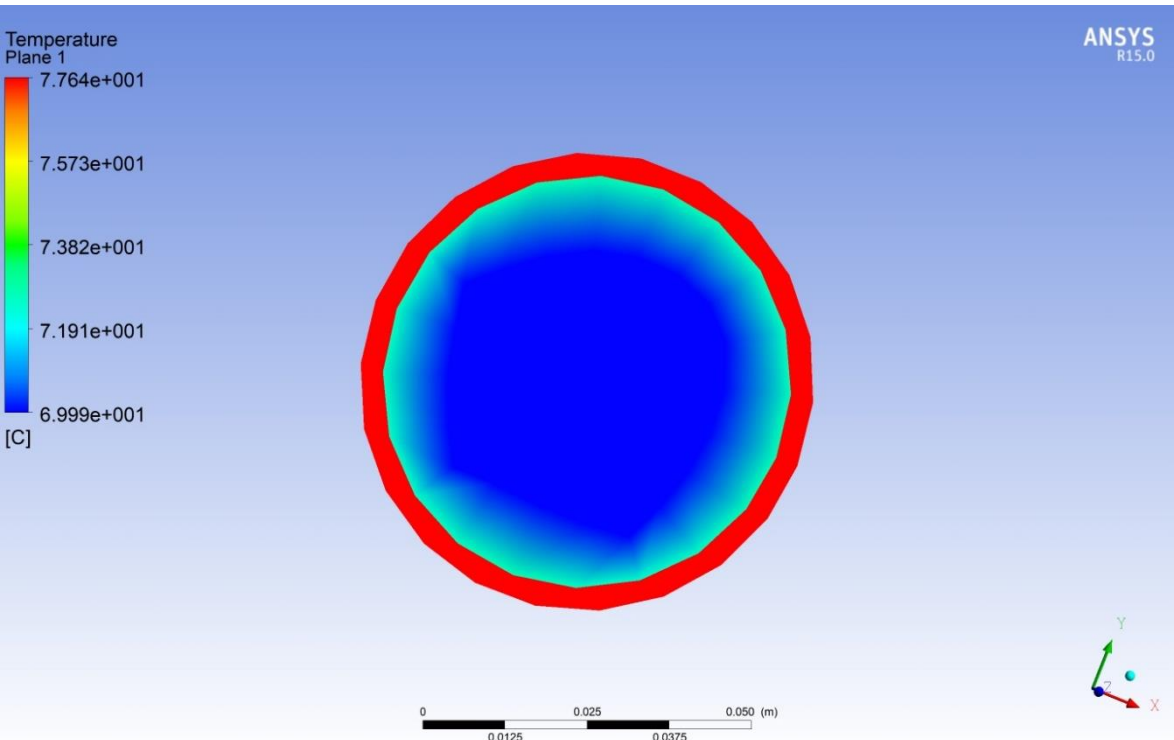
Temperature at 10 am in T4



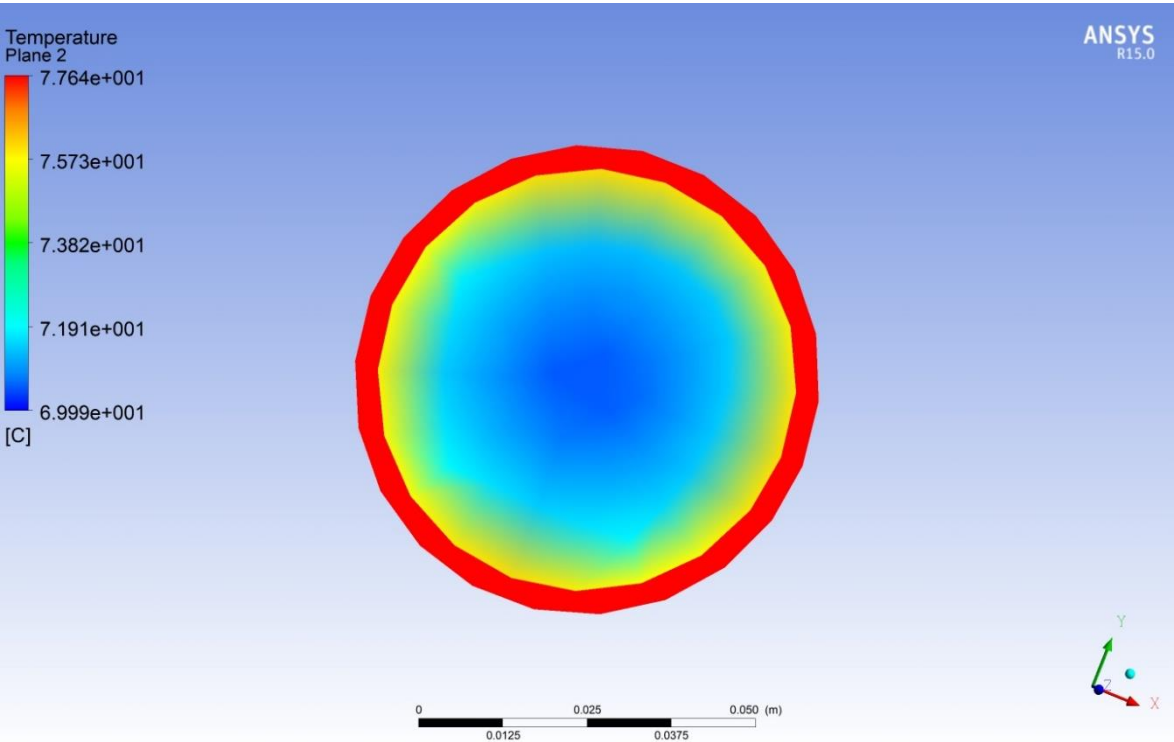
Temperature at 10 am in T5



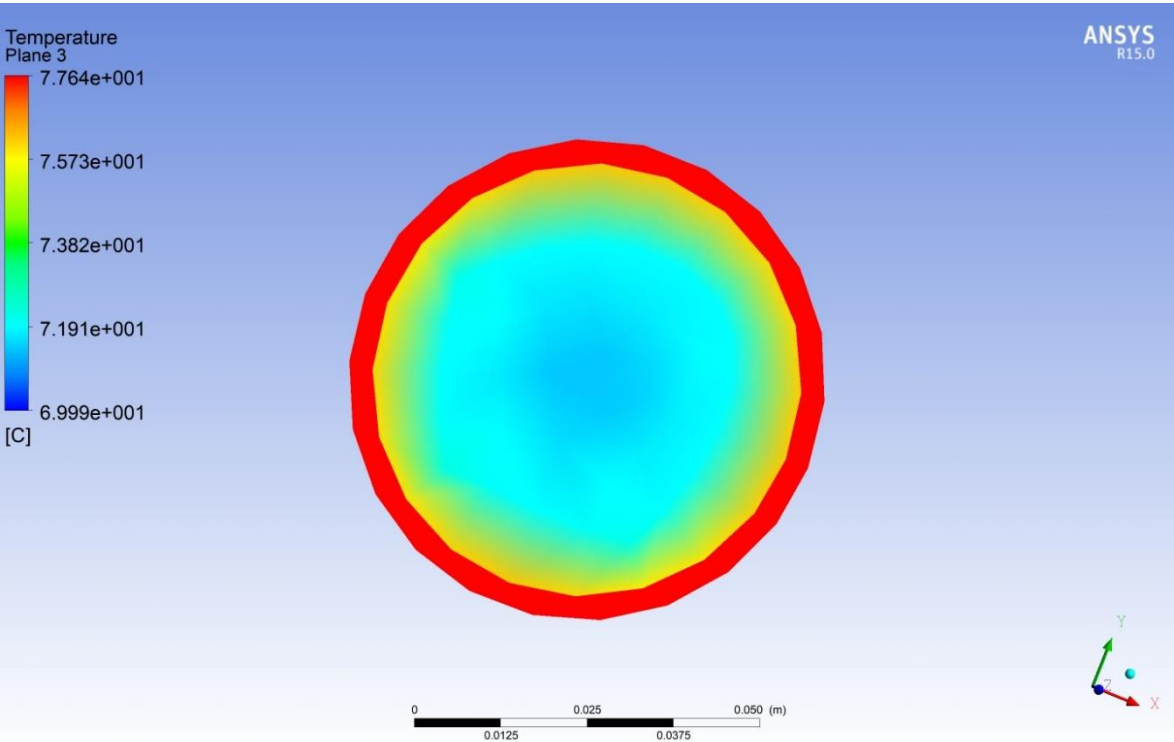
Temperature at 12 pm in T1



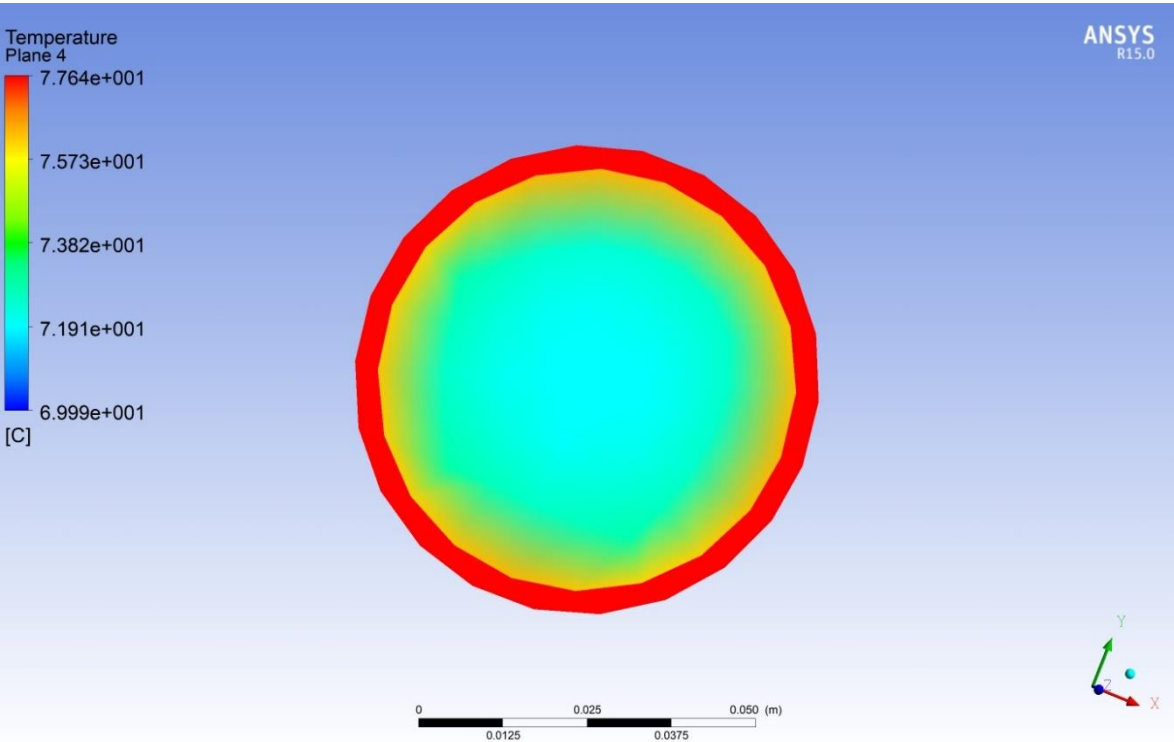
Temperature at 12 pm in T2



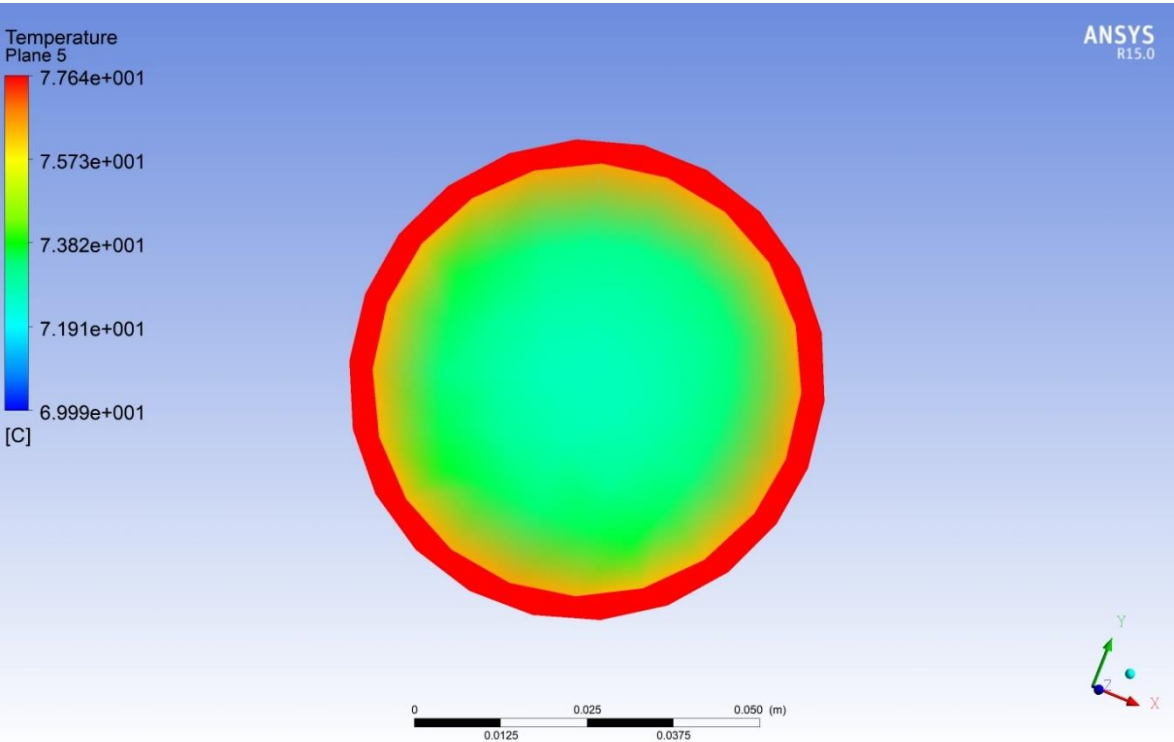
Temperature at 12 pm in T3



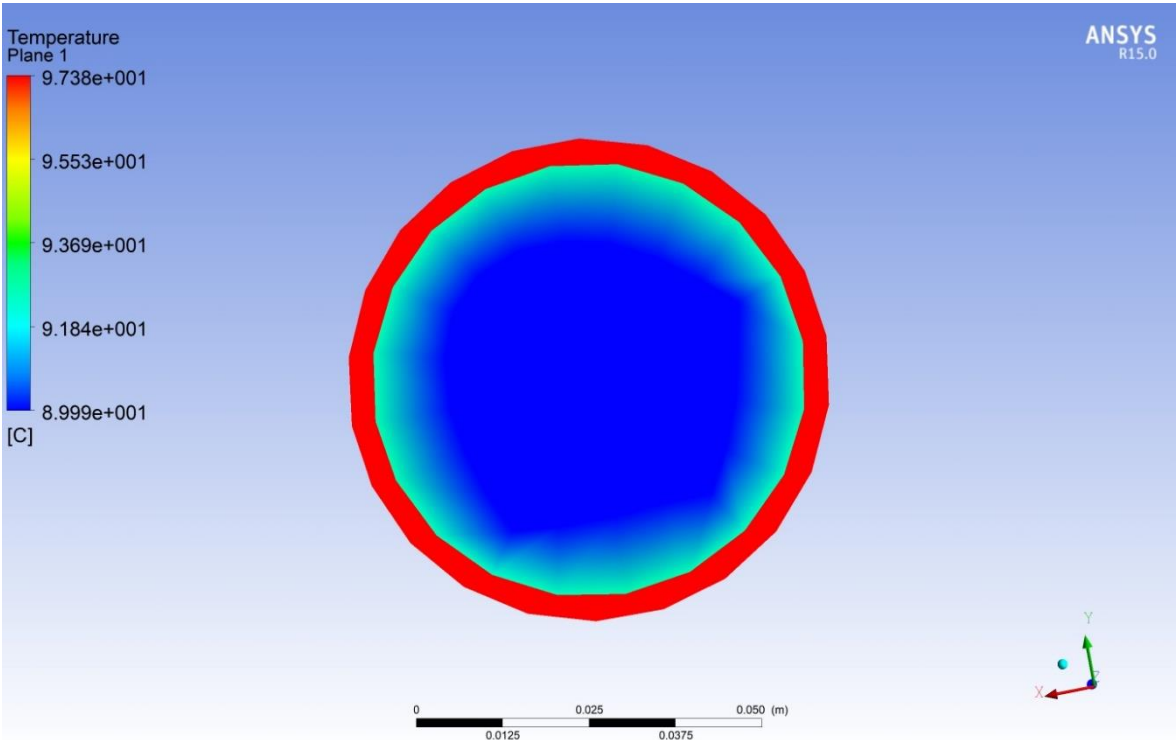
Temperature at 12 pm in T4



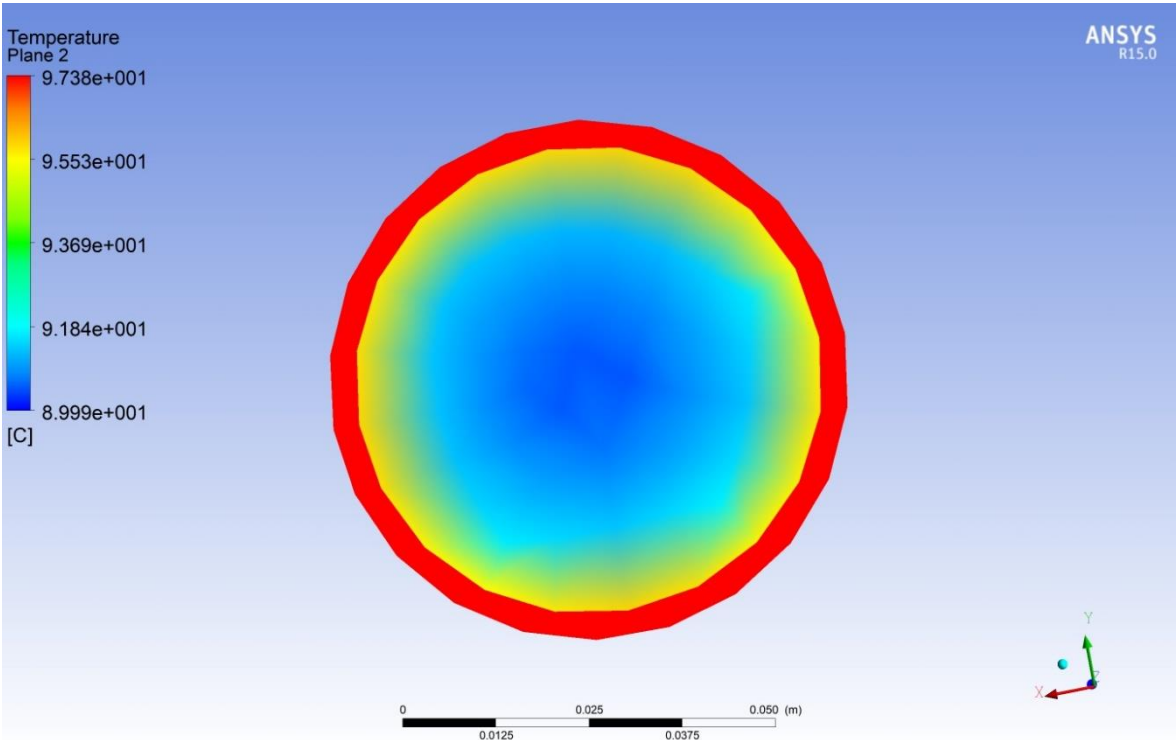
Temperature at 12 pm in T5



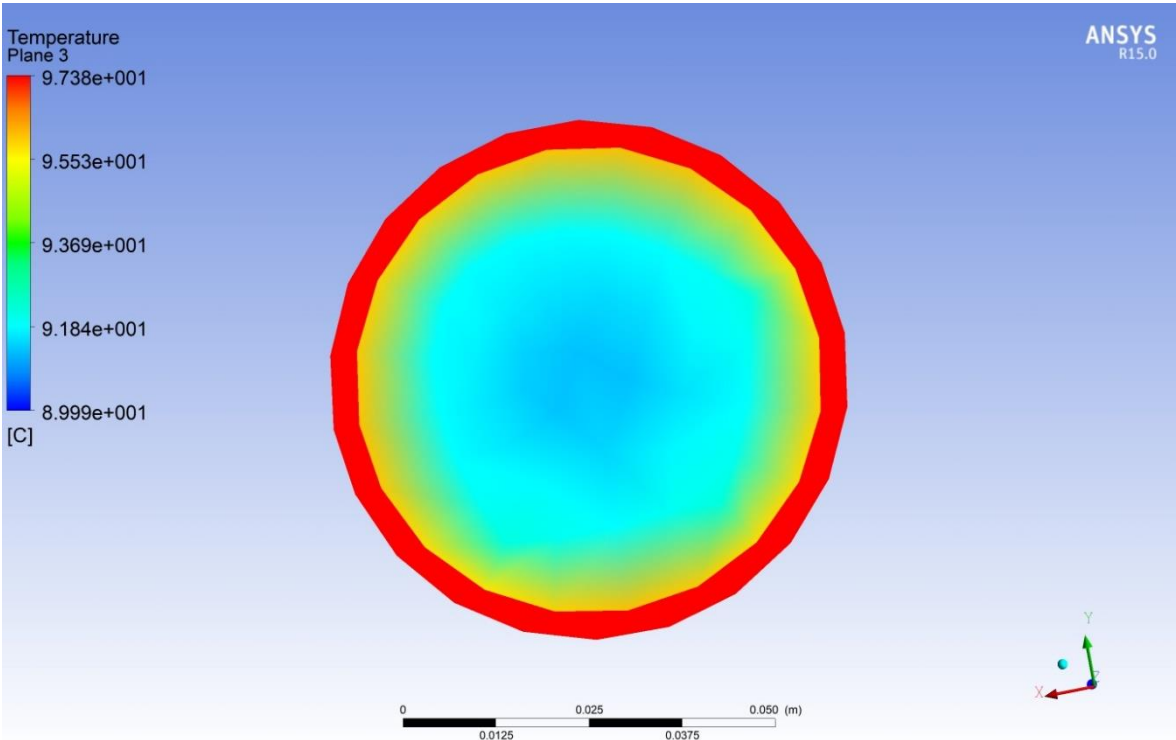
Temperature at 2 pm in T1



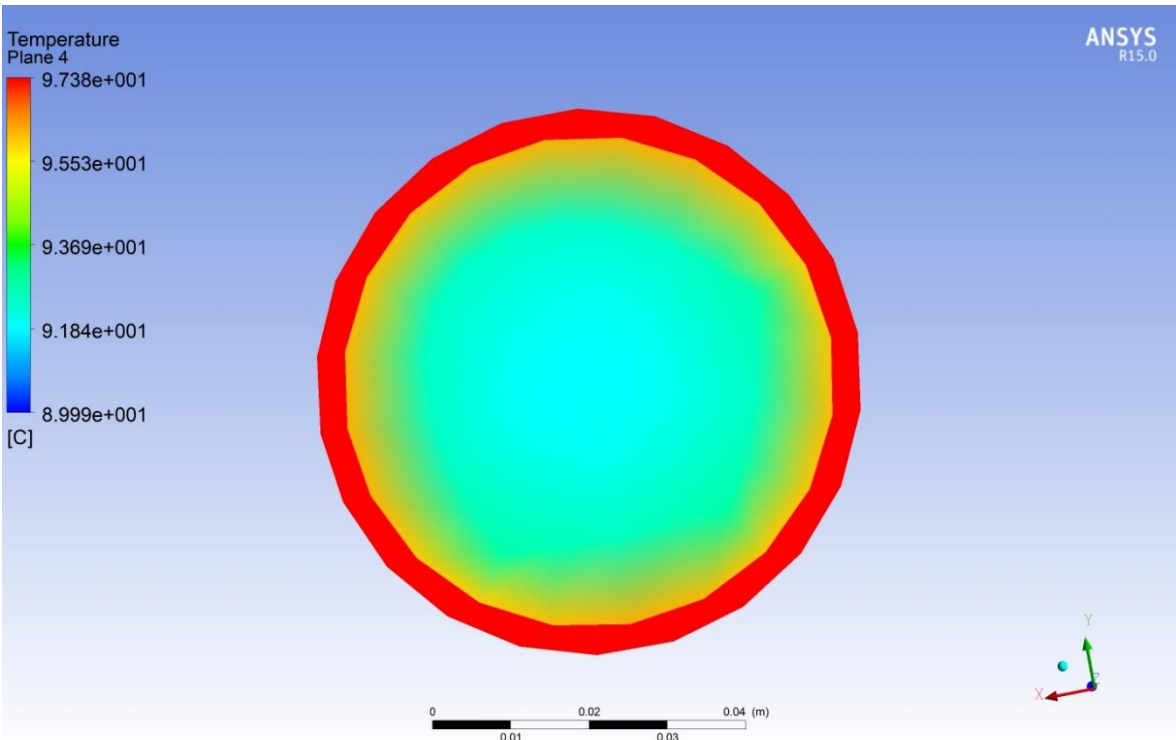
Temperature at 2 pm in T2



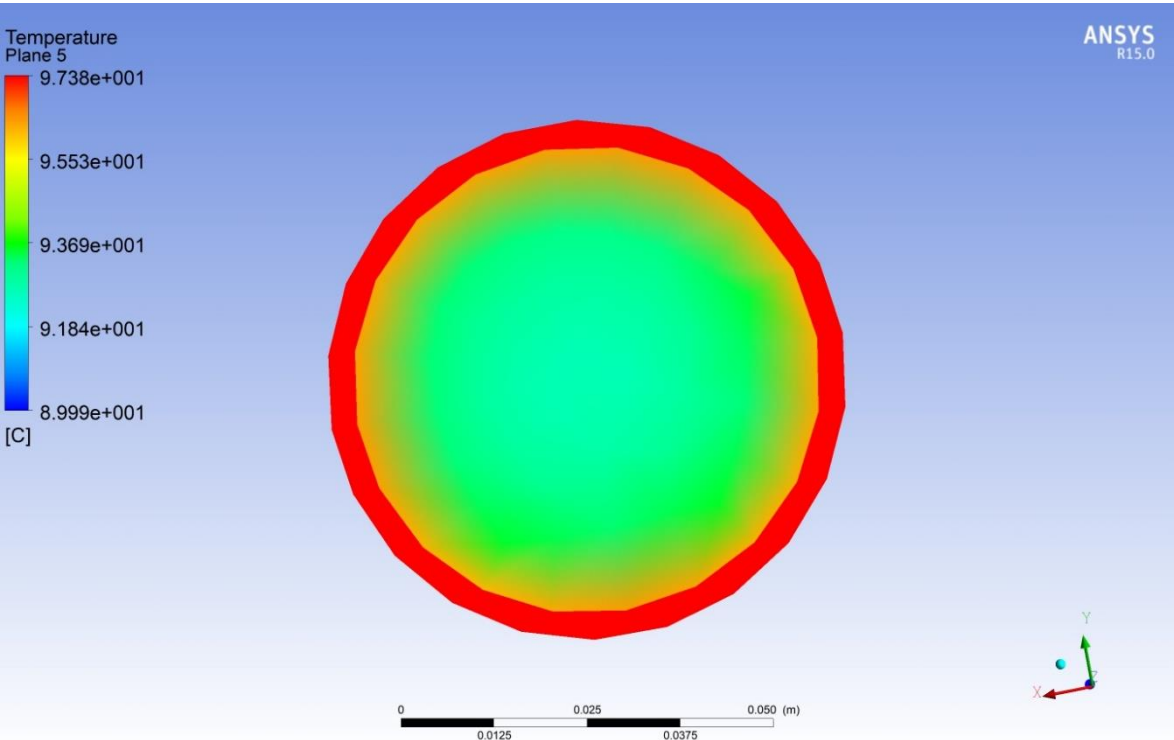
Temperature at 2 pm in T3



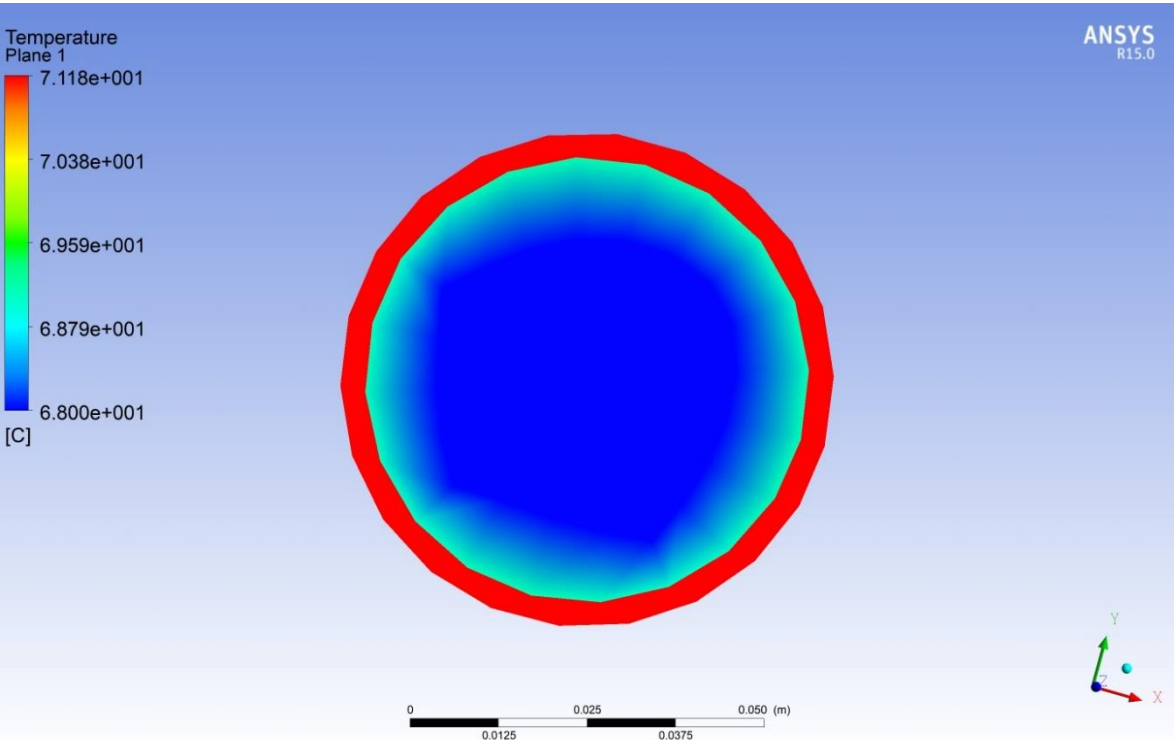
Temperature at 2 pm in T4



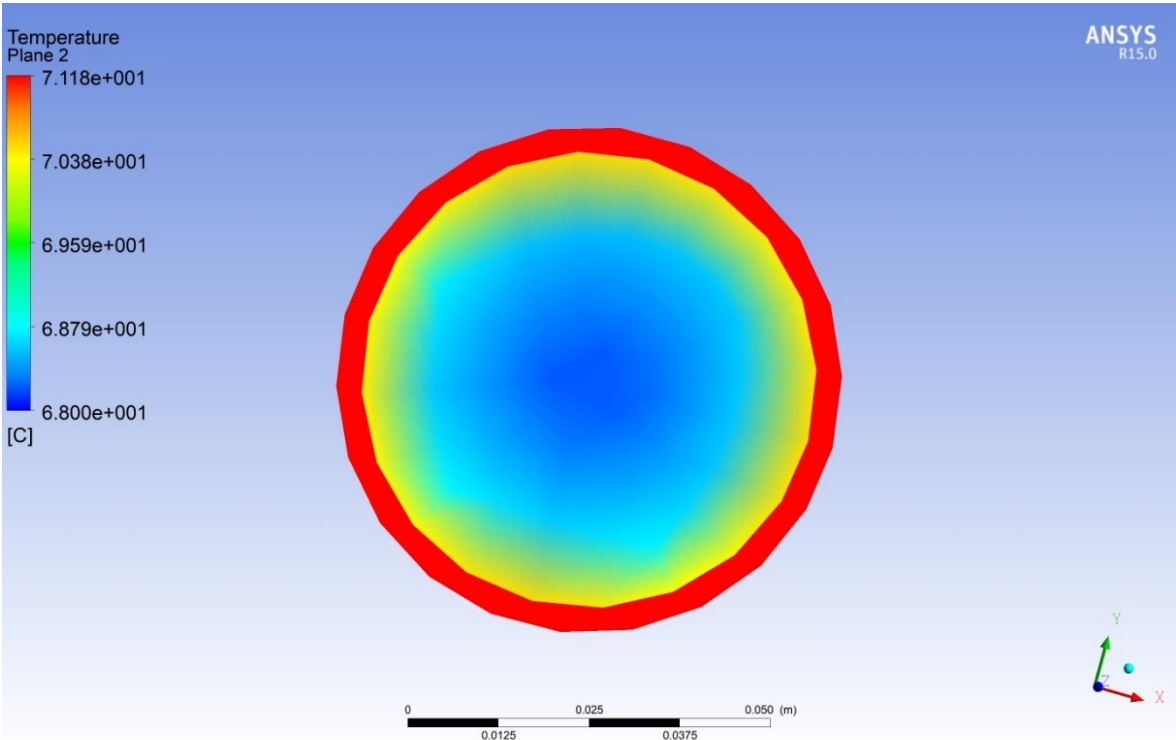
Temperature at 2 pm in T5



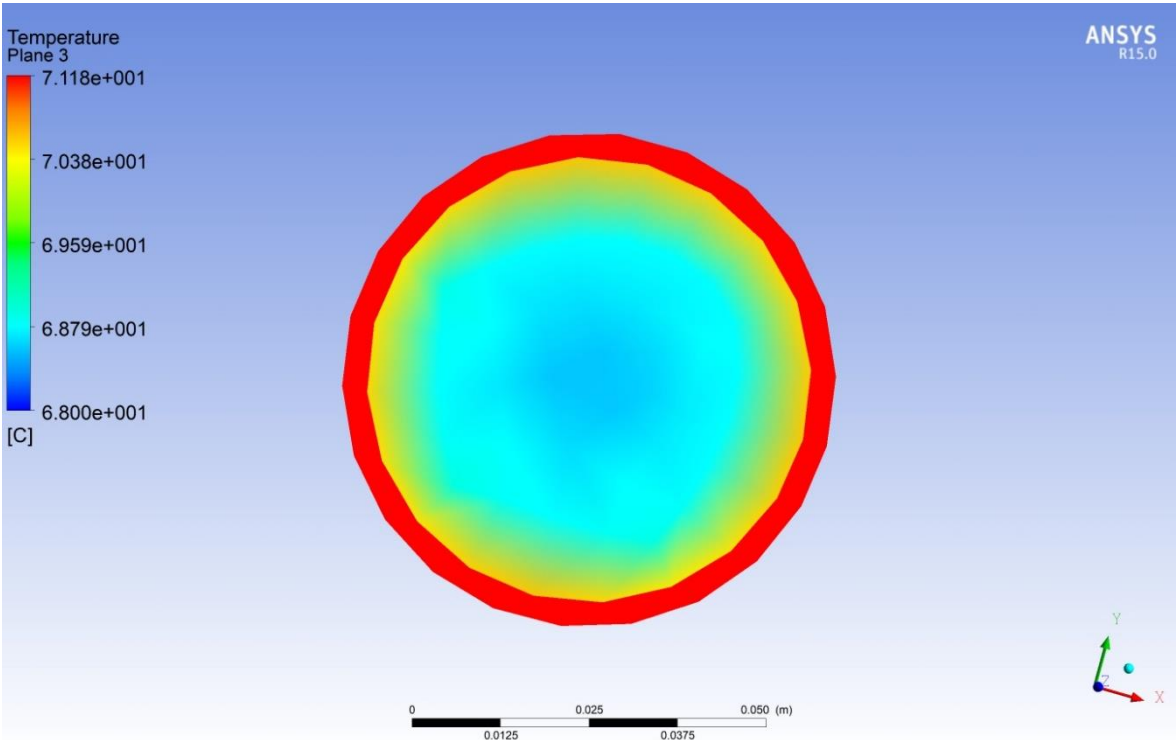
Temperature at 4 pm in T1



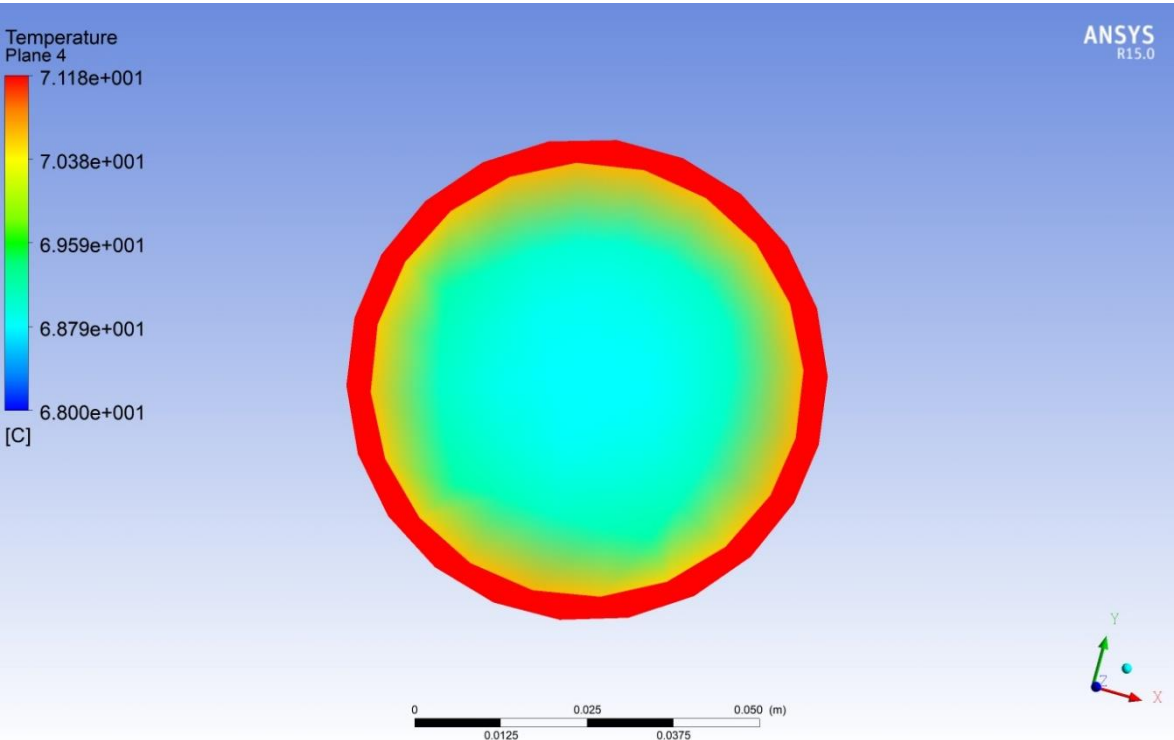
Temperature at 4 pm in T2



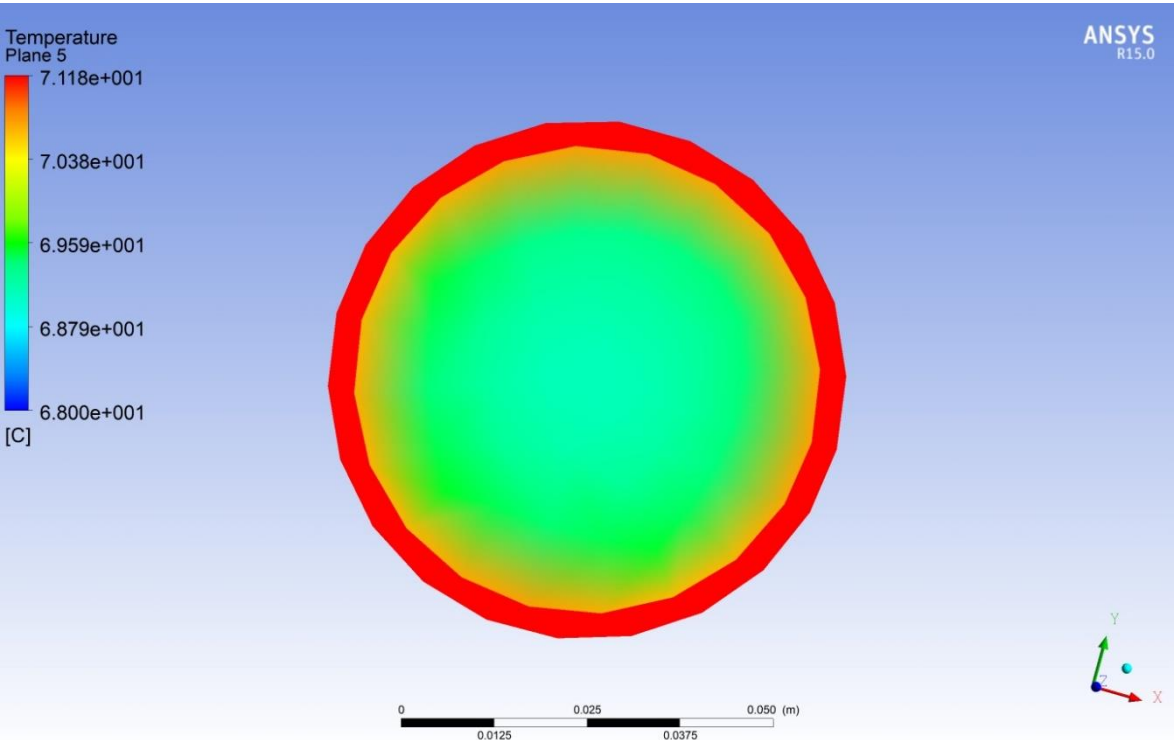
Temperature at 4 pm in T3



Temperature at 4 pm in T4



Temperature at 4 pm in T5

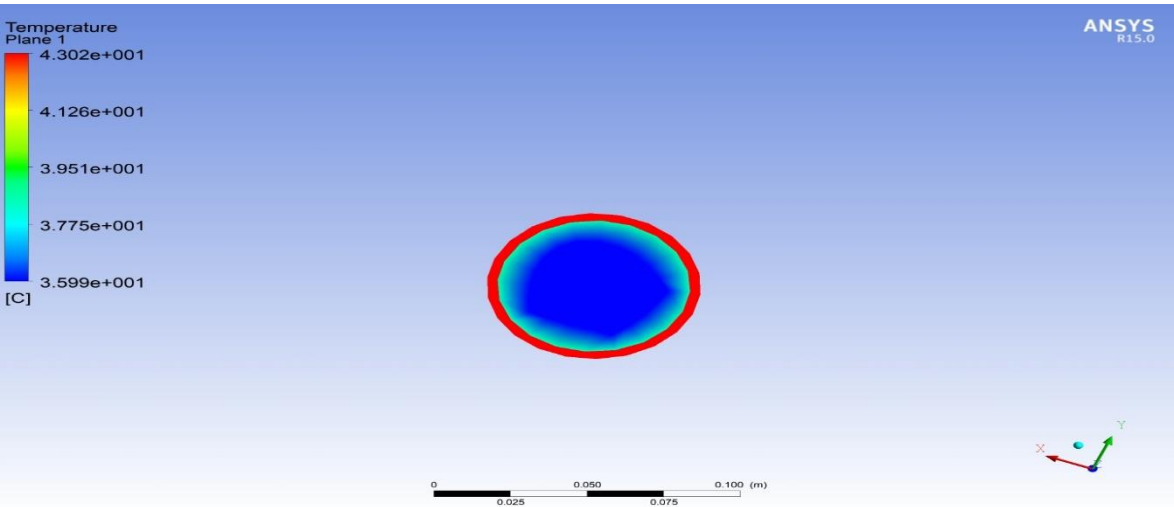


The calculations and readings which are obtained from the heat pipe is later taken for CFD analysis. The figure given below shows the heat distributon in the heat pipe using the CFD analysis.

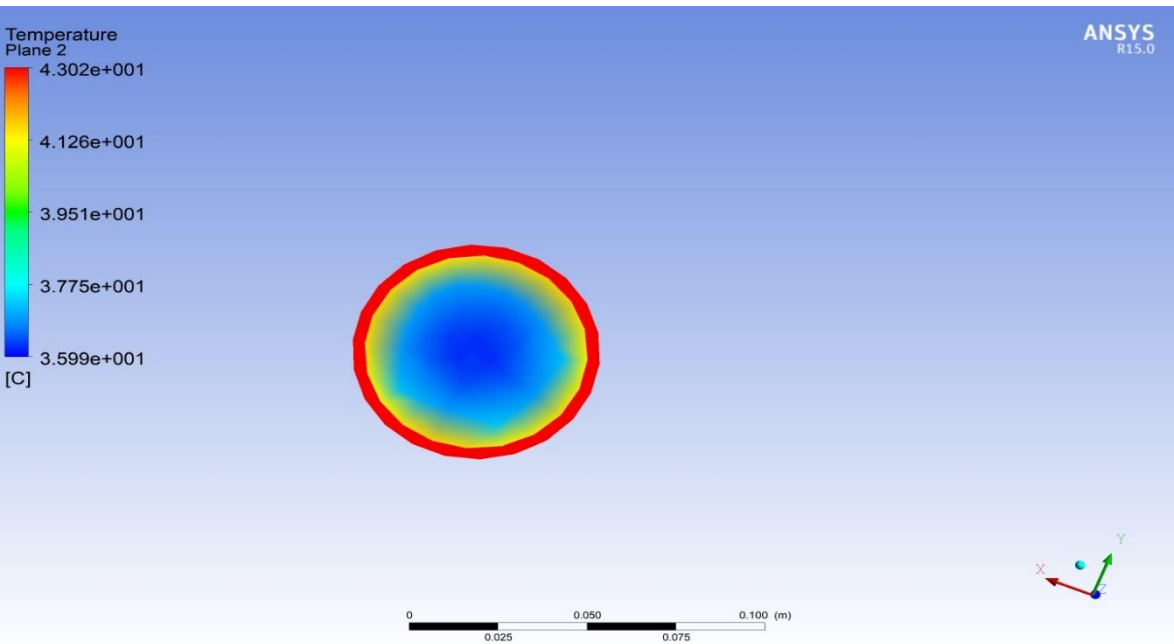
The below CFD analysis represent the Day 05 reading of each points in the pipe at different time

DAY 05

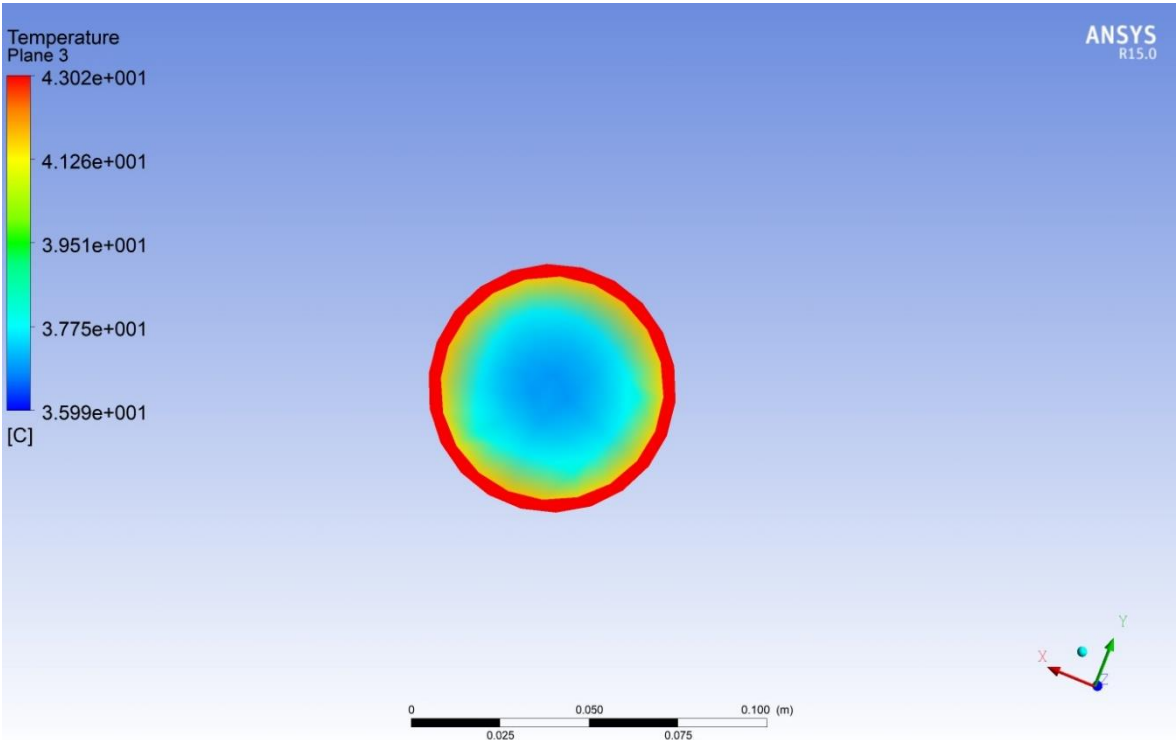
Temperature at 8 am in T1



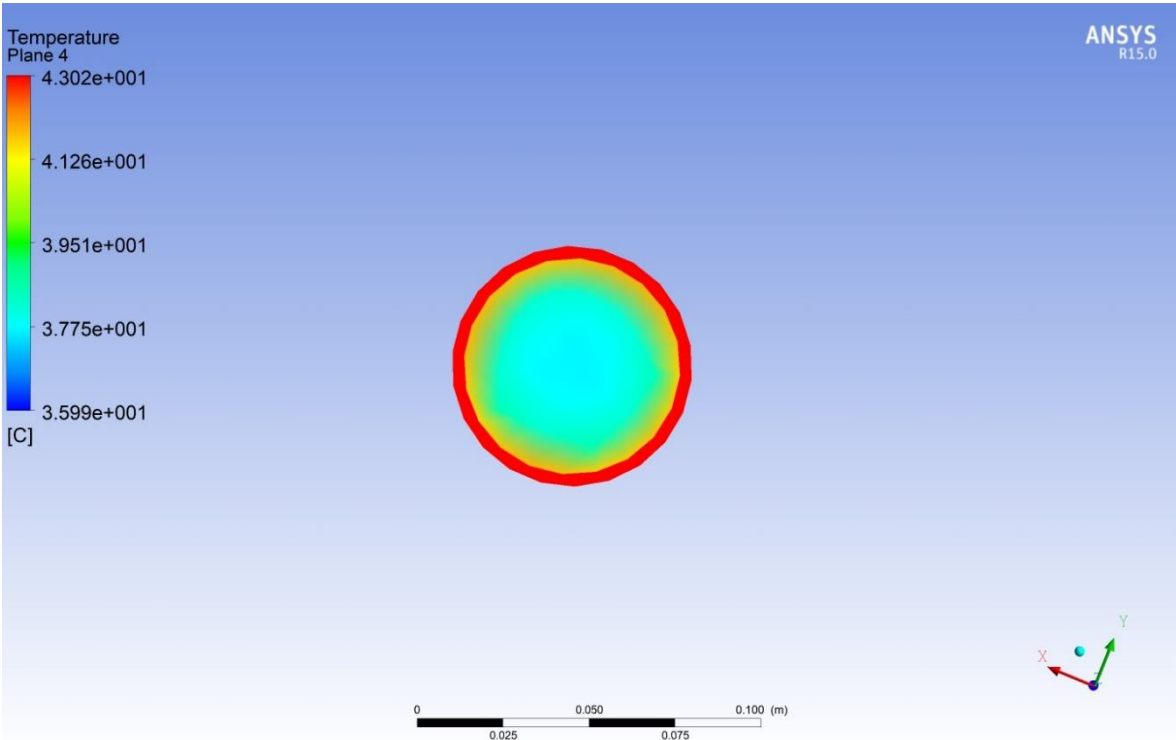
Temperature at 8am in T2



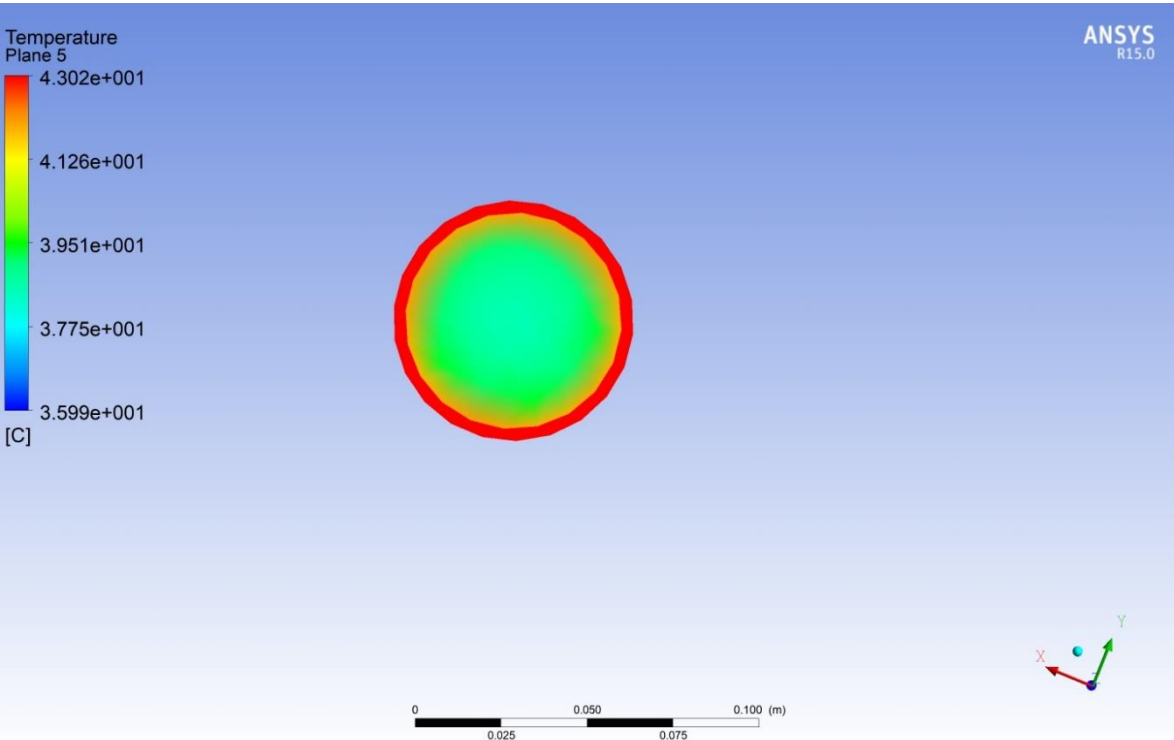
Temperature at 8am in T3



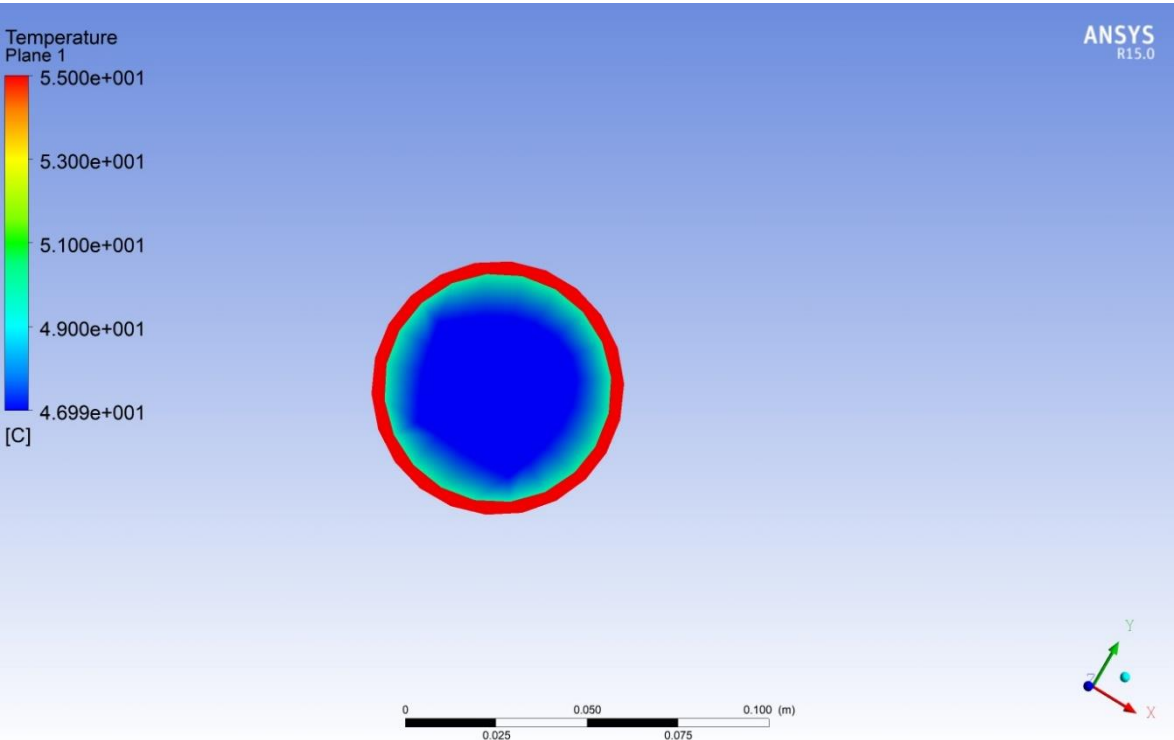
Temperature at 8 am in T4



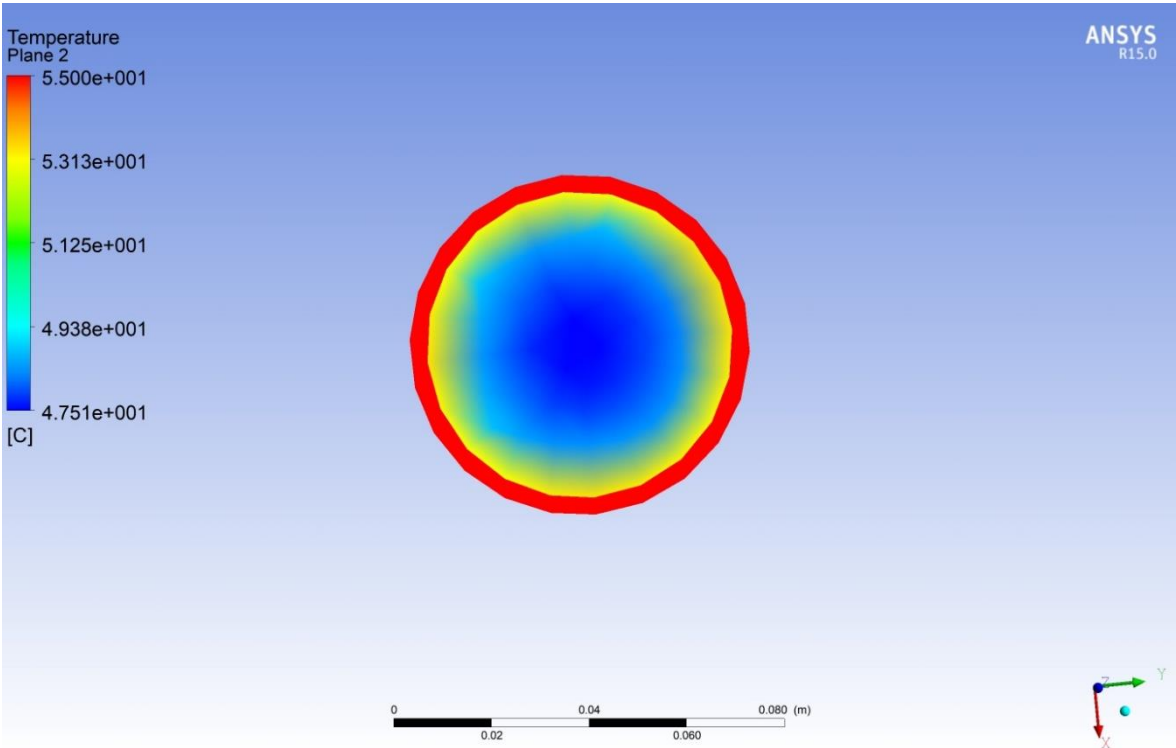
Temperature at 8 am in T5



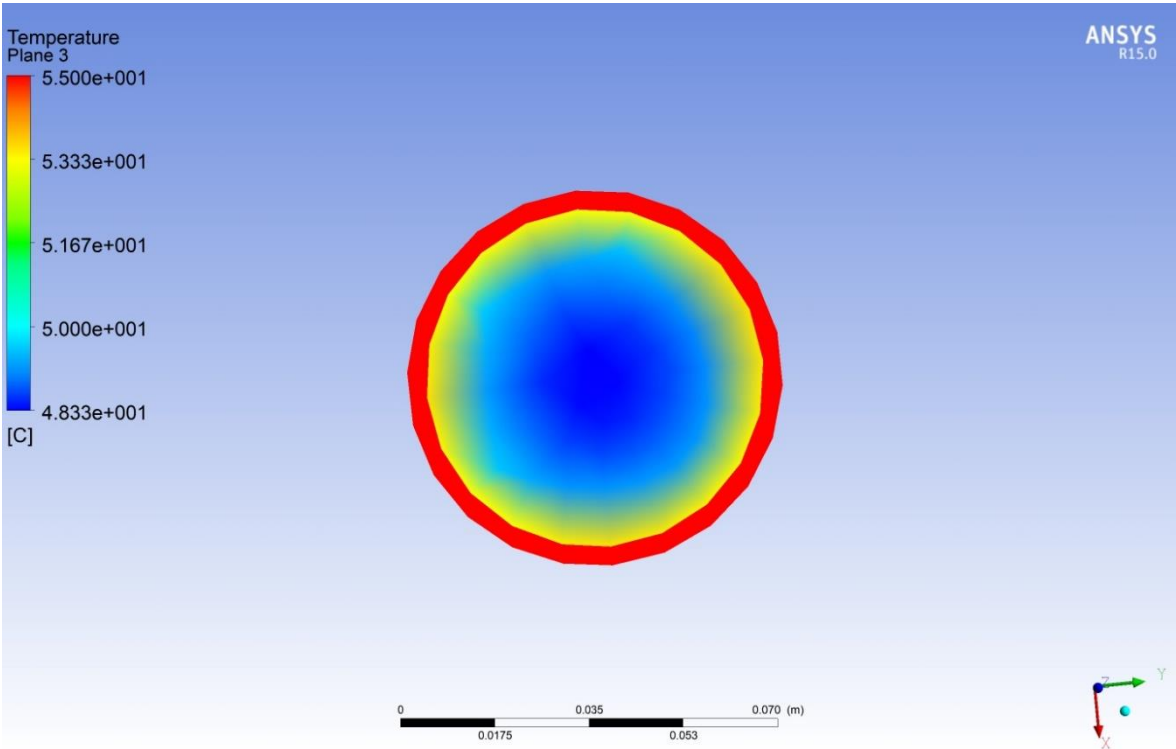
Temperature at 10 am in T1



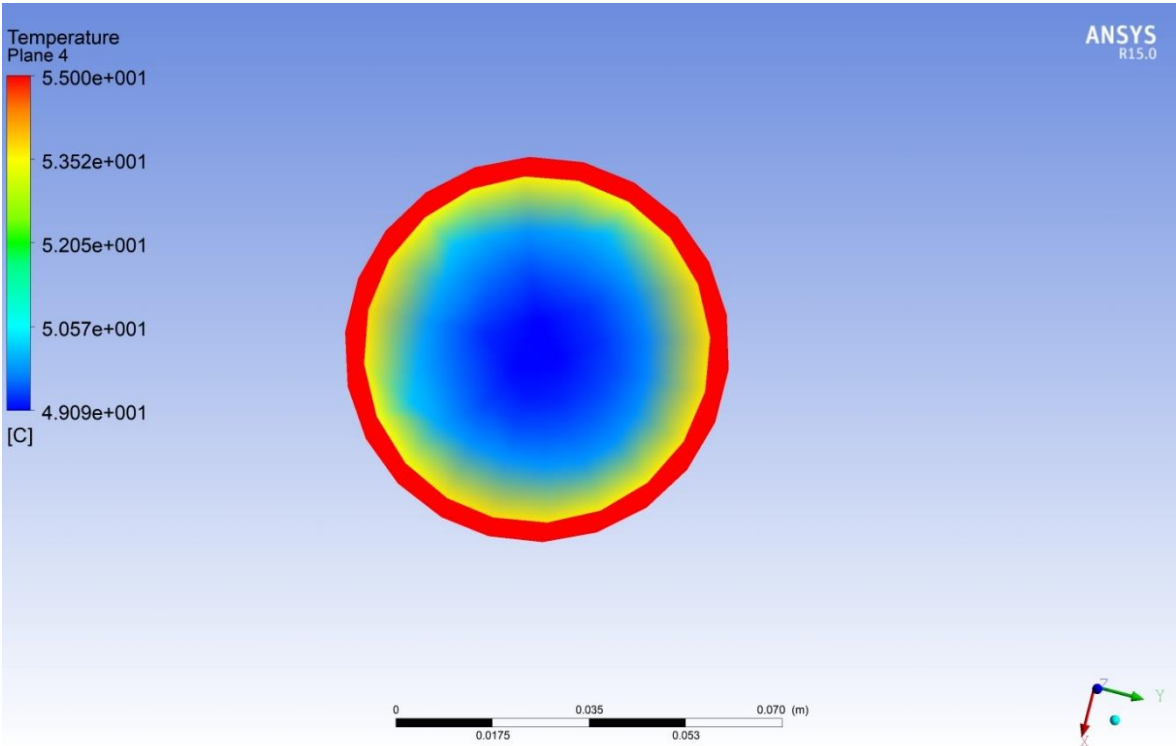
Temperature at 10 am in T2



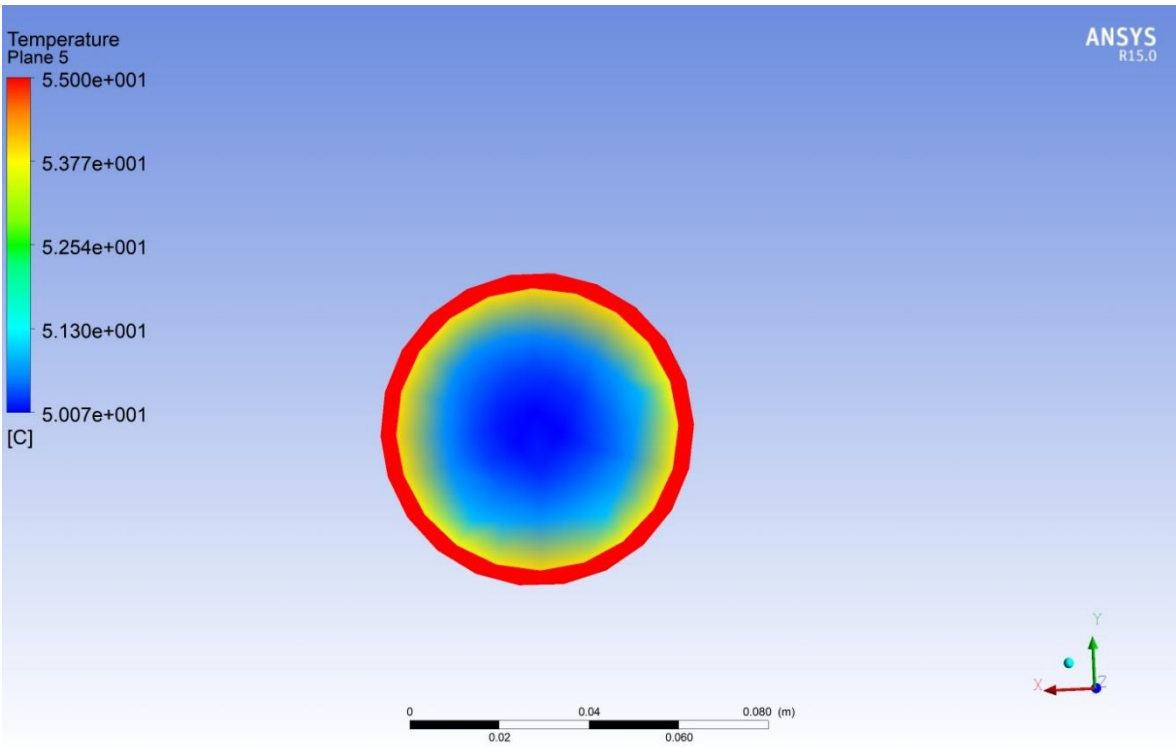
Temperature at 10 am in T3



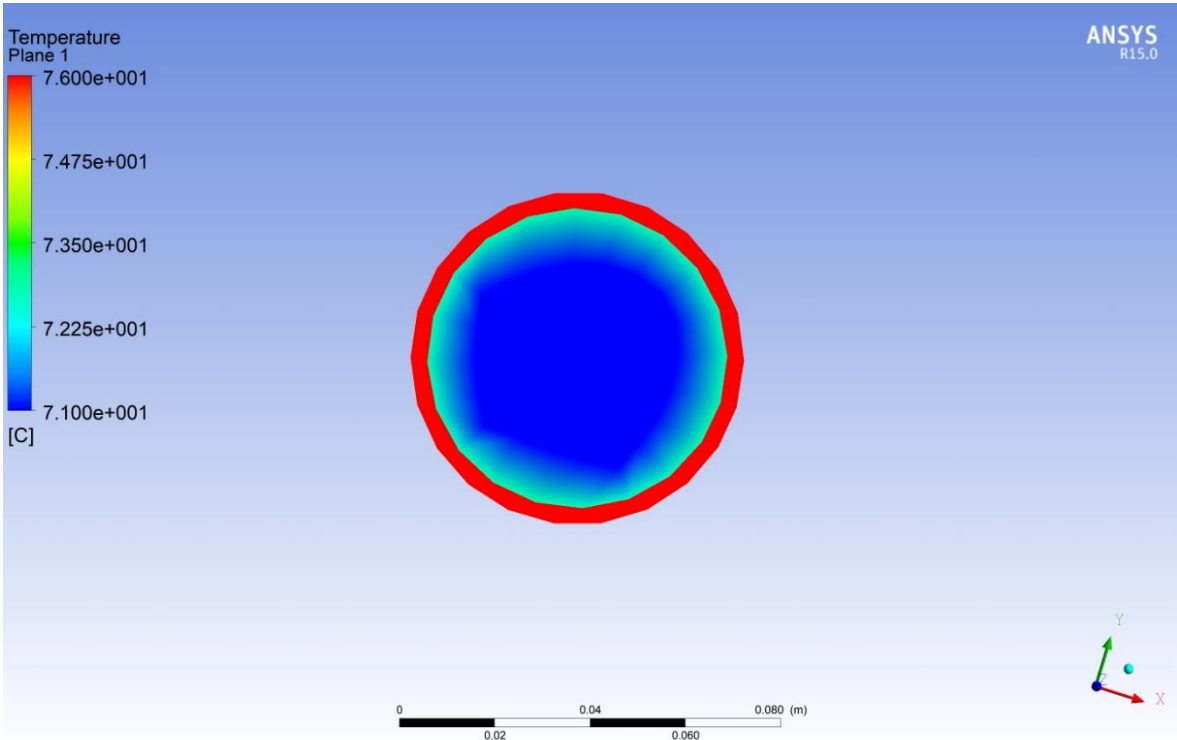
Temperature at 10 am in T4



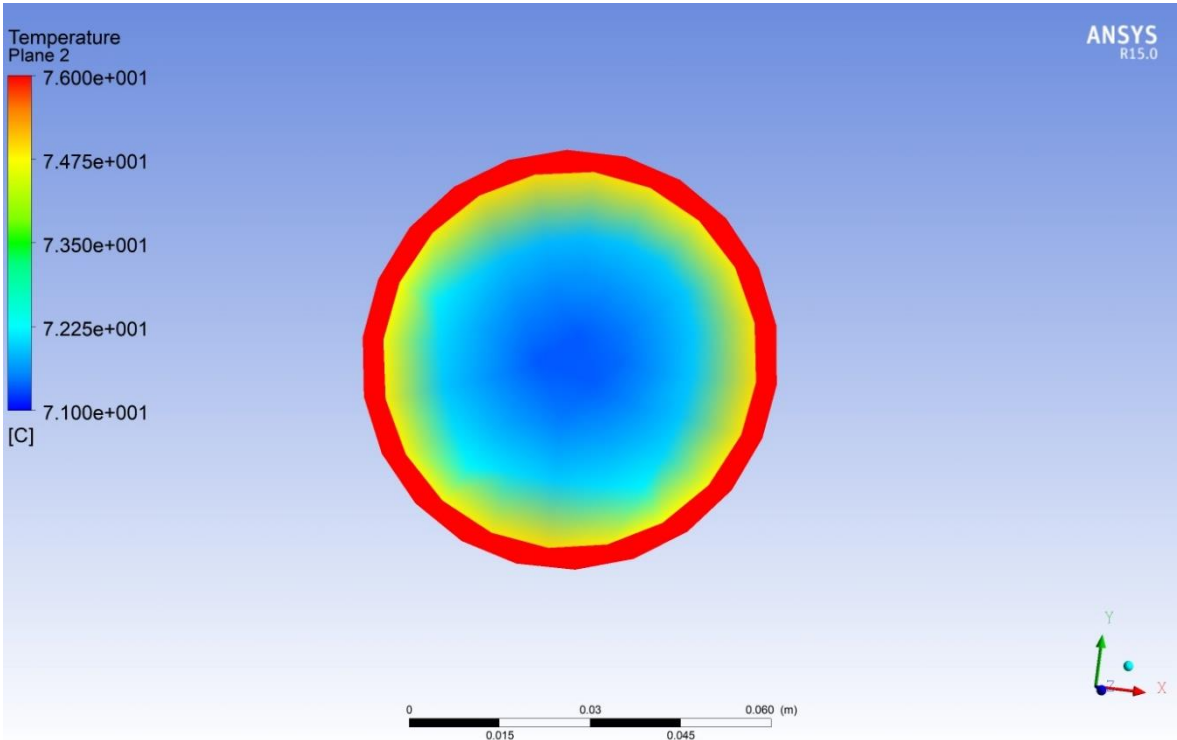
Temperature at 10 am in T5



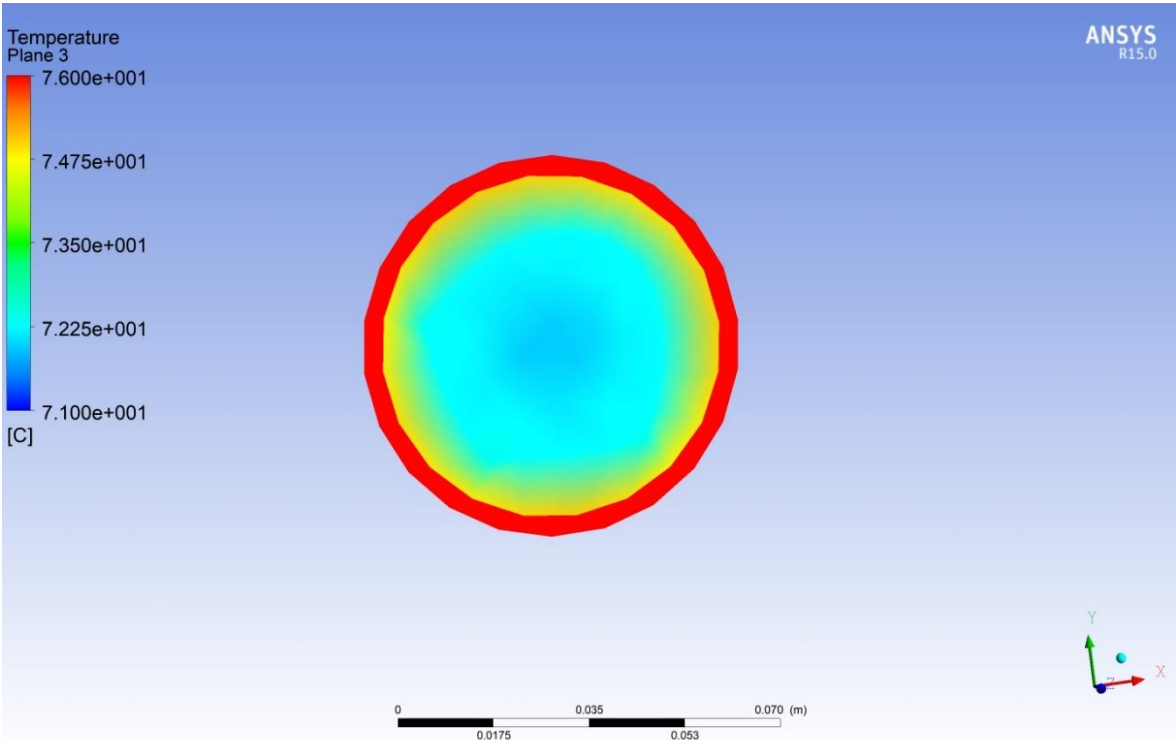
Temperature at 12 pm in T1



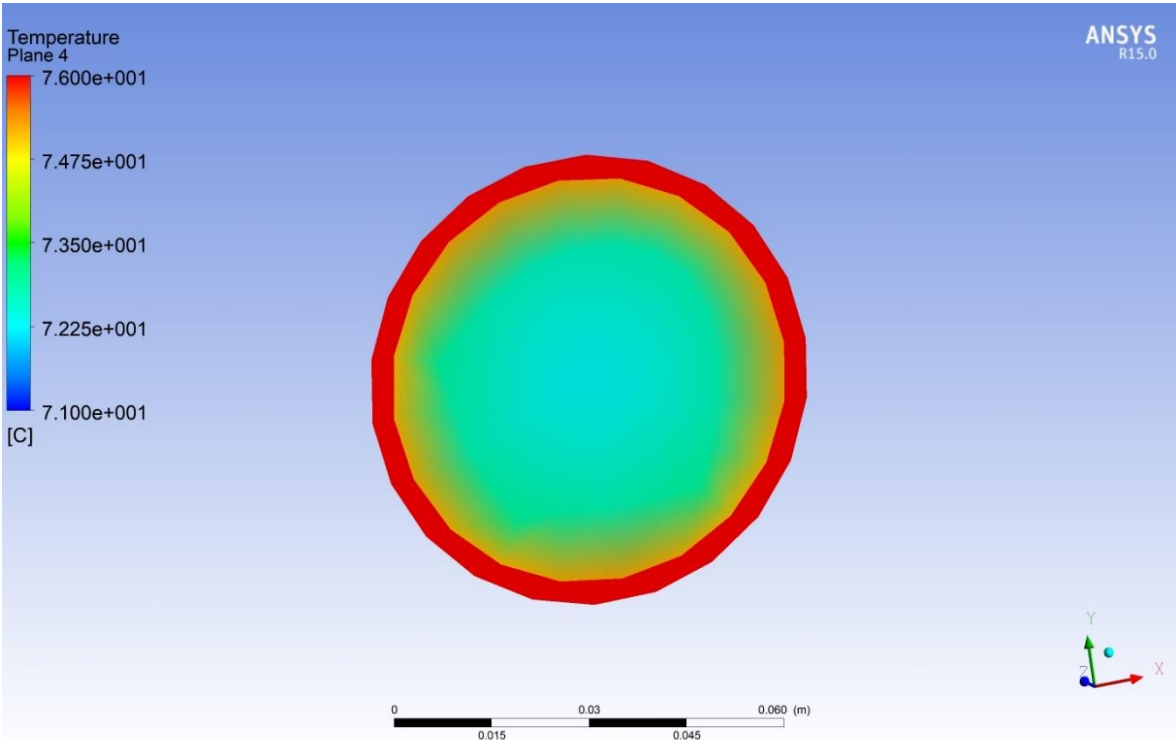
Temperature at 12 pm in T3



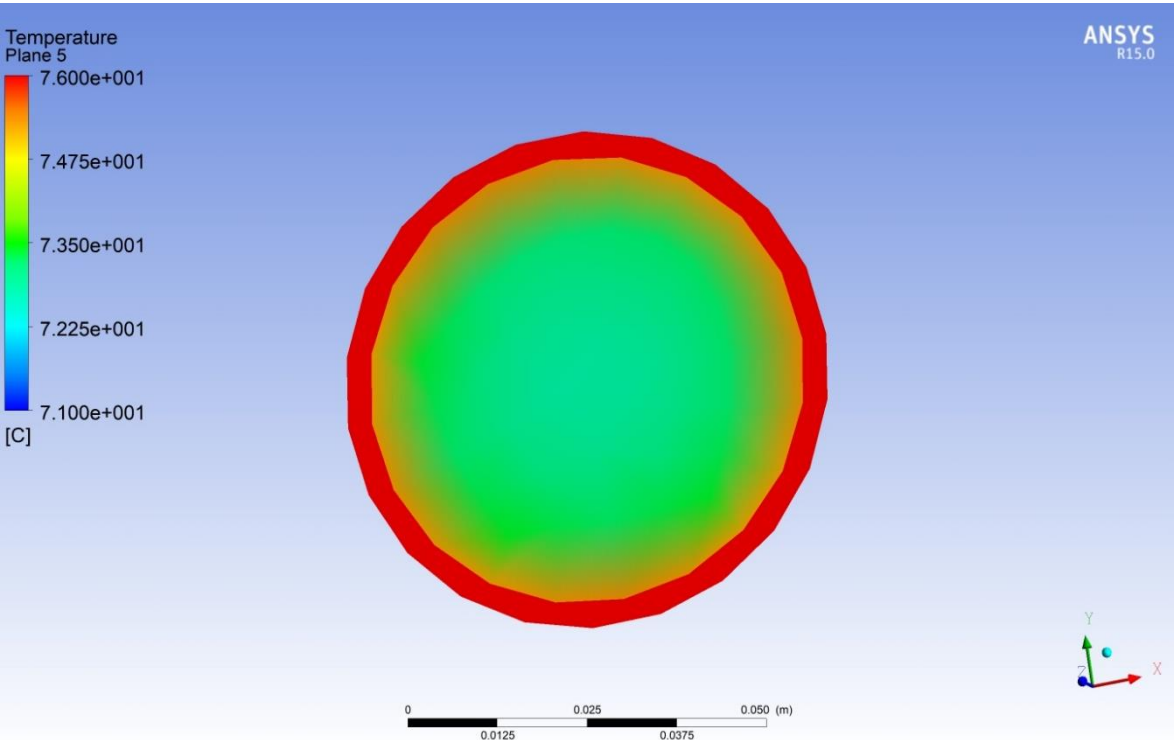
Temperature at 12 am in T3



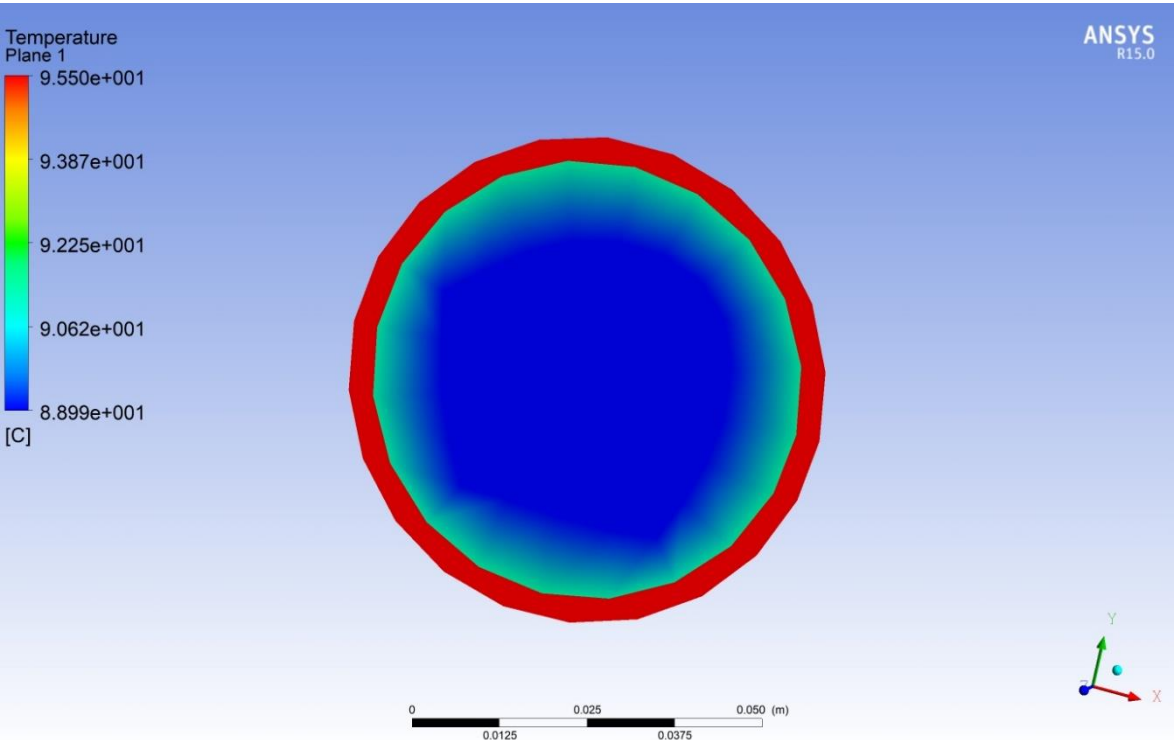
Temperature at 12 pm in T4



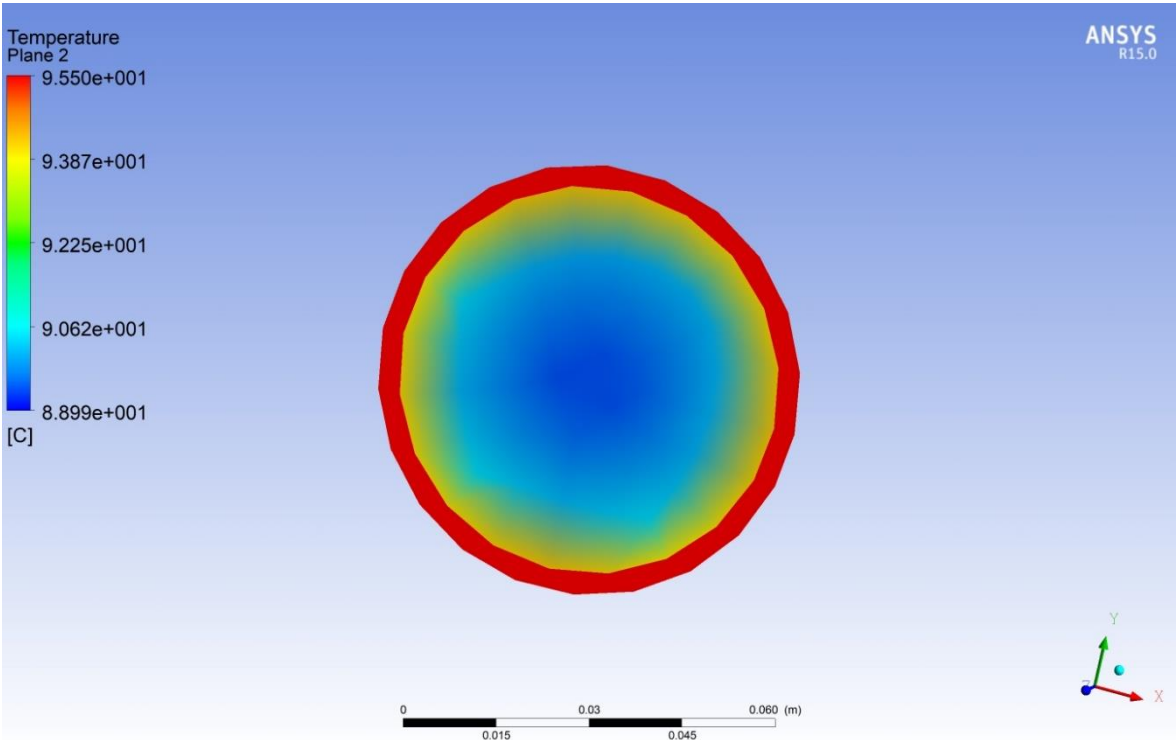
Temperature at 12 pm in T5



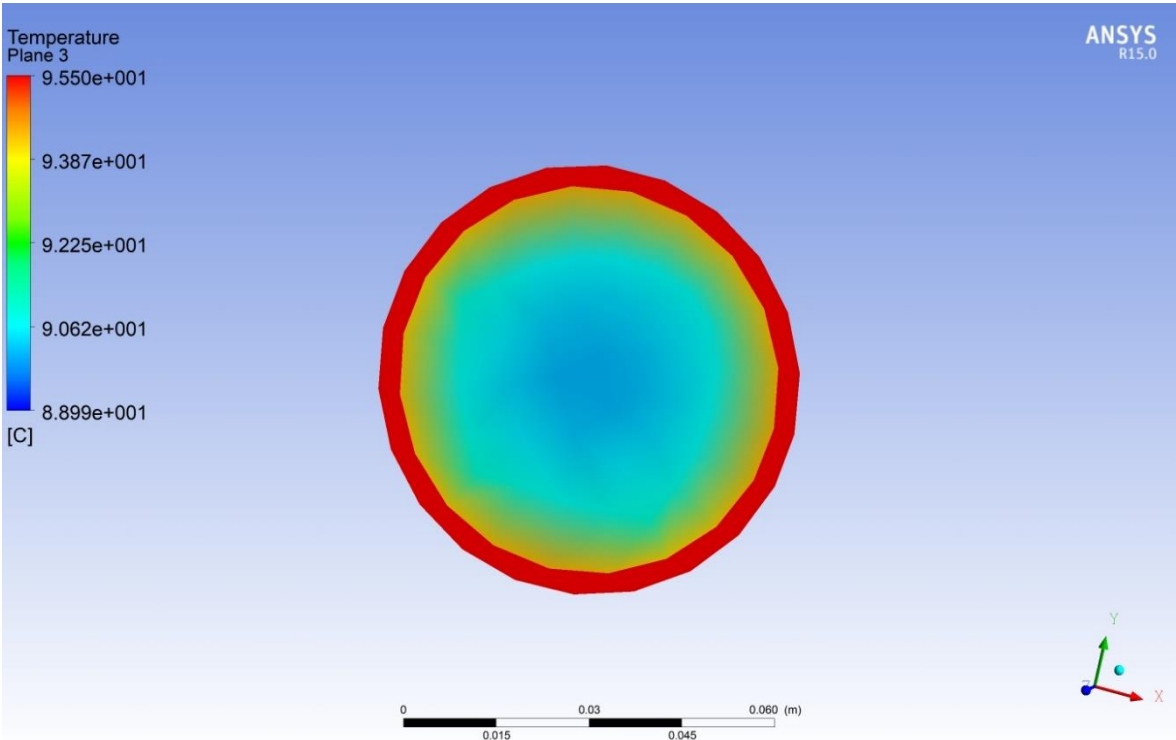
Temperature at 2 pm in T1



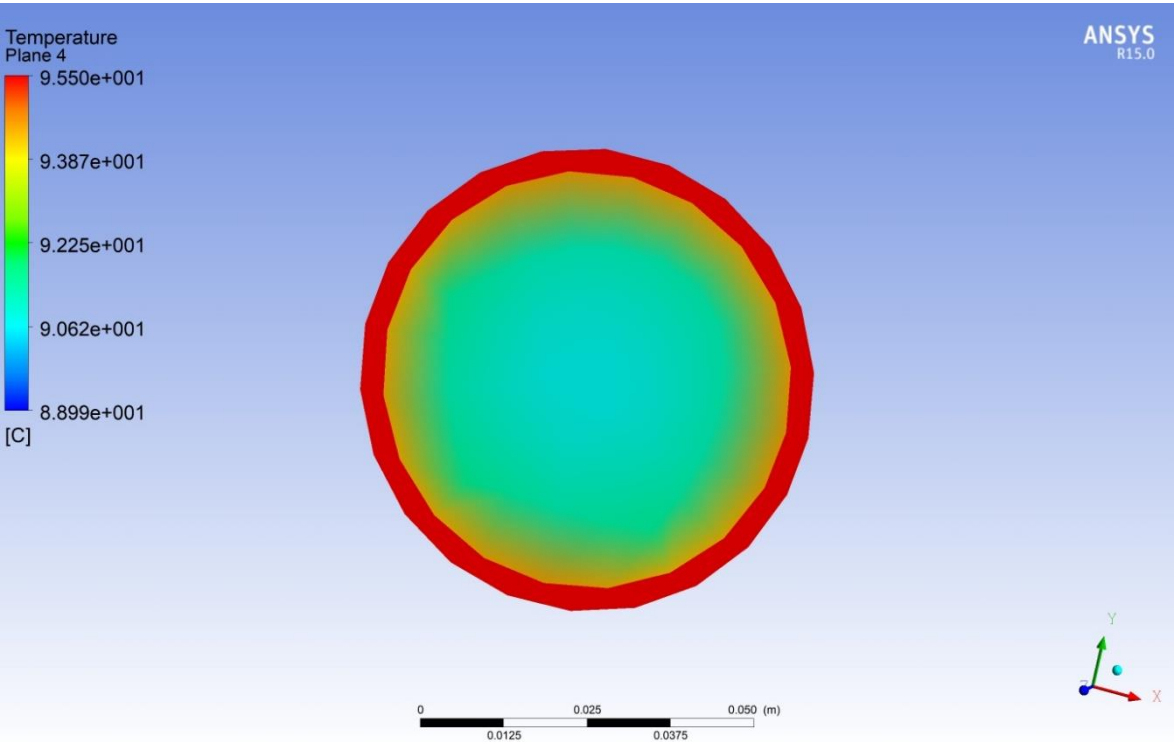
Temperature at 2 pm in T2



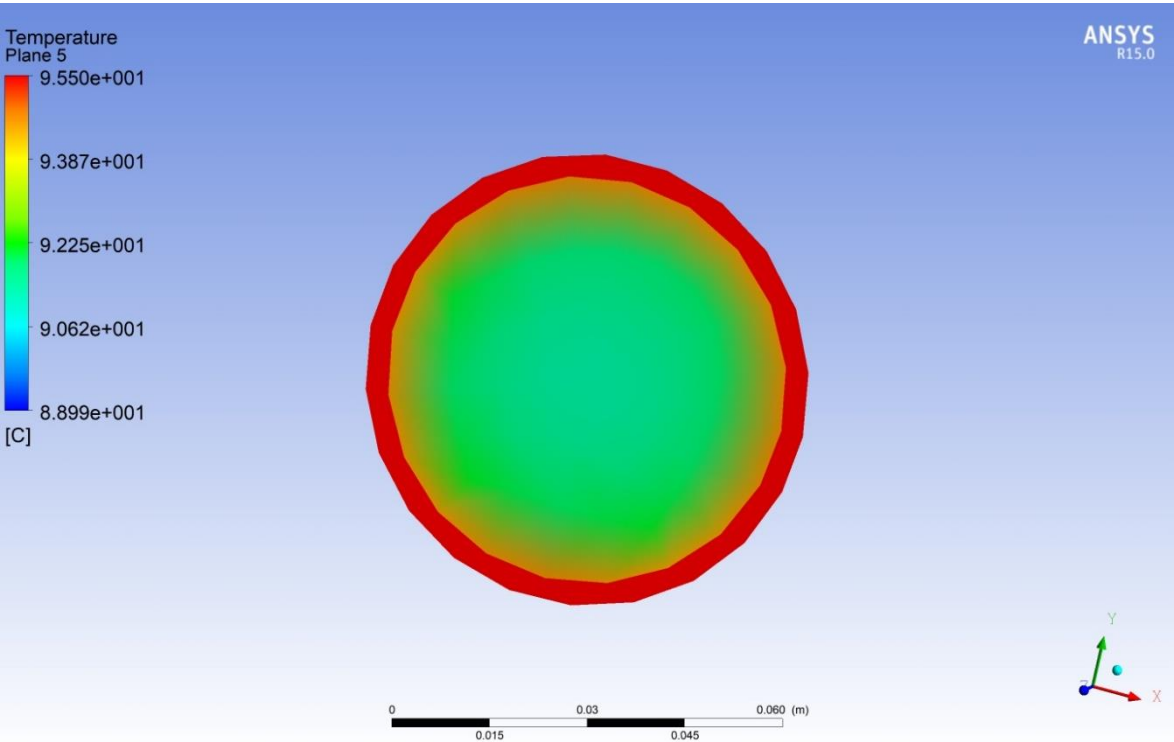
Temperature at 2 pm in T3



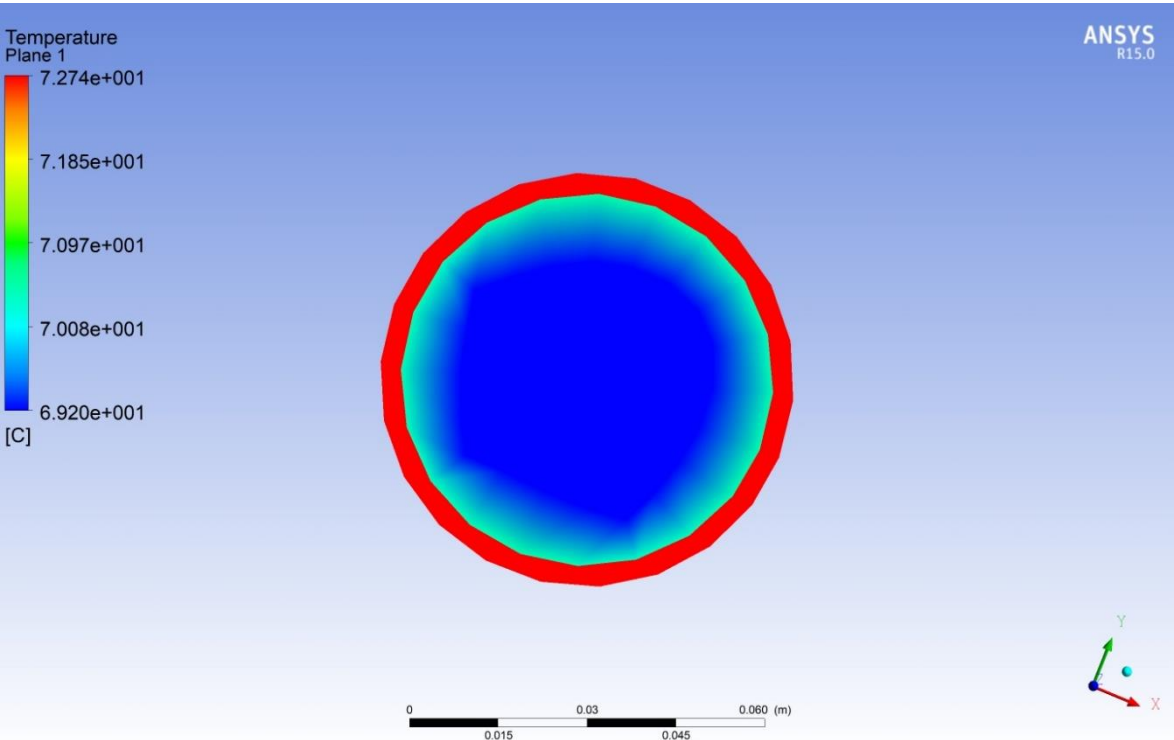
Temperature at 2  $\mu\text{m}$  in T4



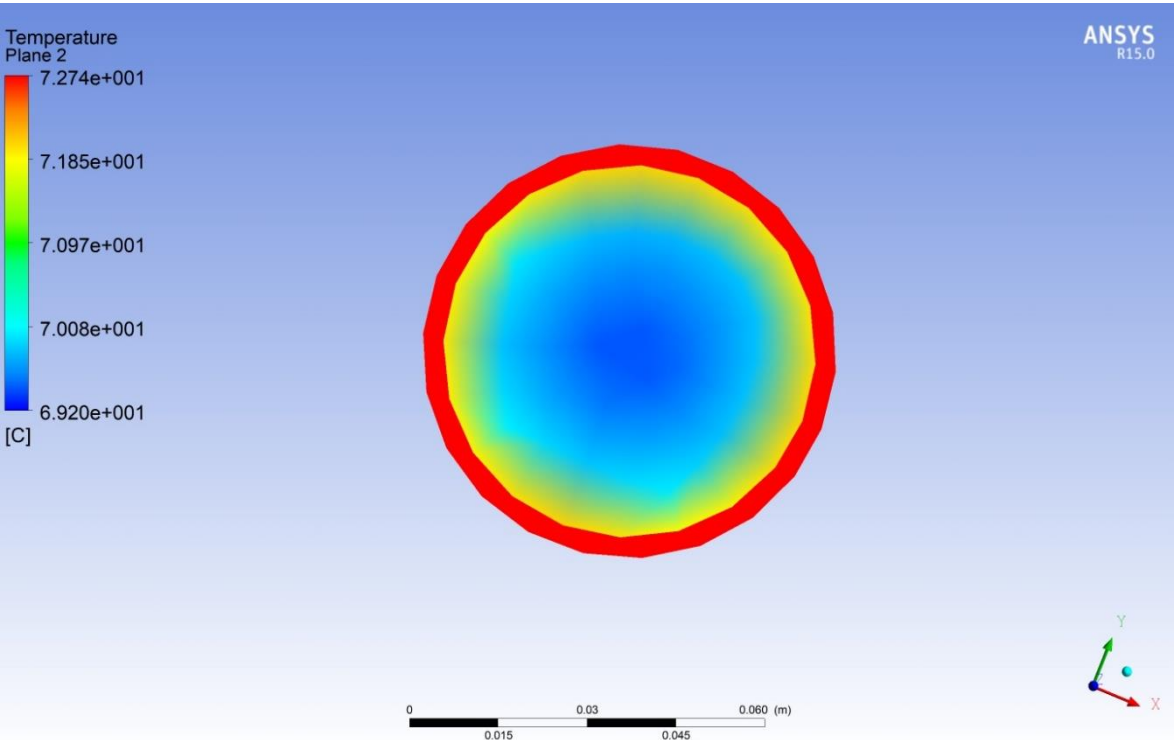
Temperature at 2  $\mu\text{m}$  in T5



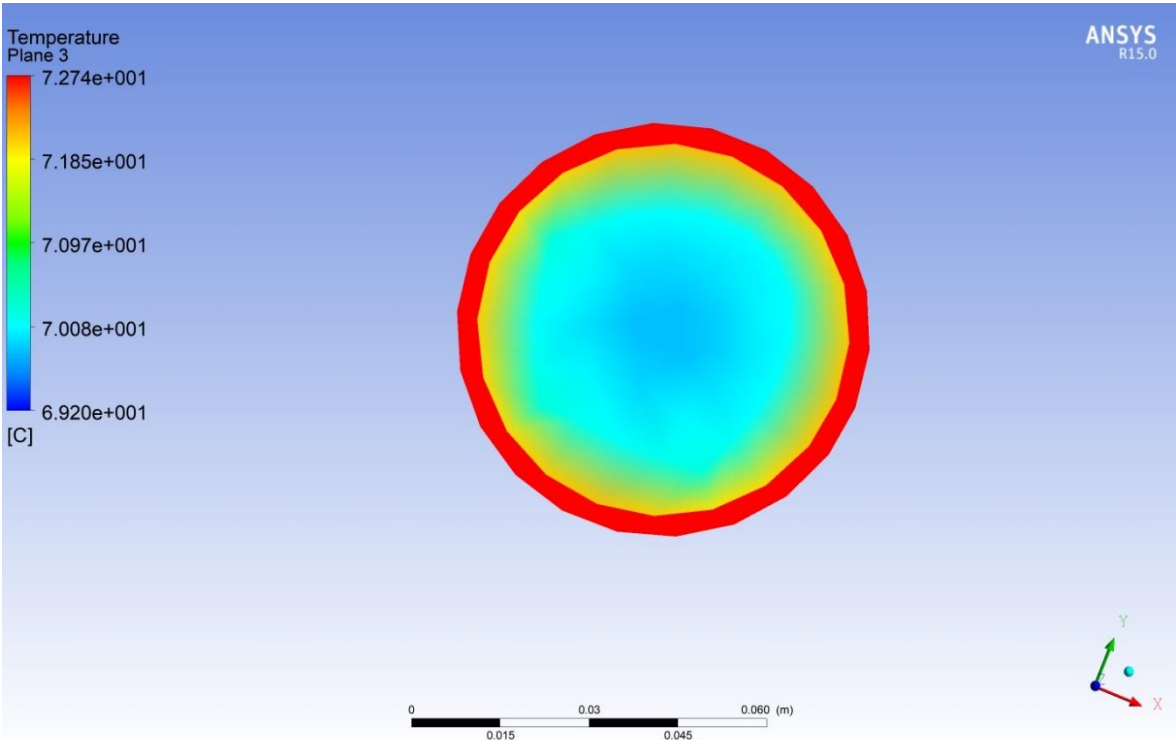
Temperature at 4 pm in T1



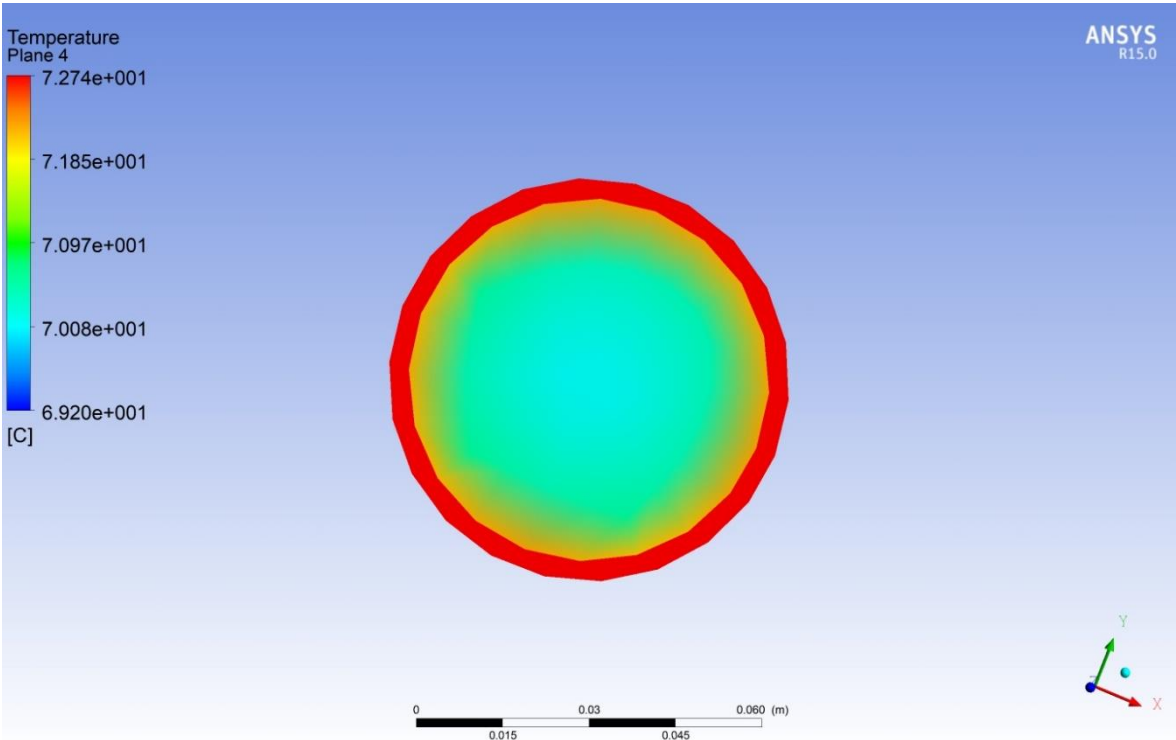
Temperature at 4 pm in T2



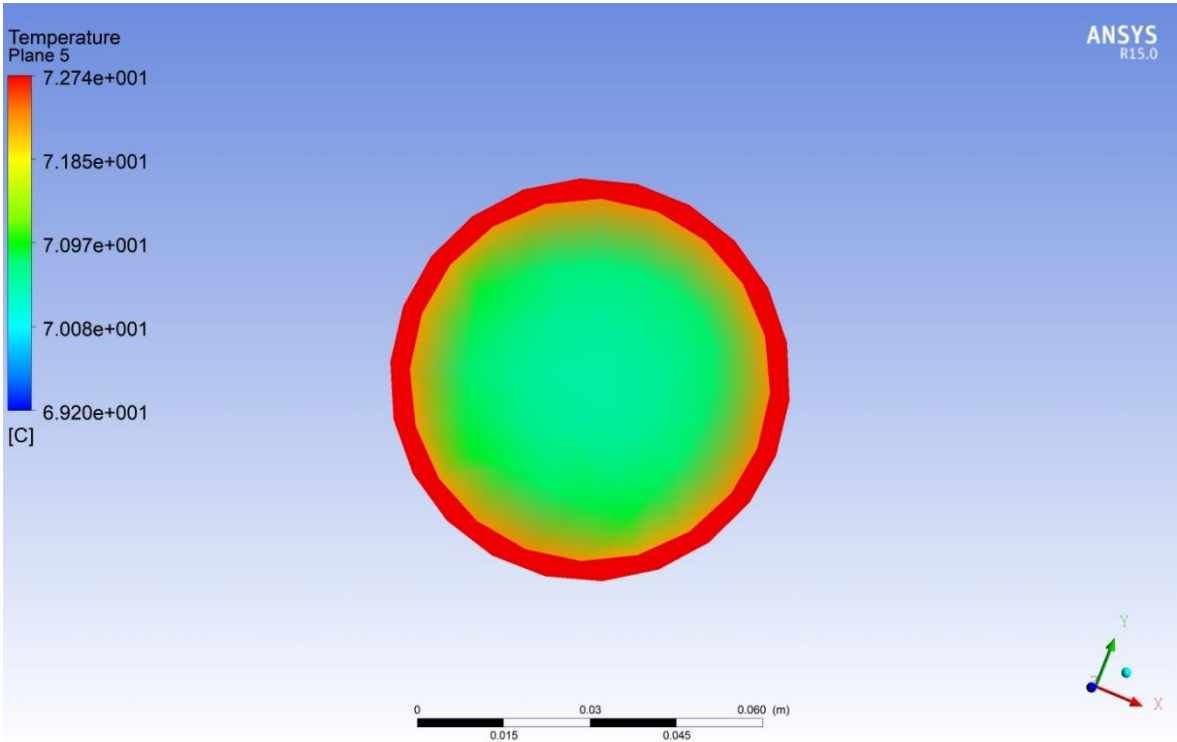
Temperature at 4 pm in T3



Temperature at 4 pm in T4



Temperature at 4 pm in T5

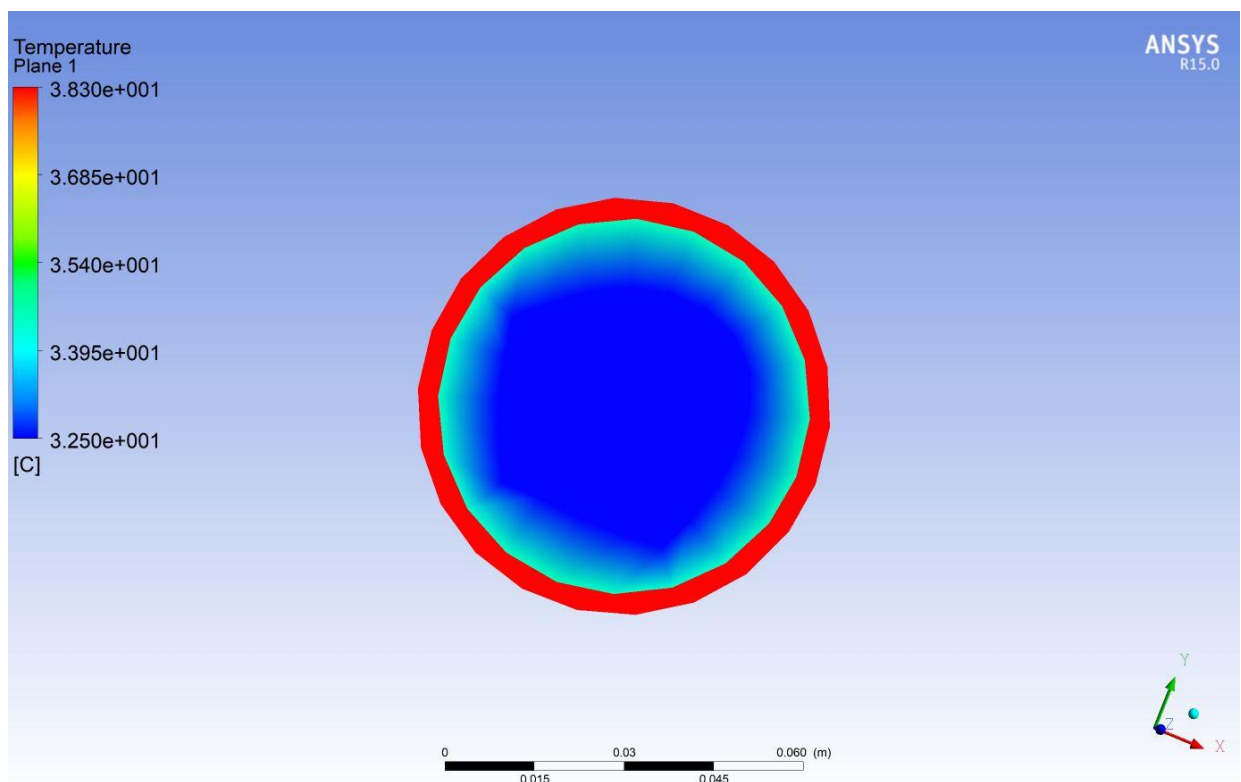


The calculations and readings which are obtained from the heat pipe is later taken for CFD analysis. The figure given below shows the heat distributon in the heat pipe using the CFD analysis.

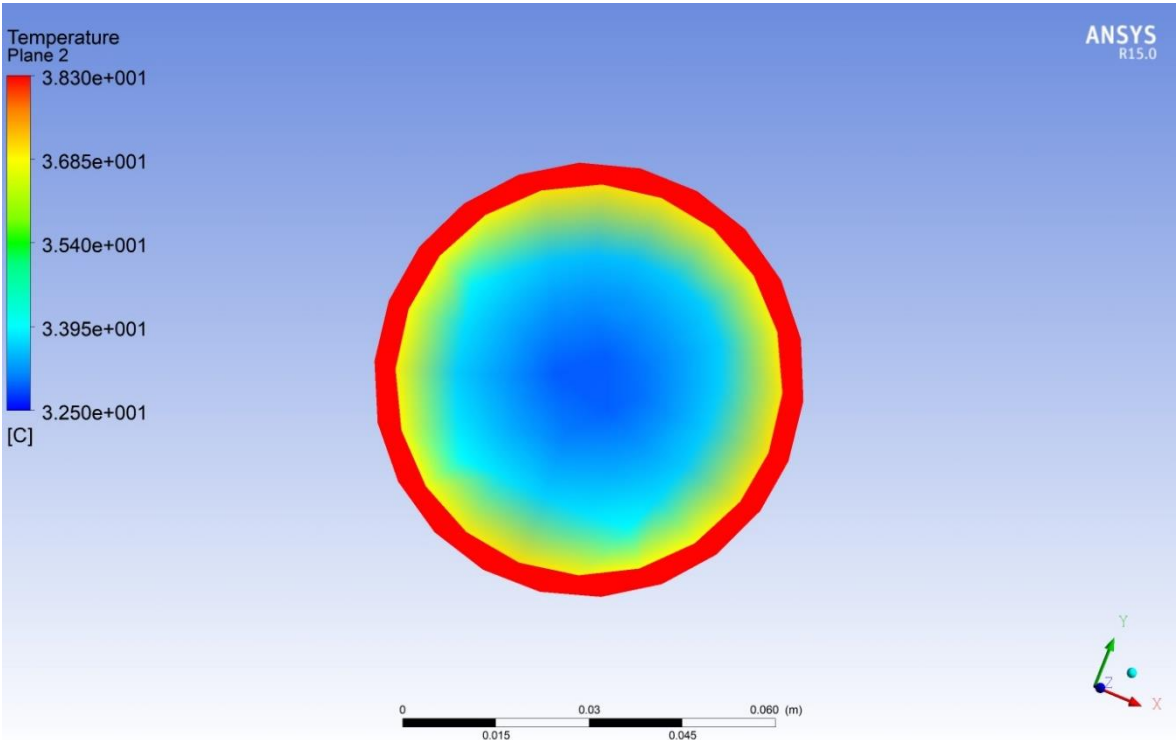
The below CFD analysis represent the Day 10 reading of each points in the pipe at different time

DAY 10

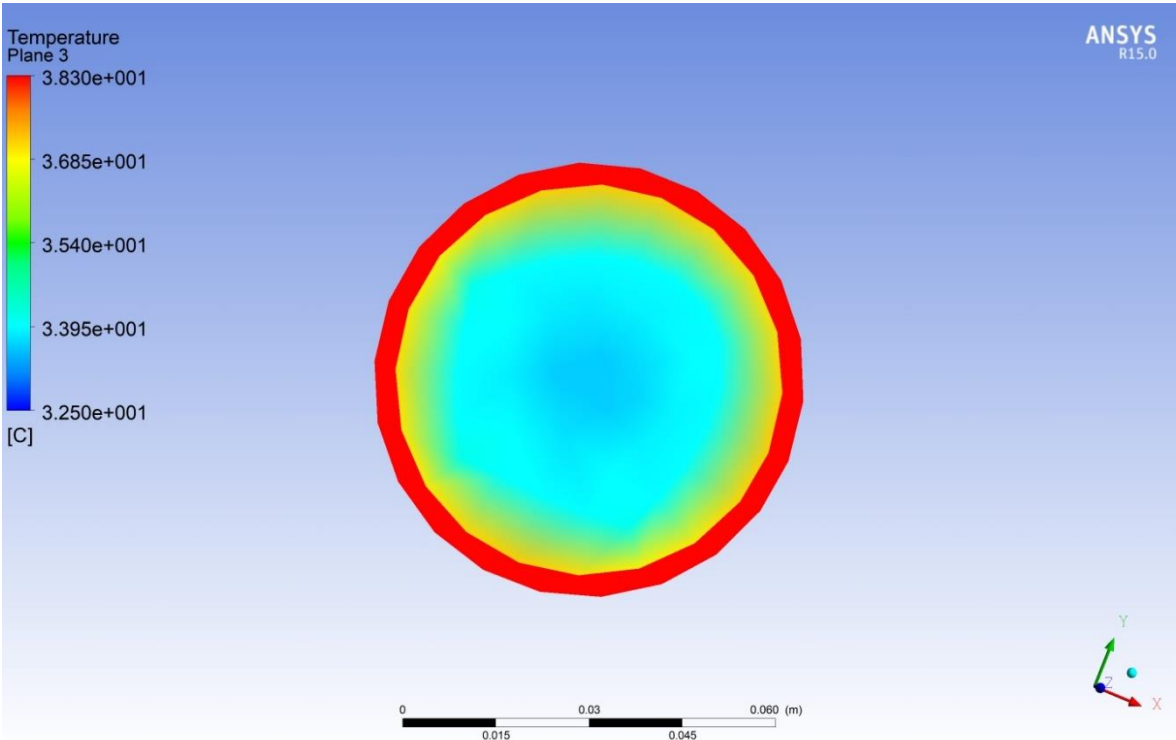
Temperature at 8 am in T1



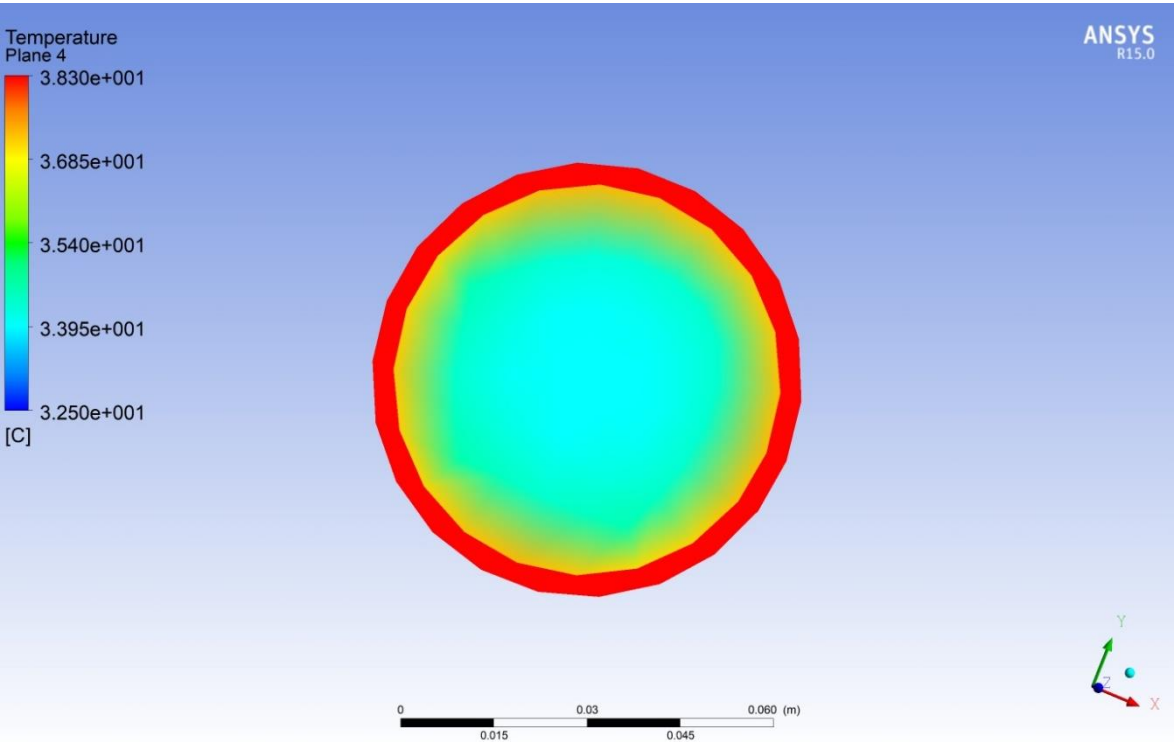
Temperature at 8 am in T2



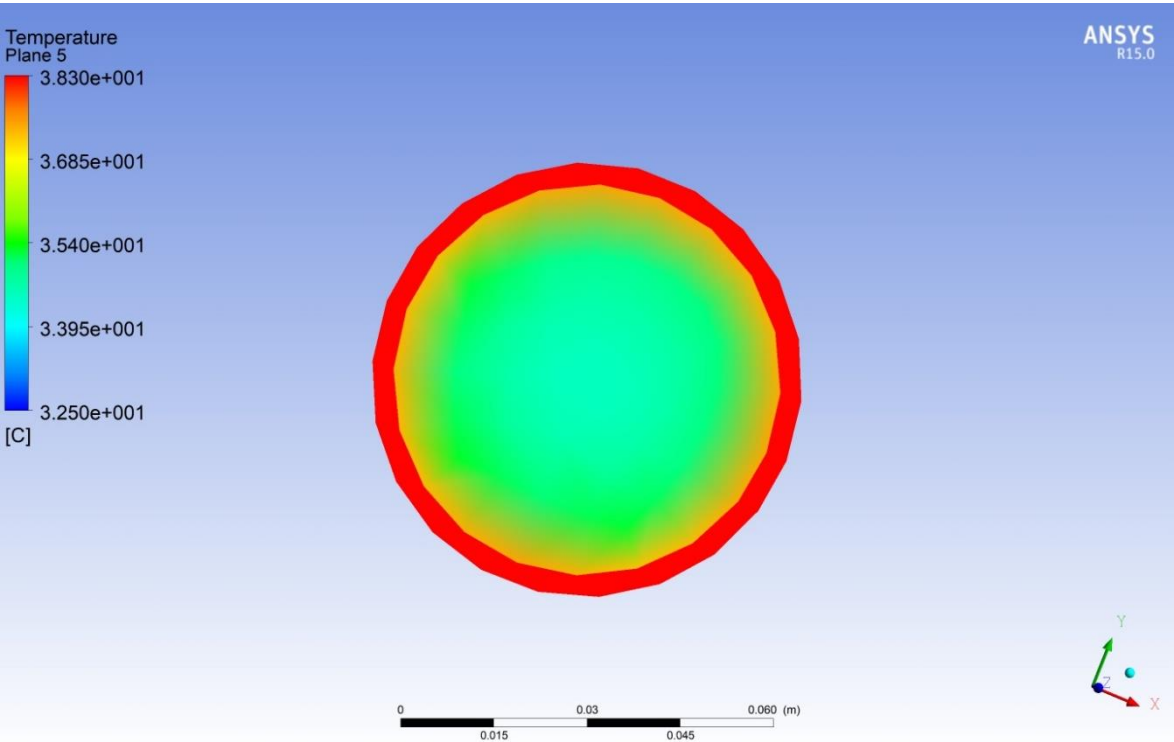
Temperature at 8 am in T3



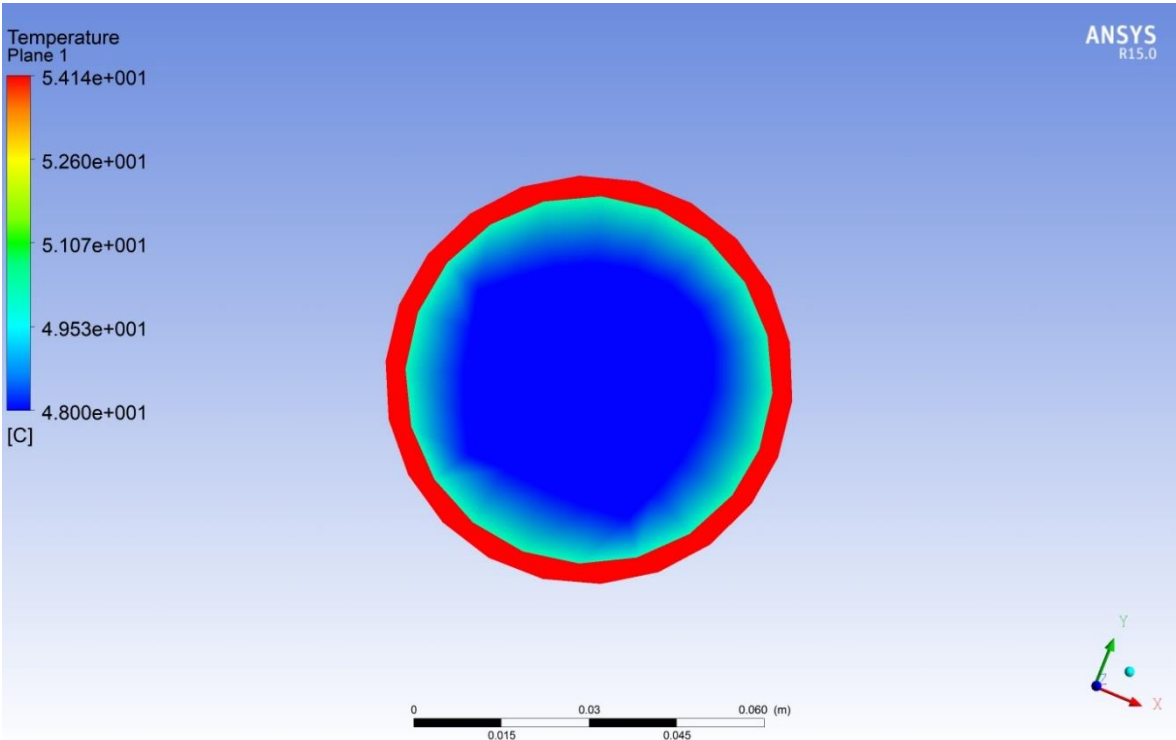
Temperature at 8 am in T4



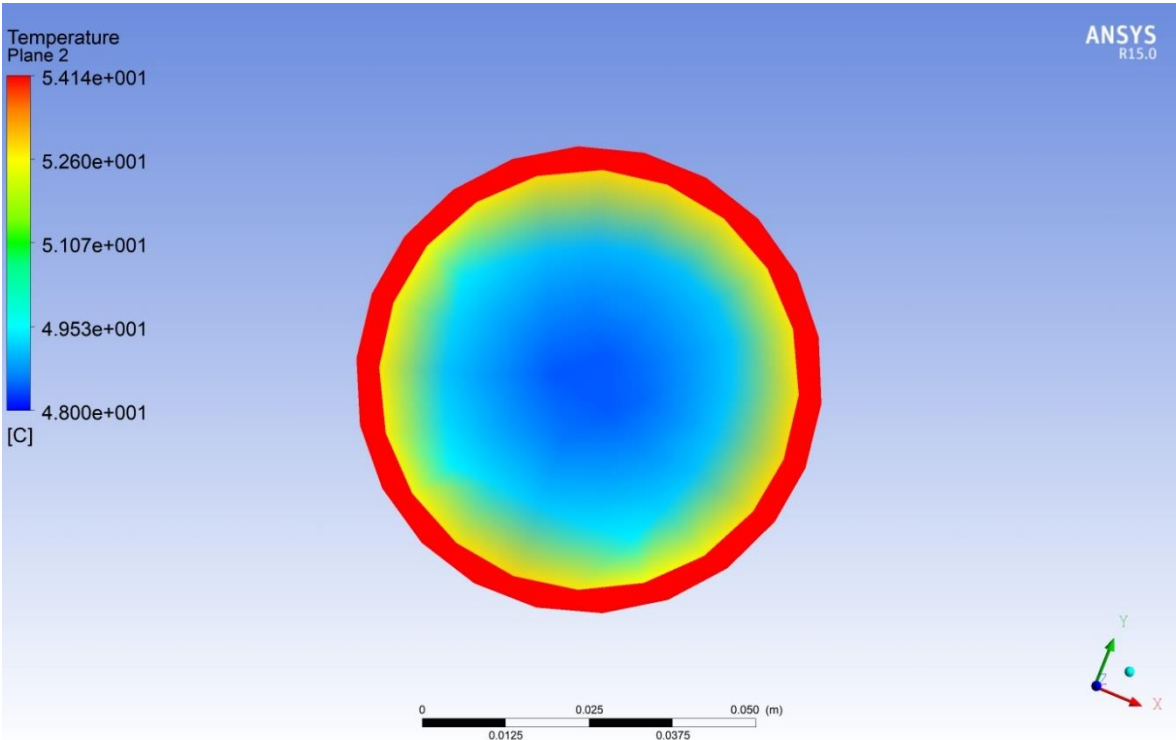
Temperature at 8 am in T5



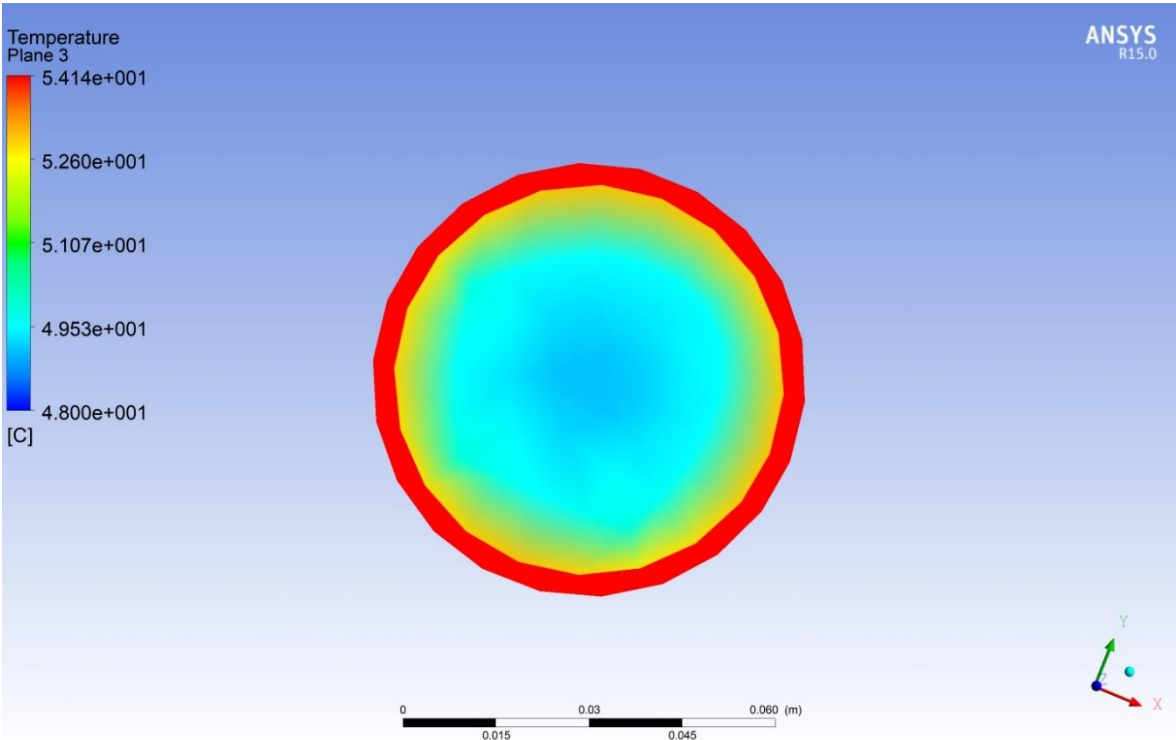
Temperature at 10 am in T1



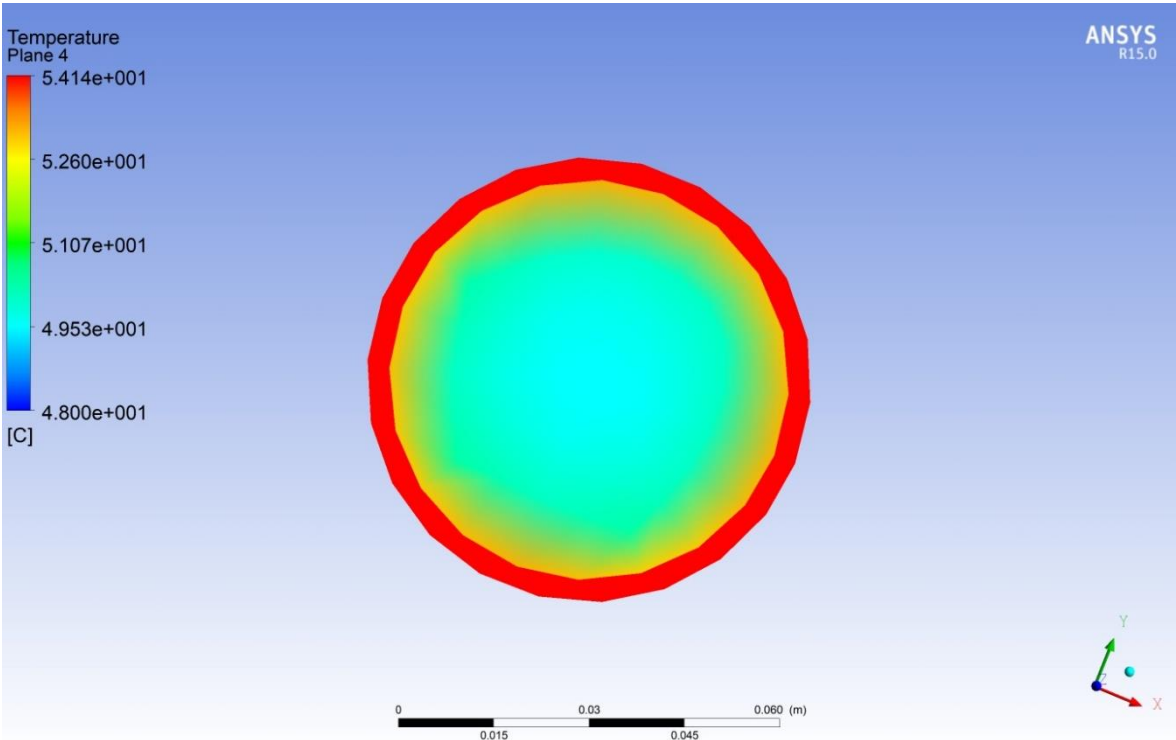
Temperature at 10 am in T2



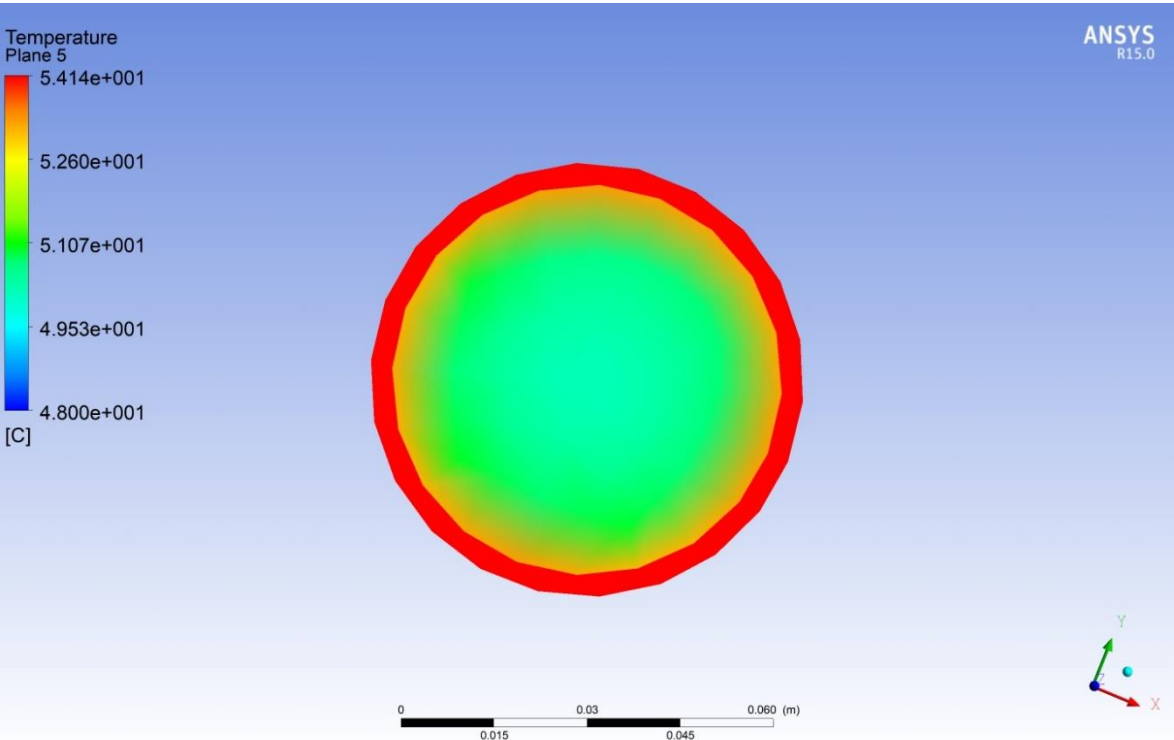
Temperature at 10 am in T3



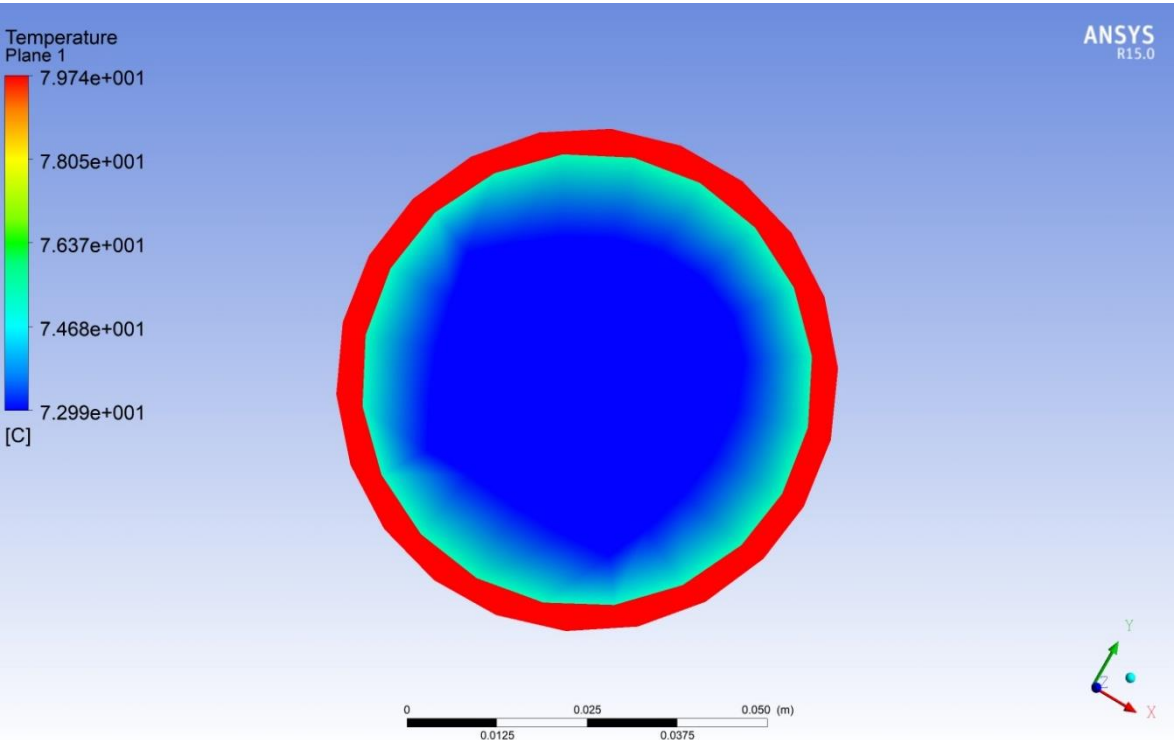
Temperature at 10 am in T4



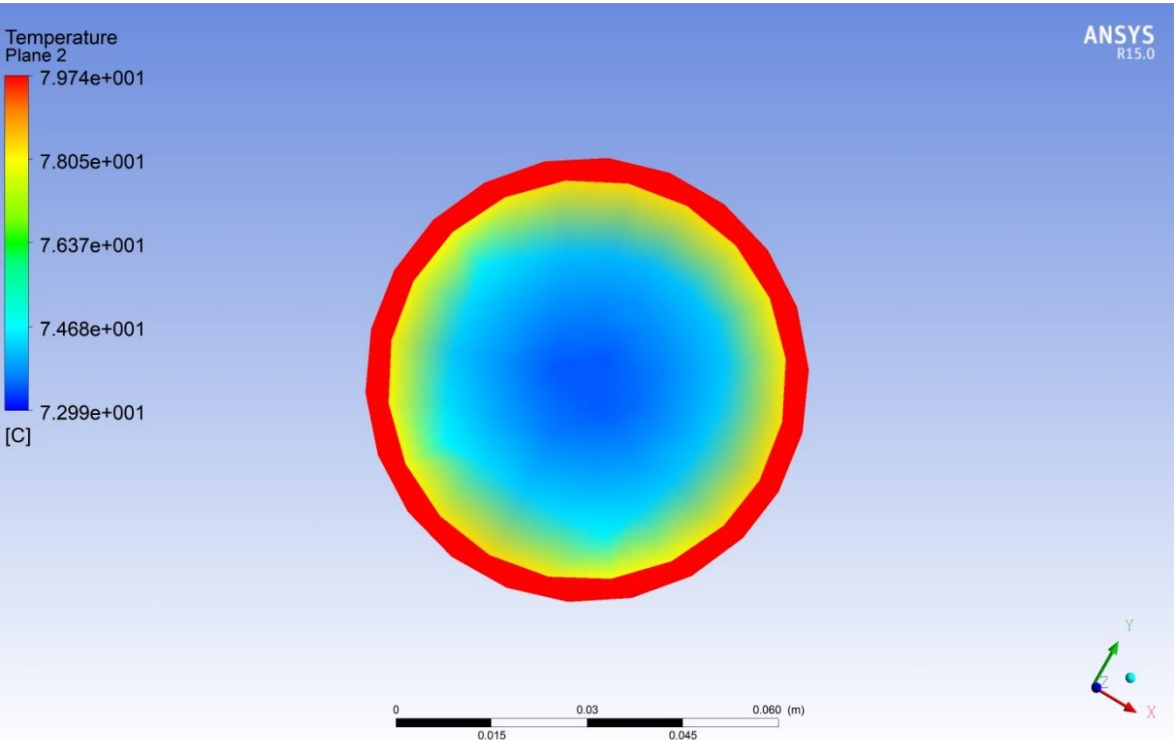
Temperature at 10 am in T5



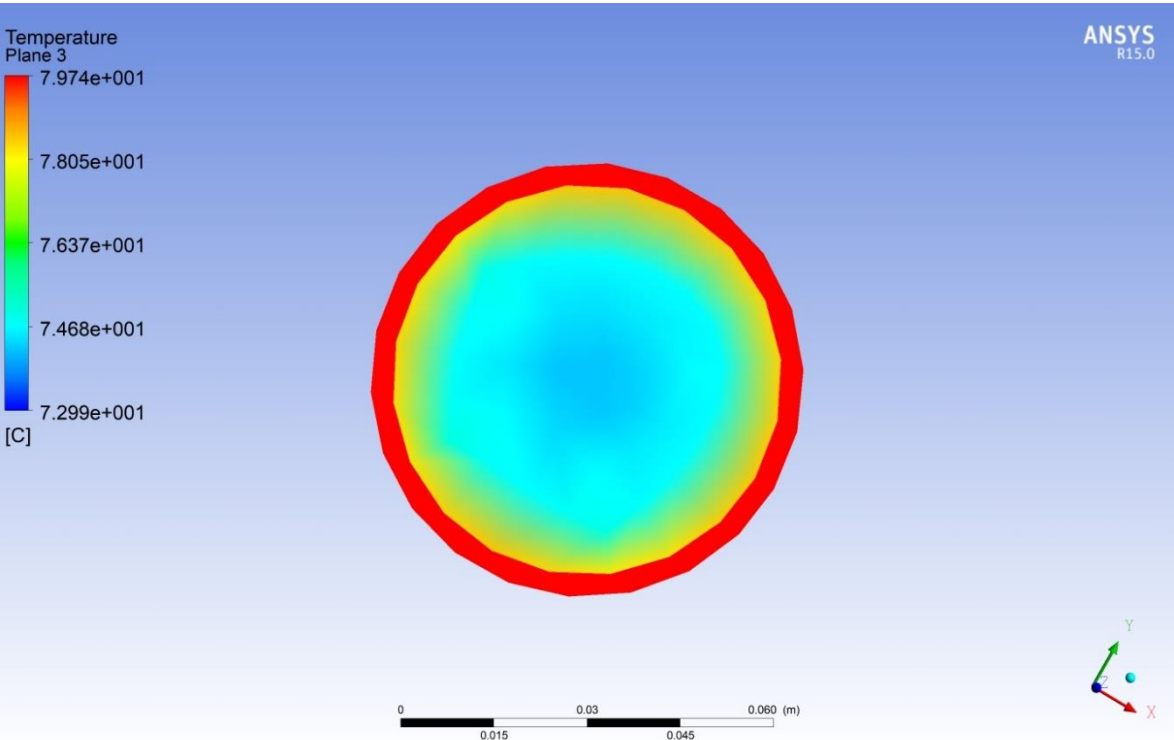
Temperature at 12 pm in T1



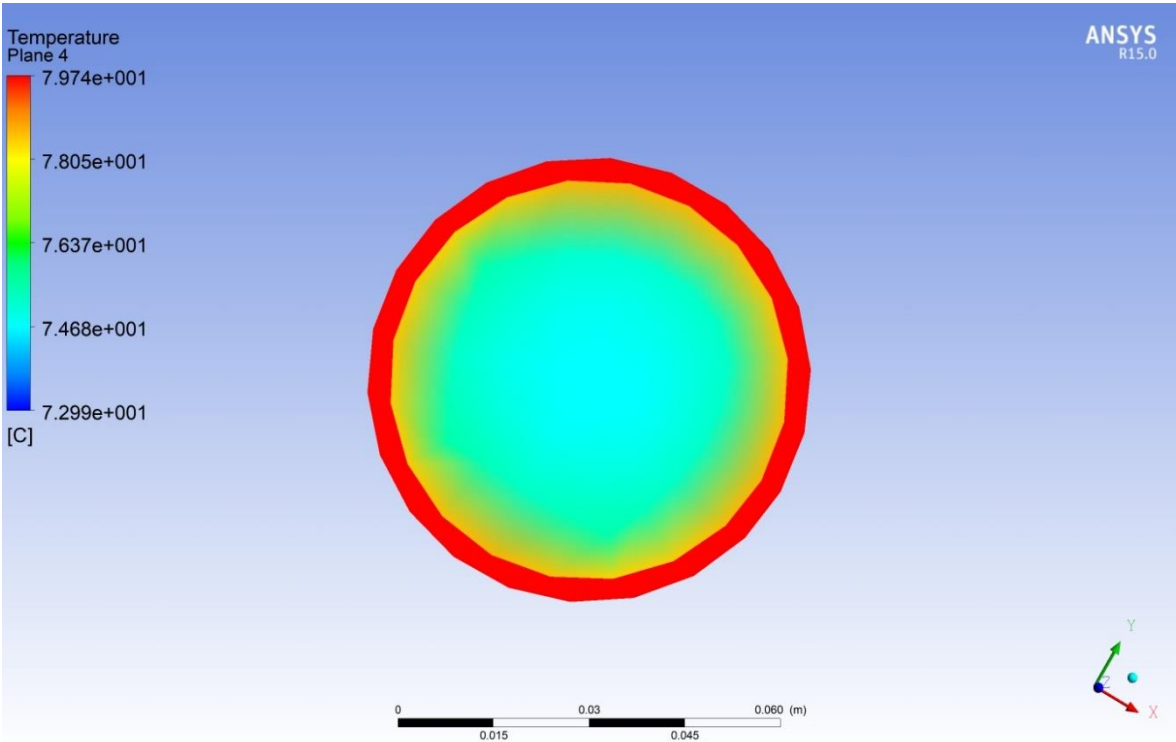
Temperature at 12 pm in T2



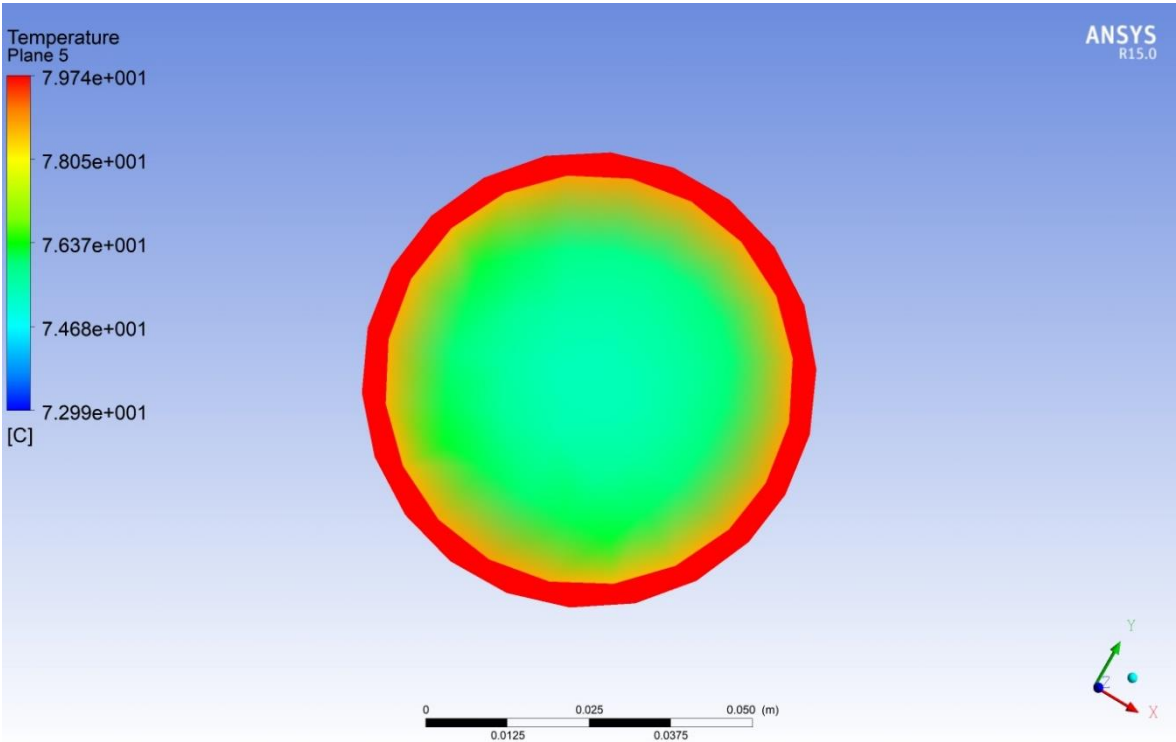
Temperature at 12 pm in T3



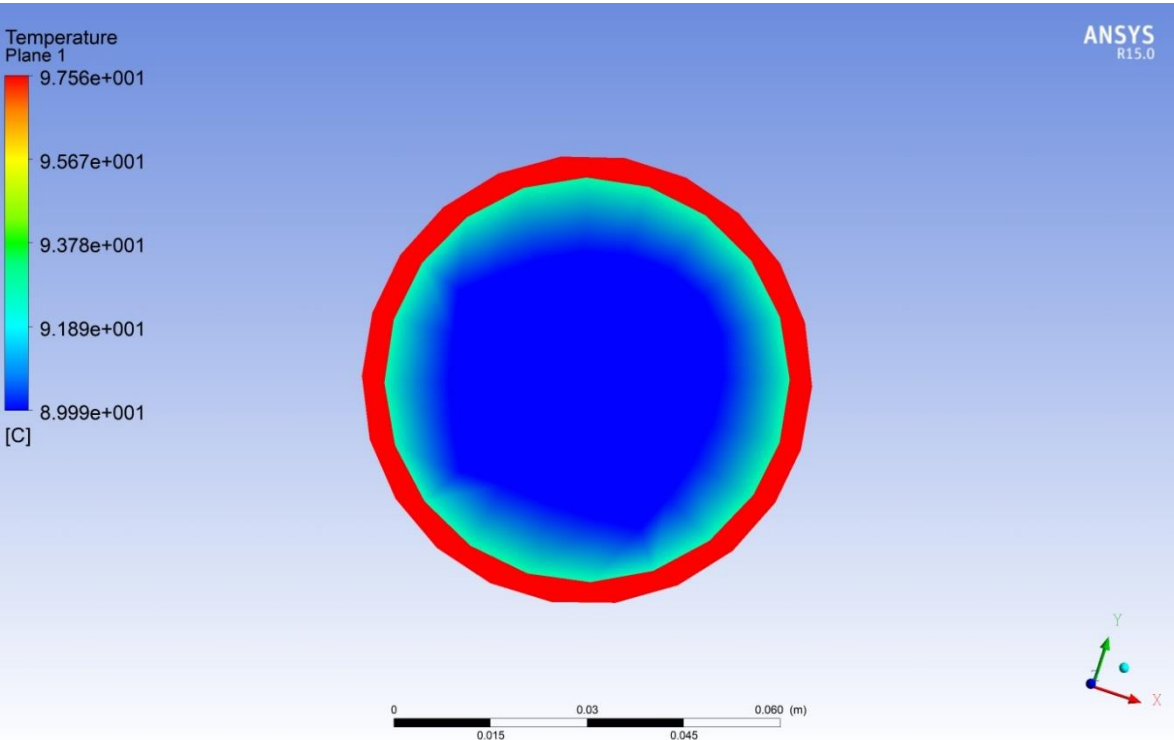
Temperature at 12 pm in T4



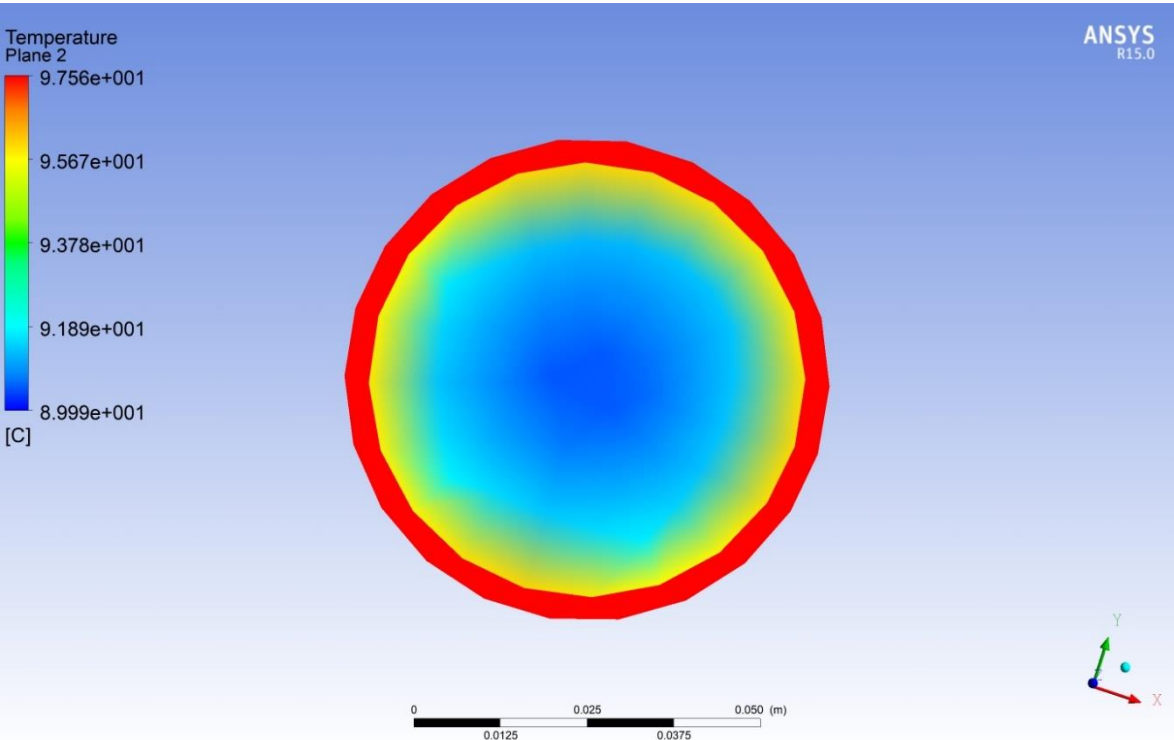
Temperature at 12 pm in T5



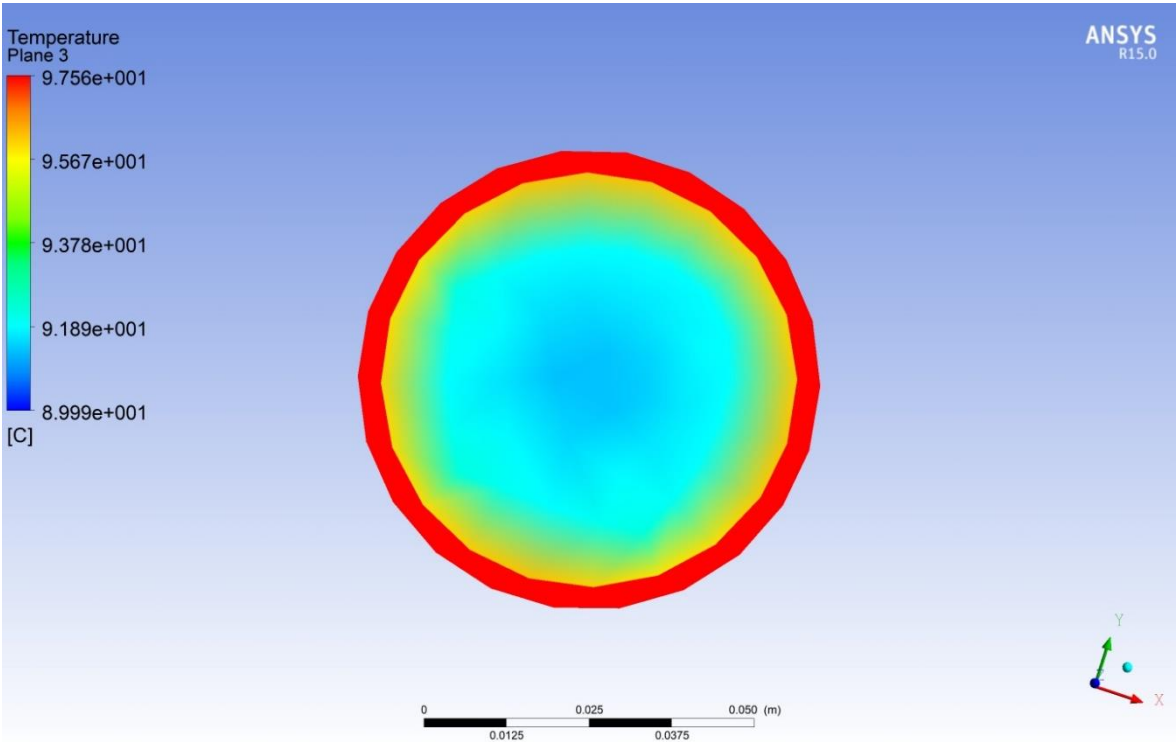
Temperature at 2 pm in T1



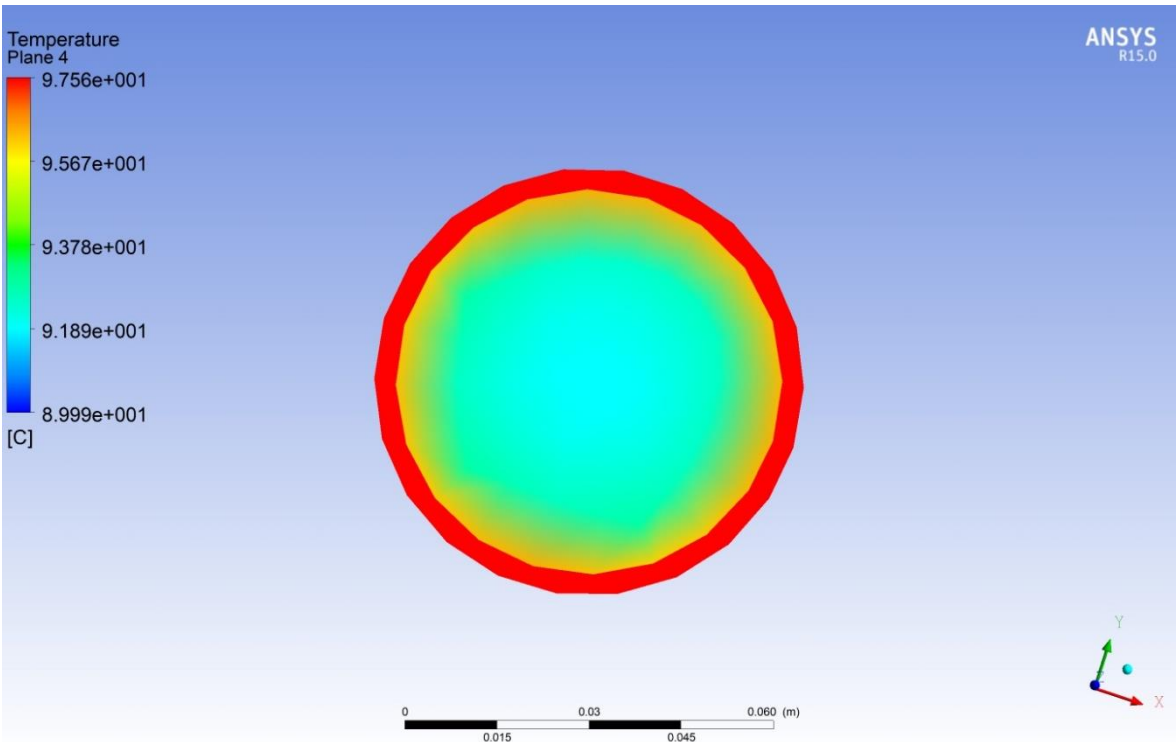
Temperature at 2 pm in T2



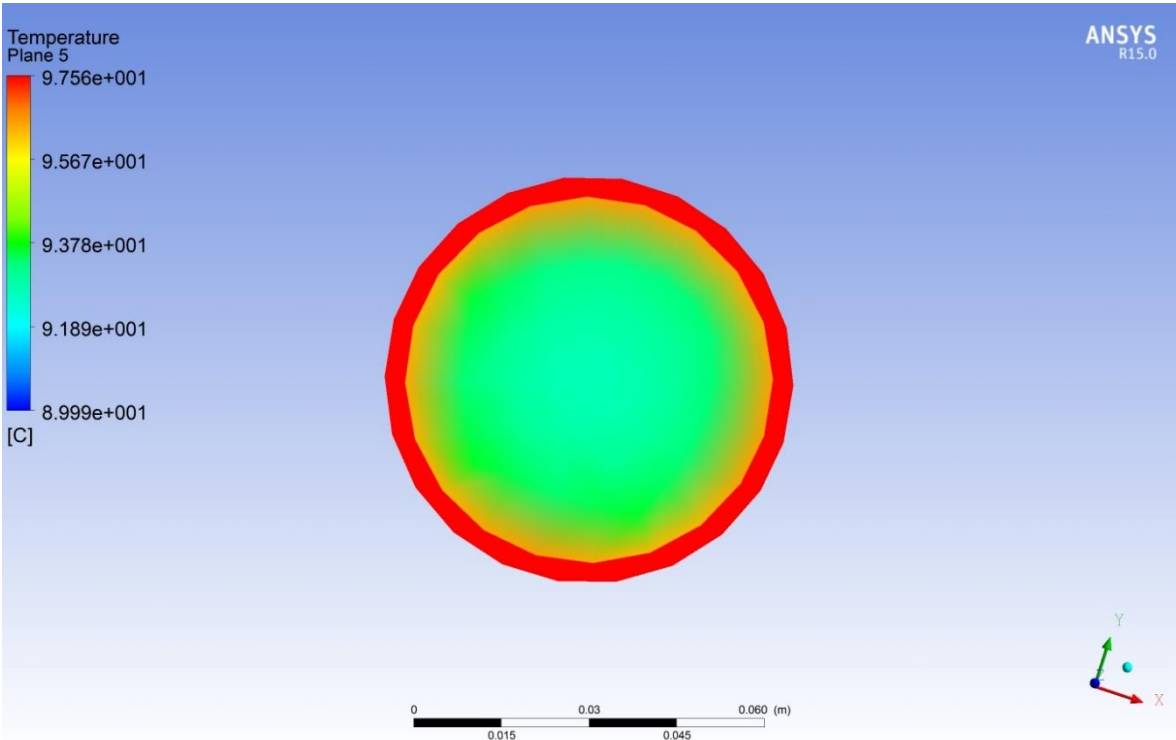
Temperature at 2 pm in T3



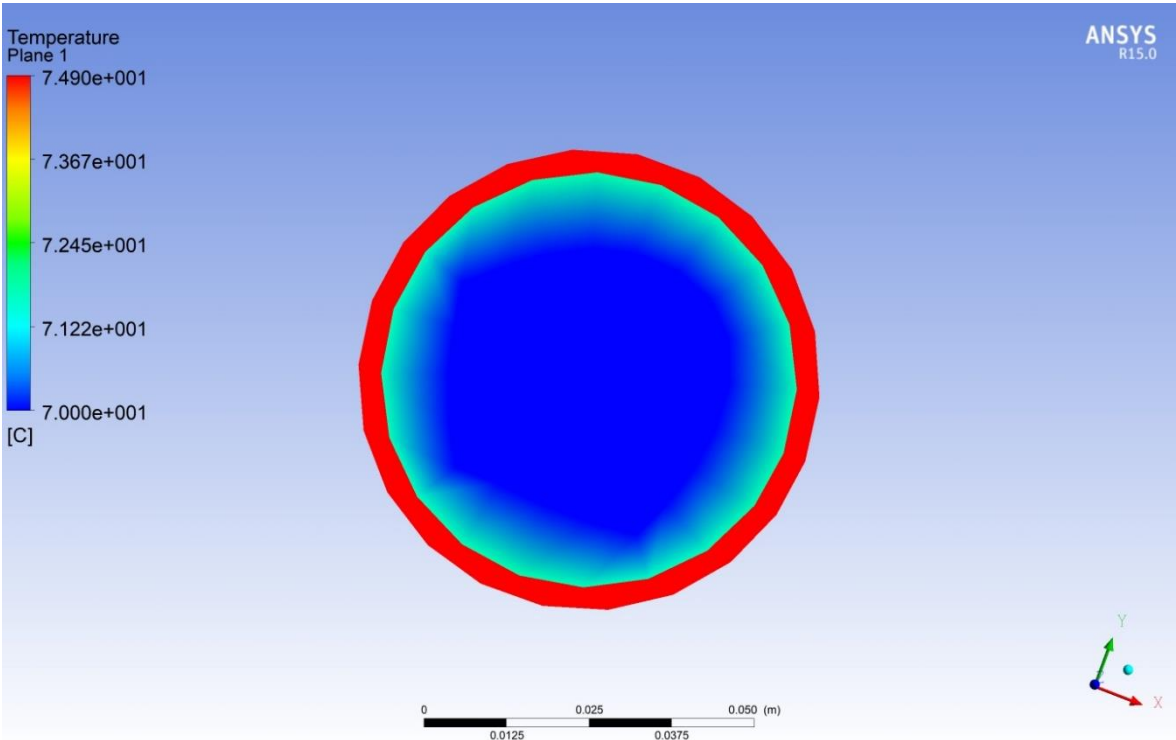
Temperature at 2 pm in T4



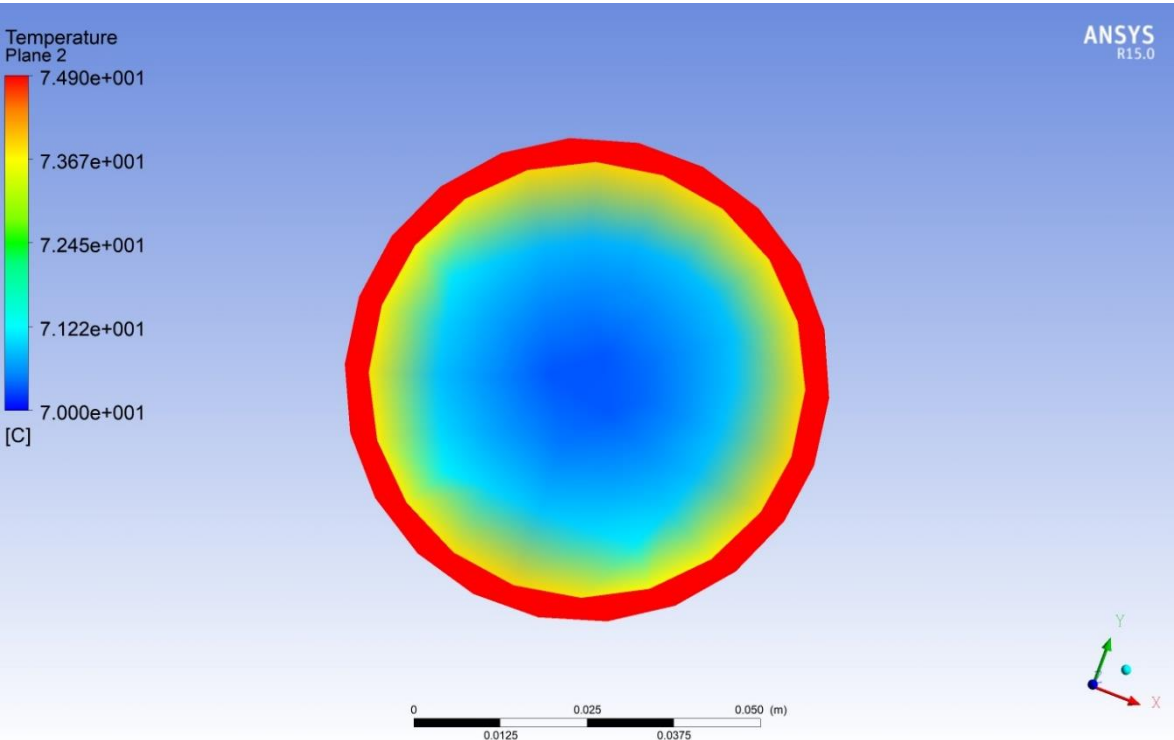
Temperature at 2 pm in T5



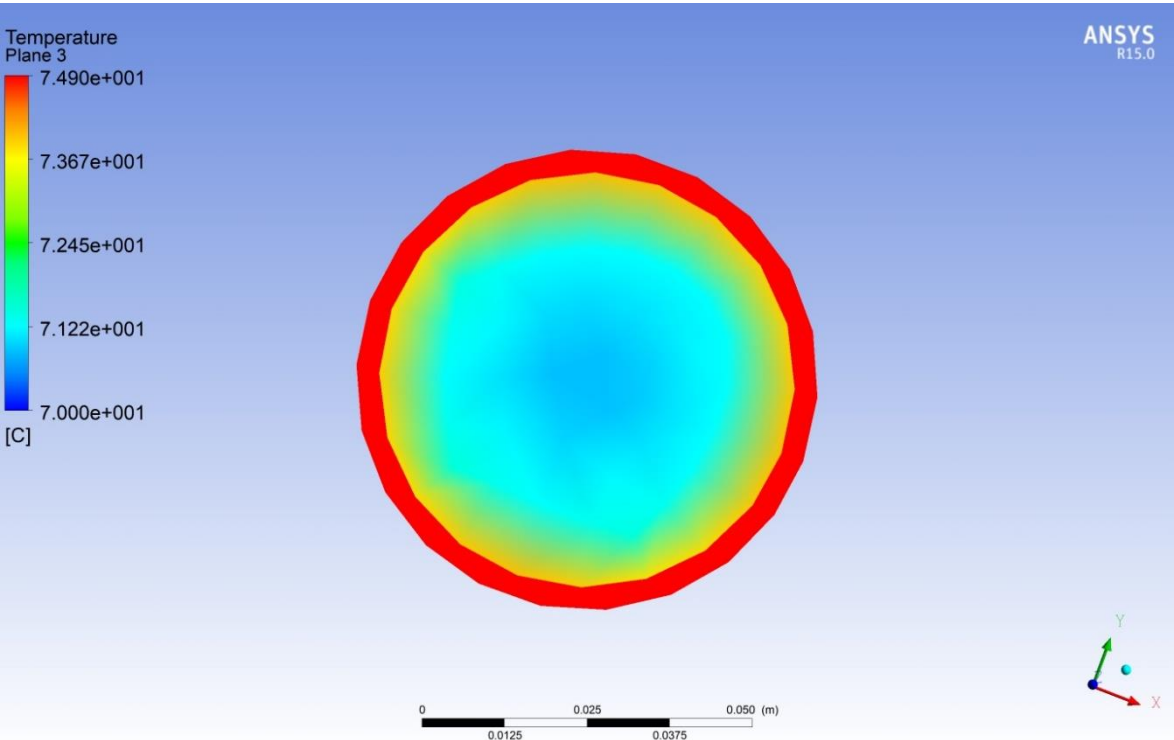
Temperature at 4 pm in T1



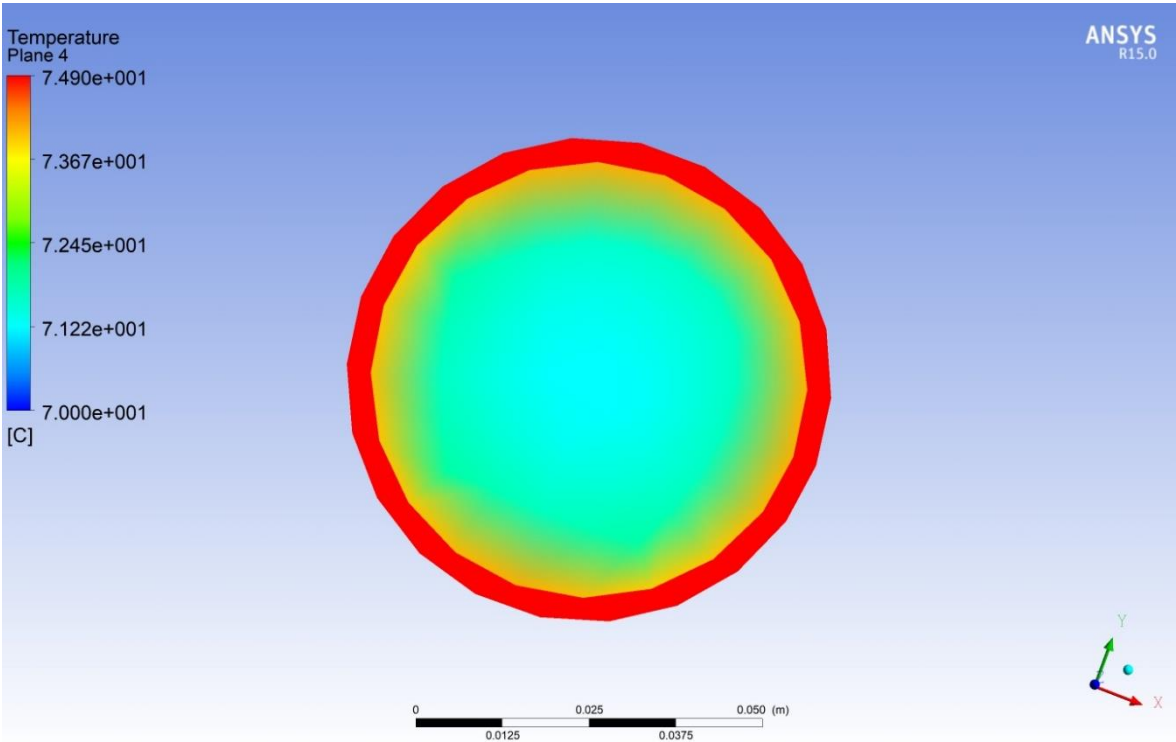
Temperature at 4 pm in T2



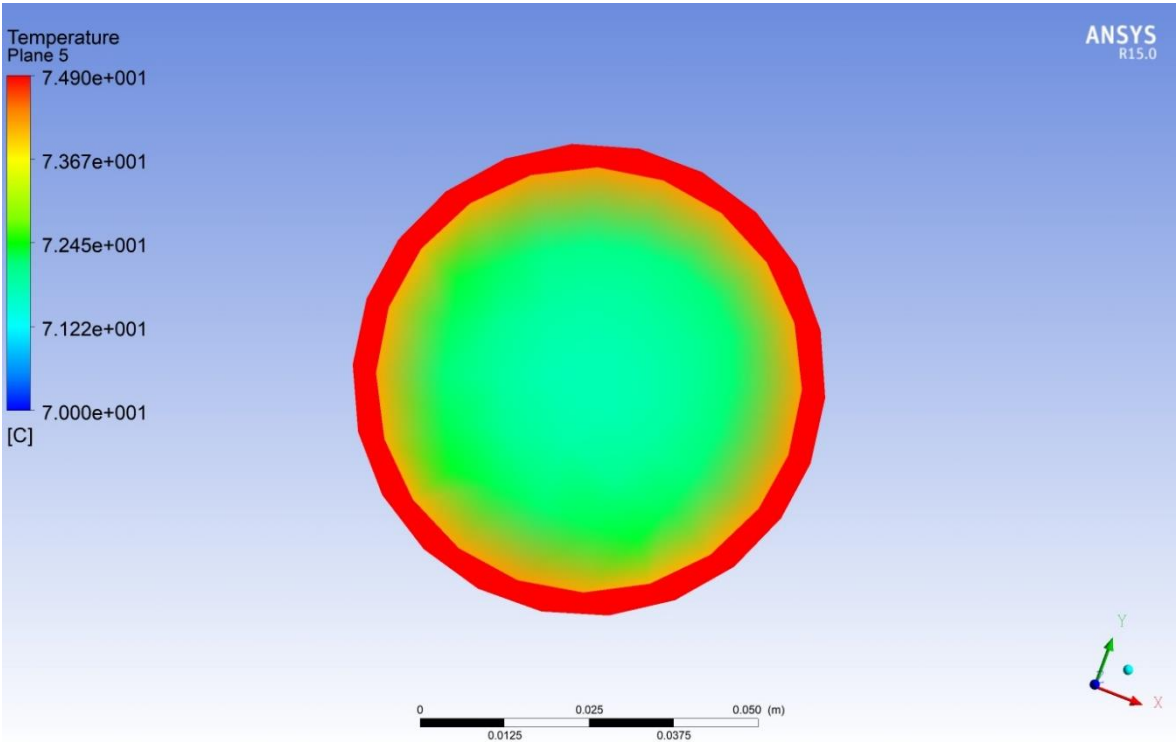
Temperature at 4 pm in T3



Temperature at 4 pm in T4



Temperature at 4 pm in T5

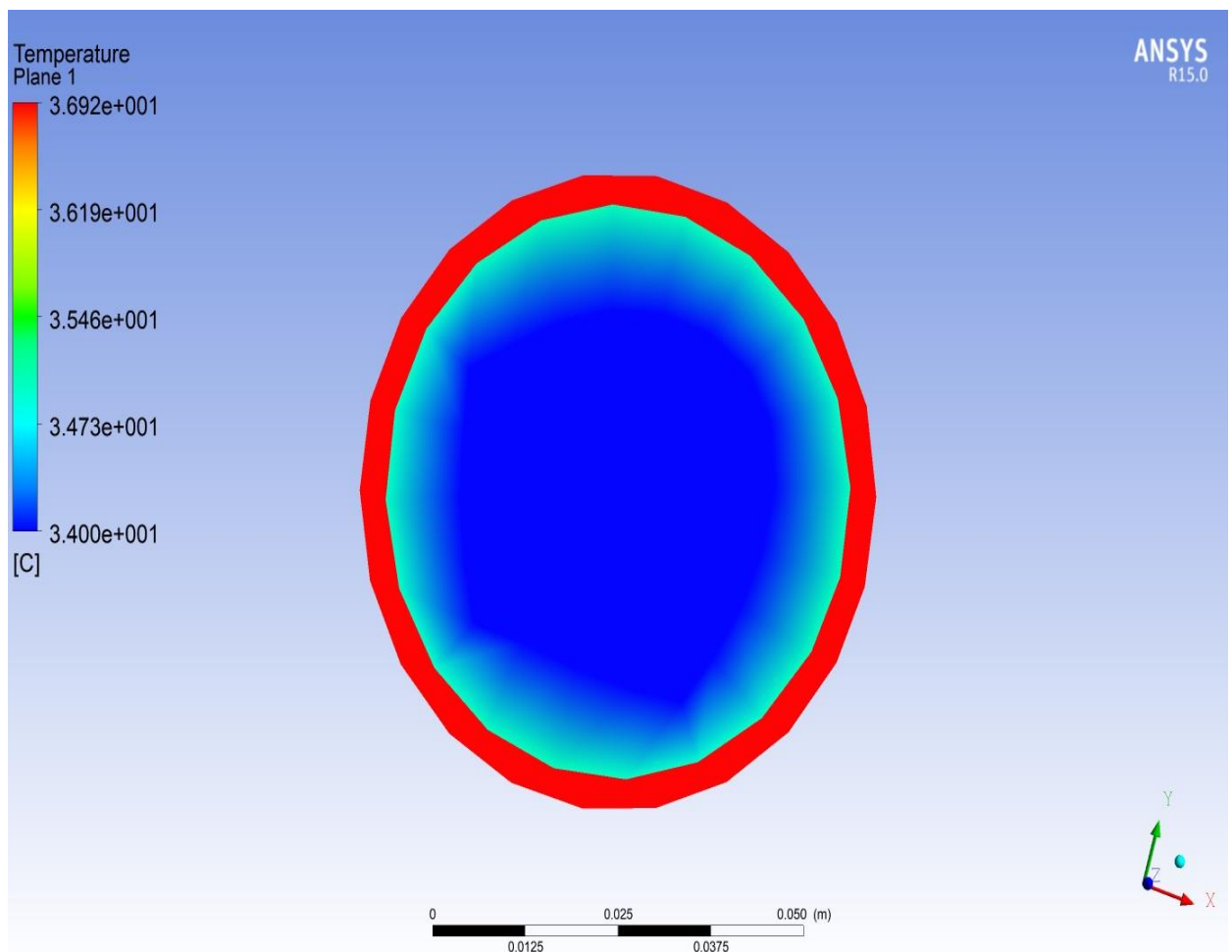


The calculations and readings which are obtained from the heat pipe is later taken for CFD analysis. The figure given below shows the heat distributon in the heat pipe using the CFD analysis.

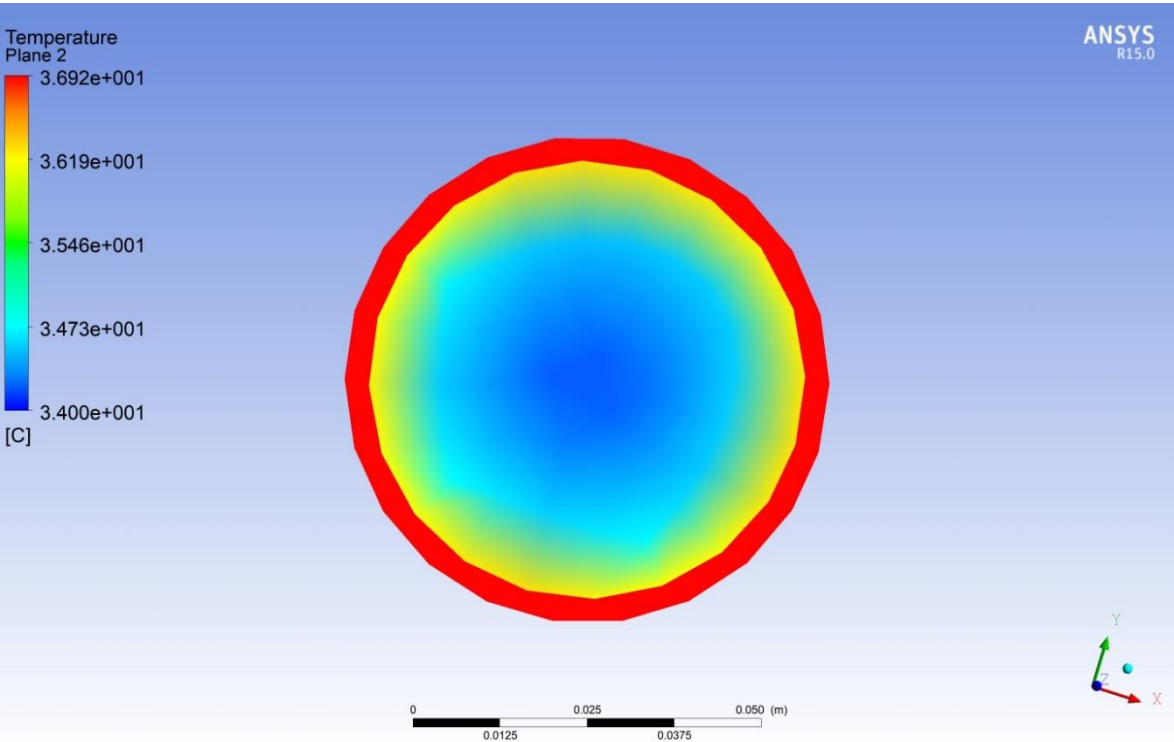
The below CFD analysis represent the Day 15 reading of each points in the pipe at different time

DAY 15

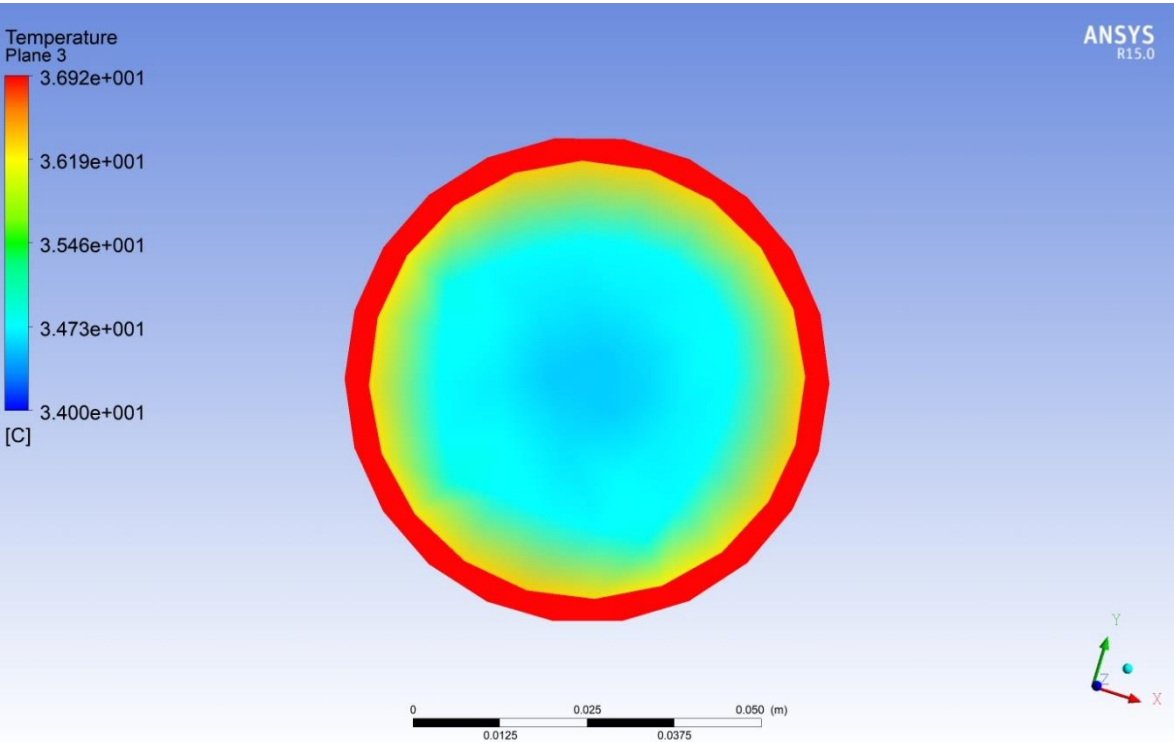
Temperature at 8 am in T1



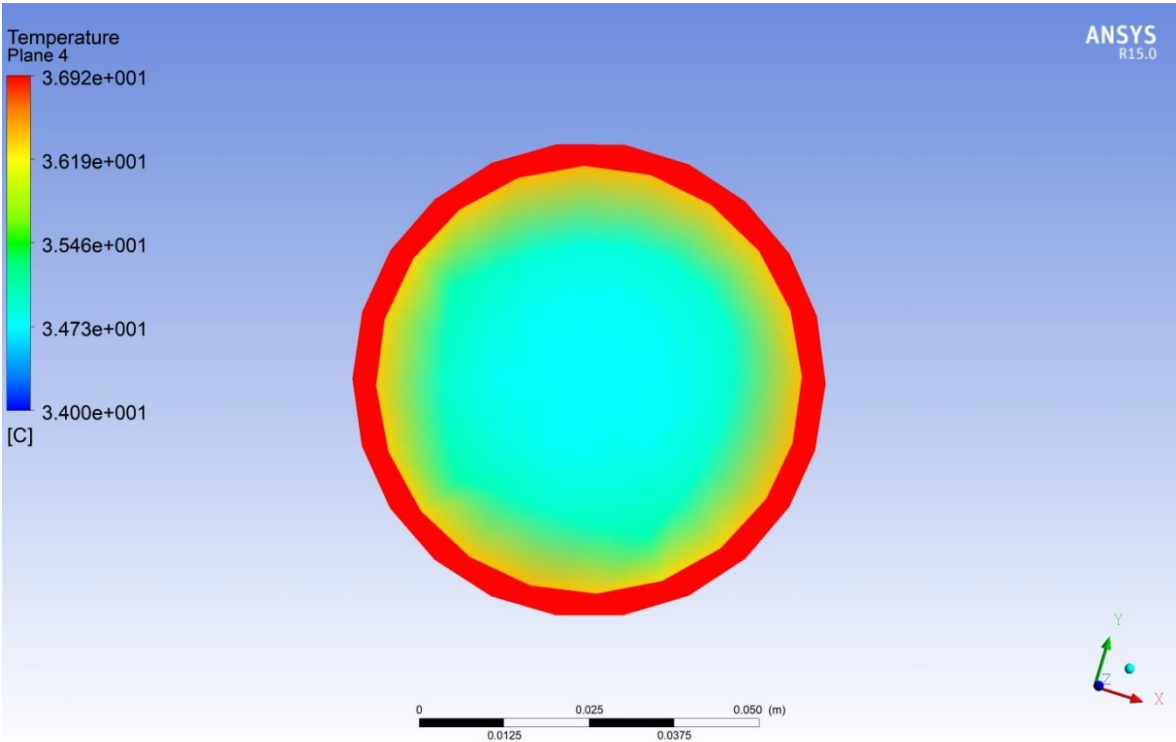
Temperature at 8 am in T2



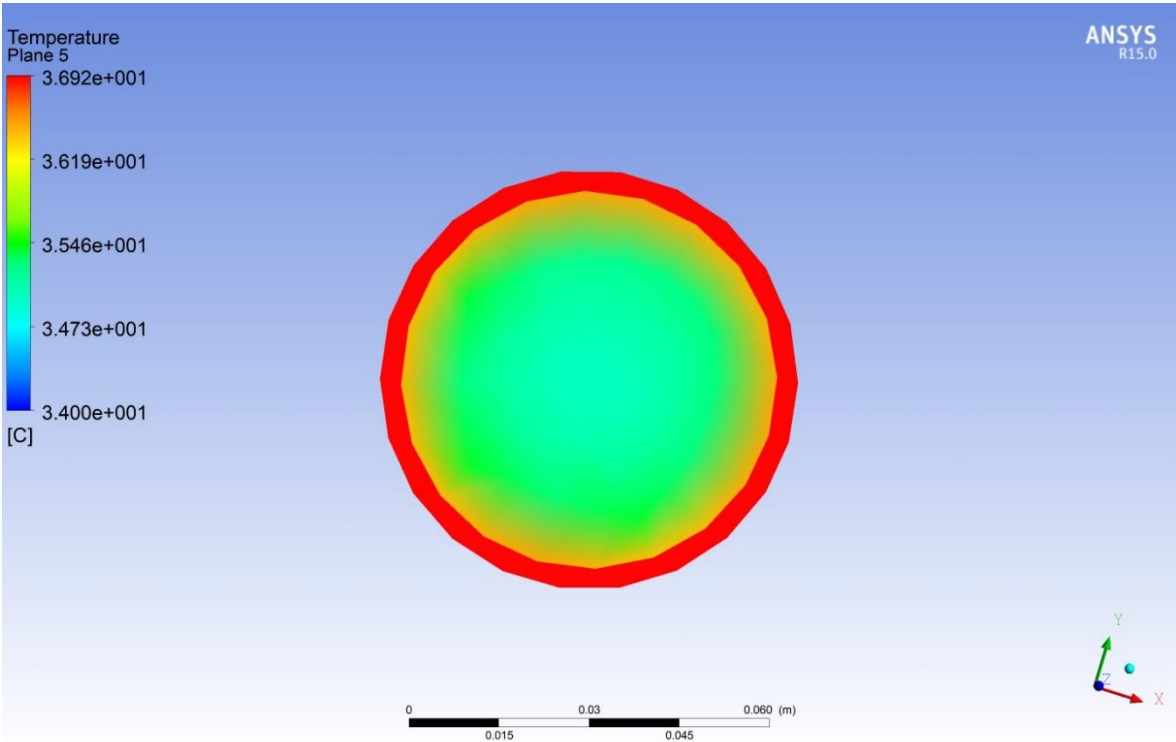
Temperature at 8 am in T3



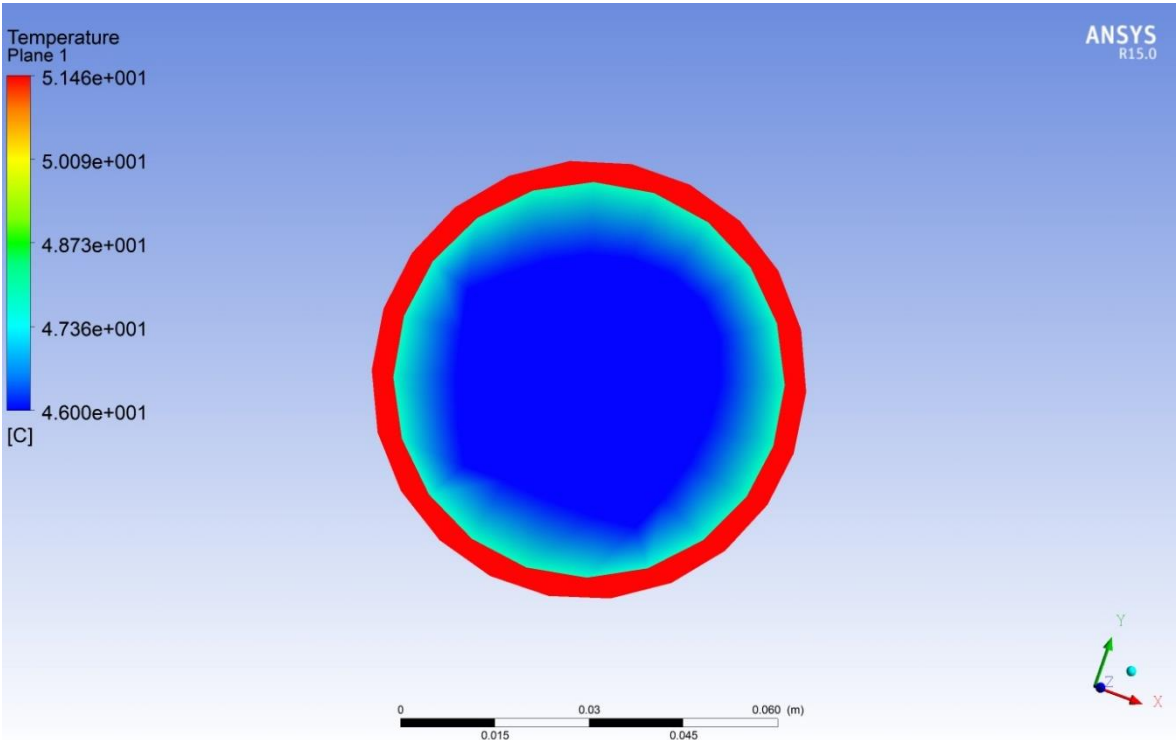
Temperature at 8 am in T4



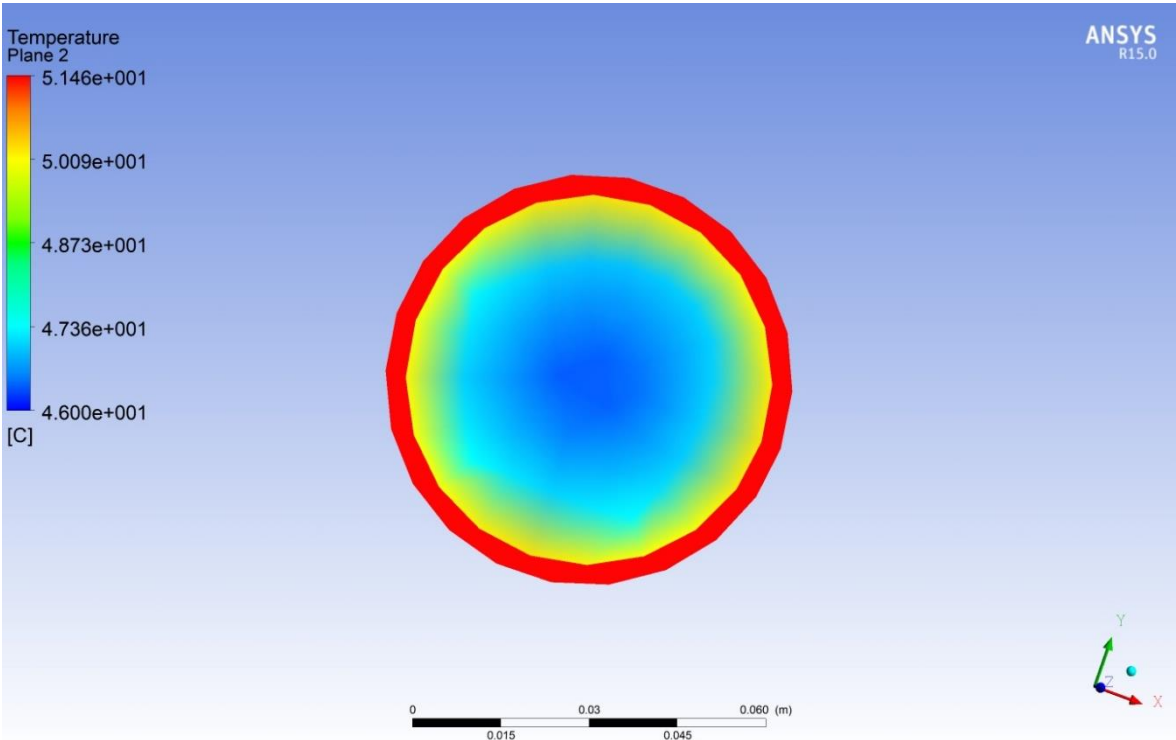
Temperature at 8 am in T5



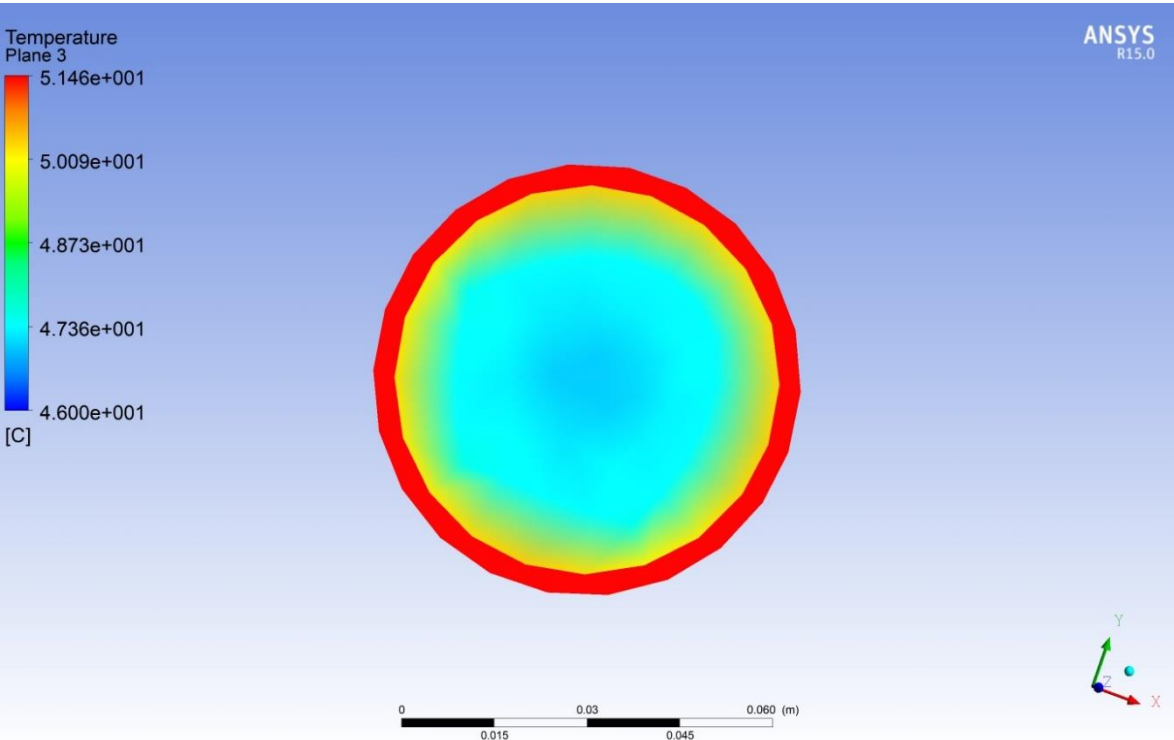
Temperature at 10 am in T1



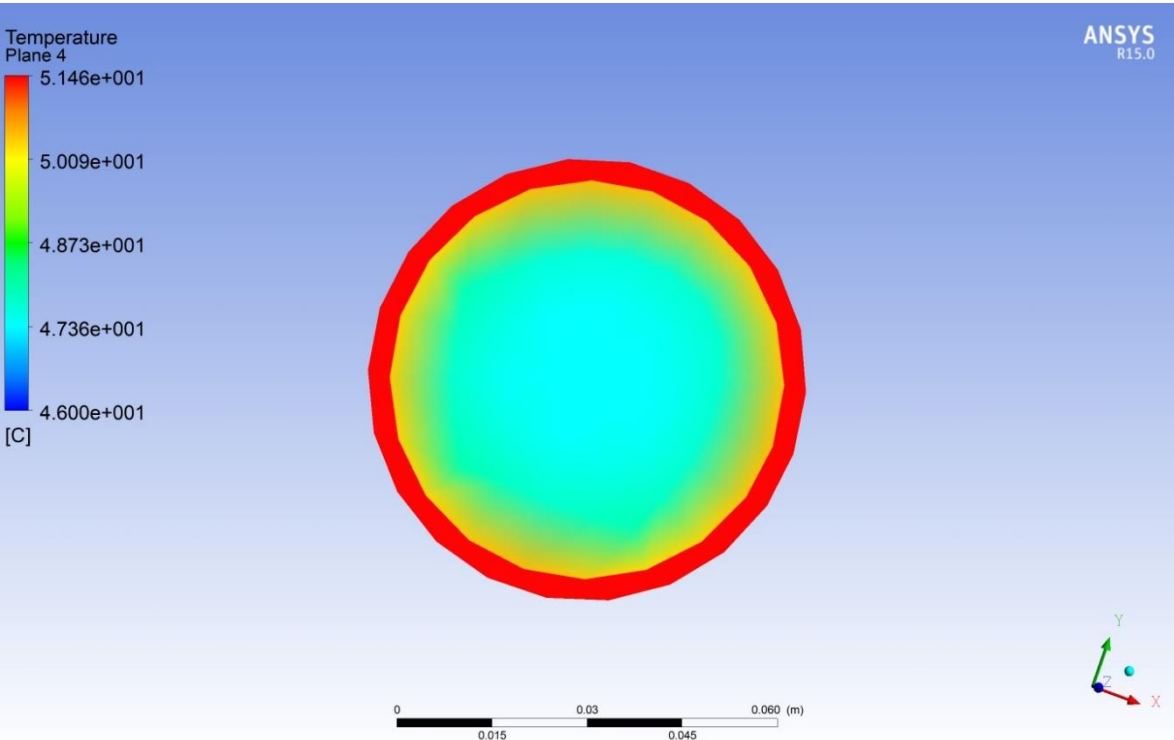
Temperature at 10 am in T2



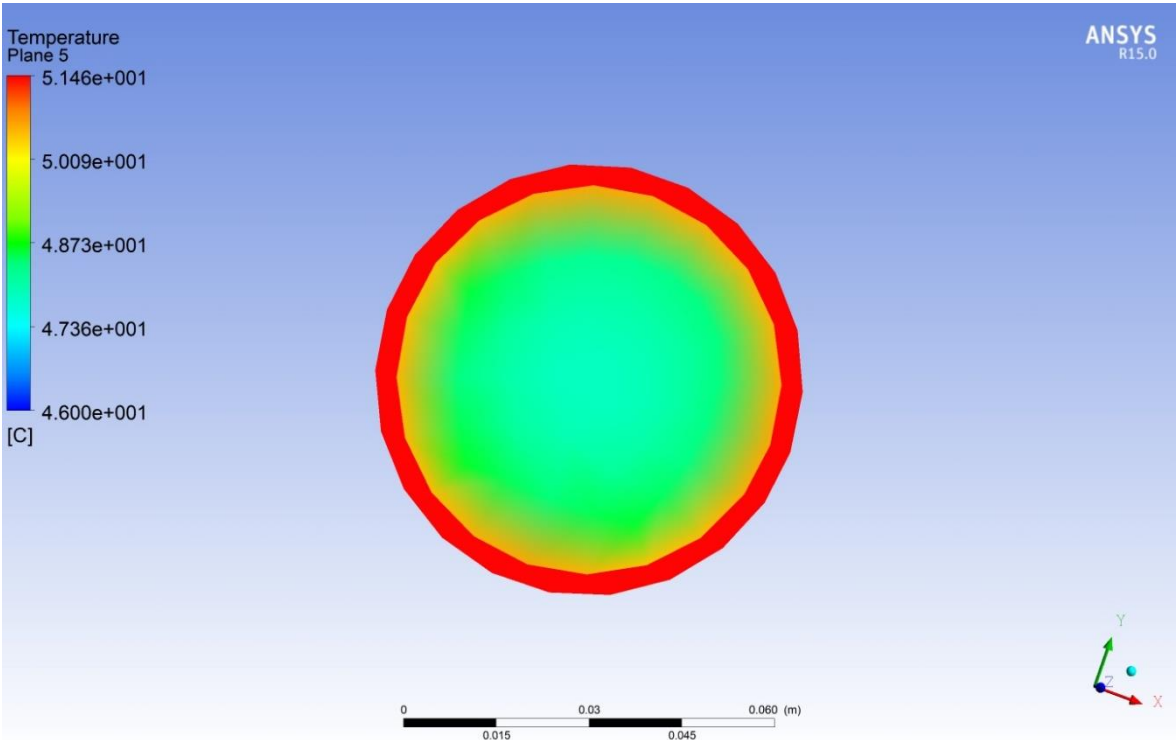
Temperature at 10 am in T3



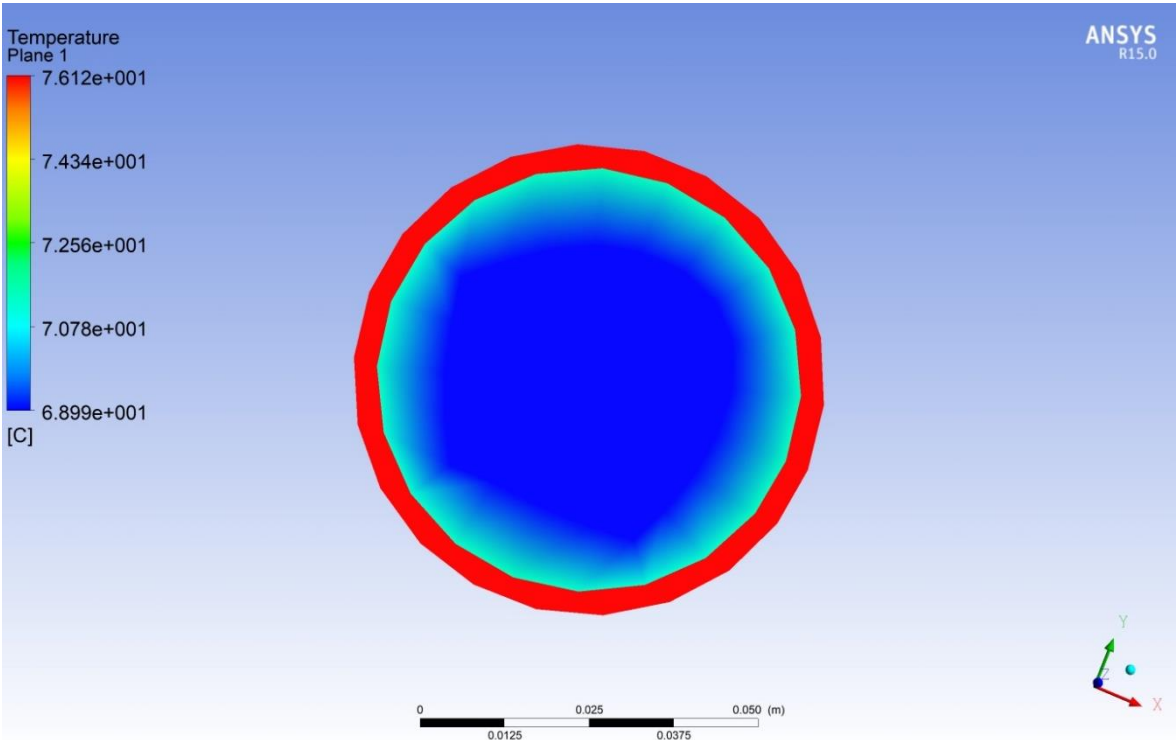
Temperature at 10 am in T4



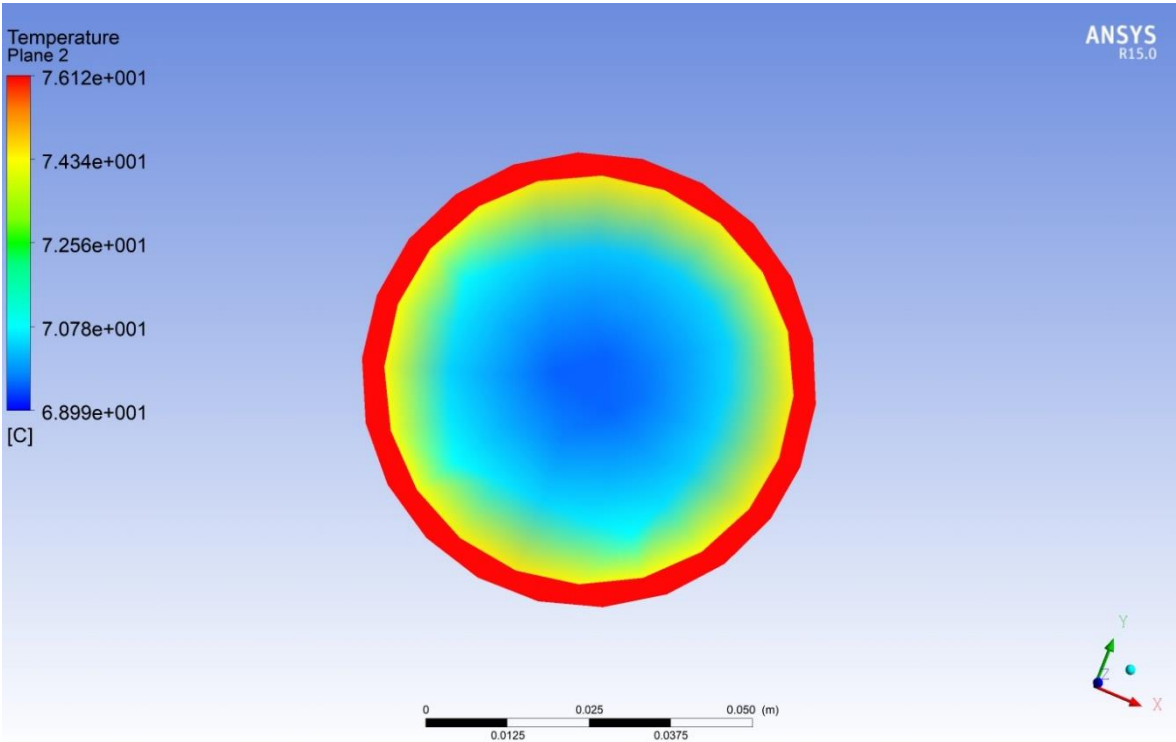
Temperature at 10 am in T5



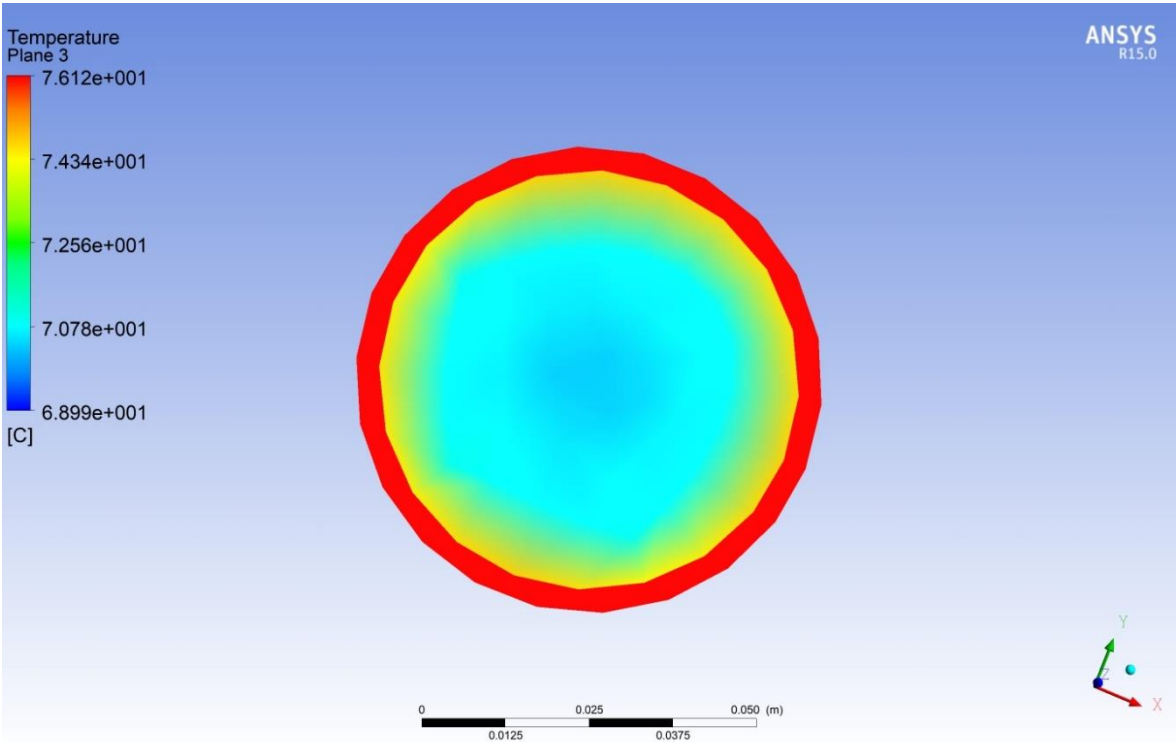
Temperature at 12 pm in T1



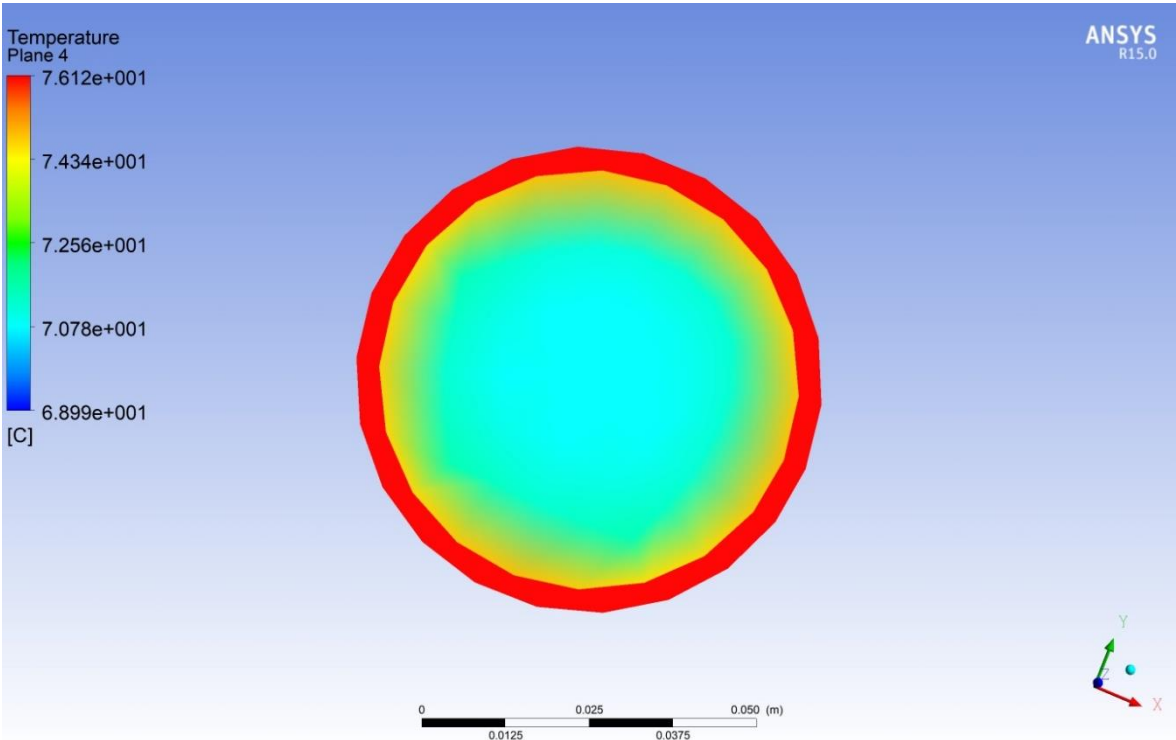
Temperature at 12 pm in T2



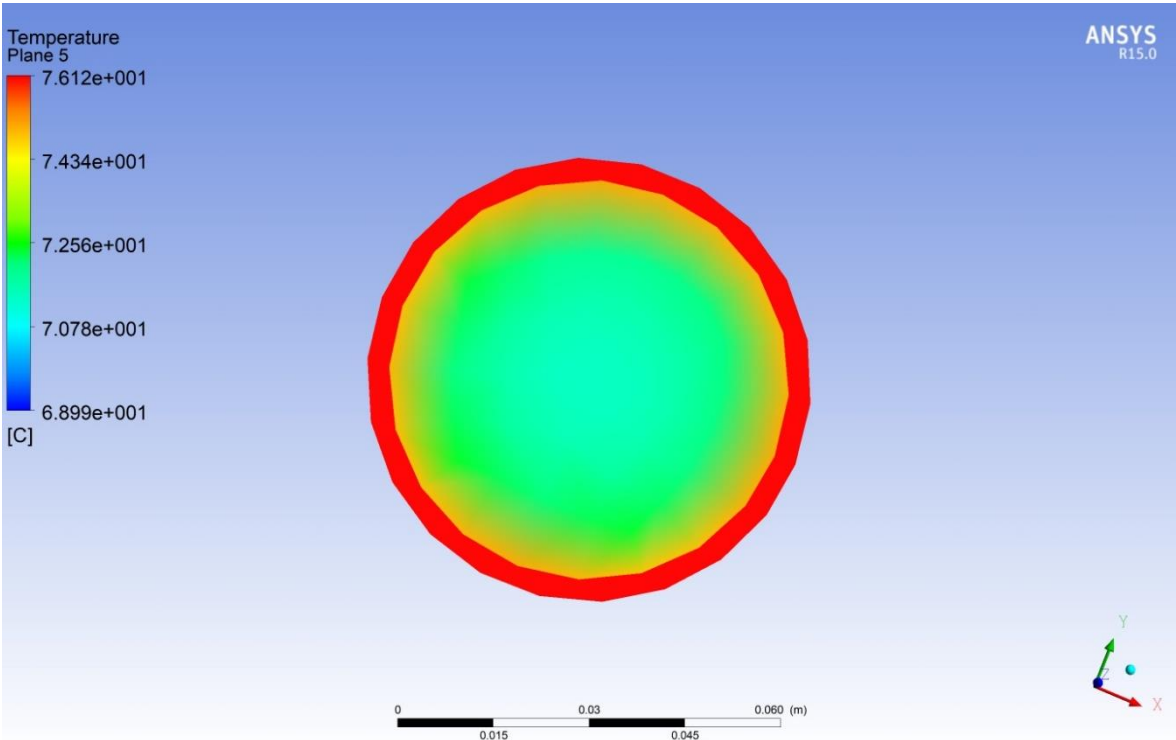
Temperature at 12 pm in T3



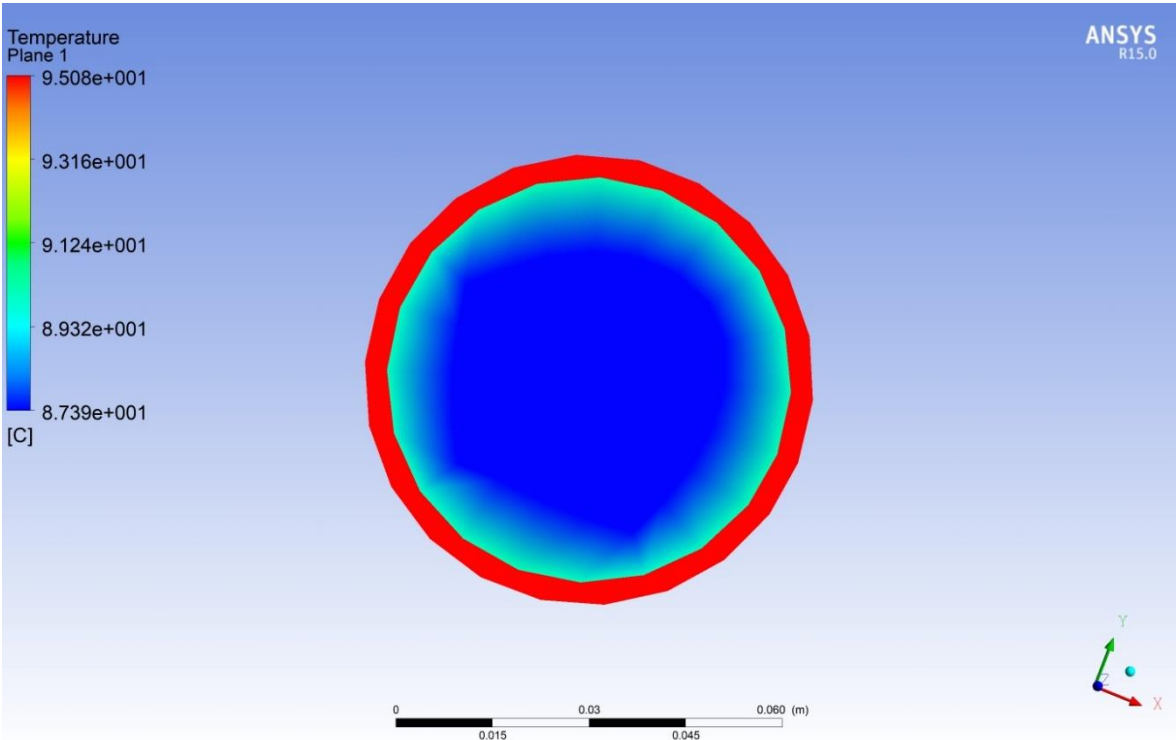
Temperature at 12 pm in T4



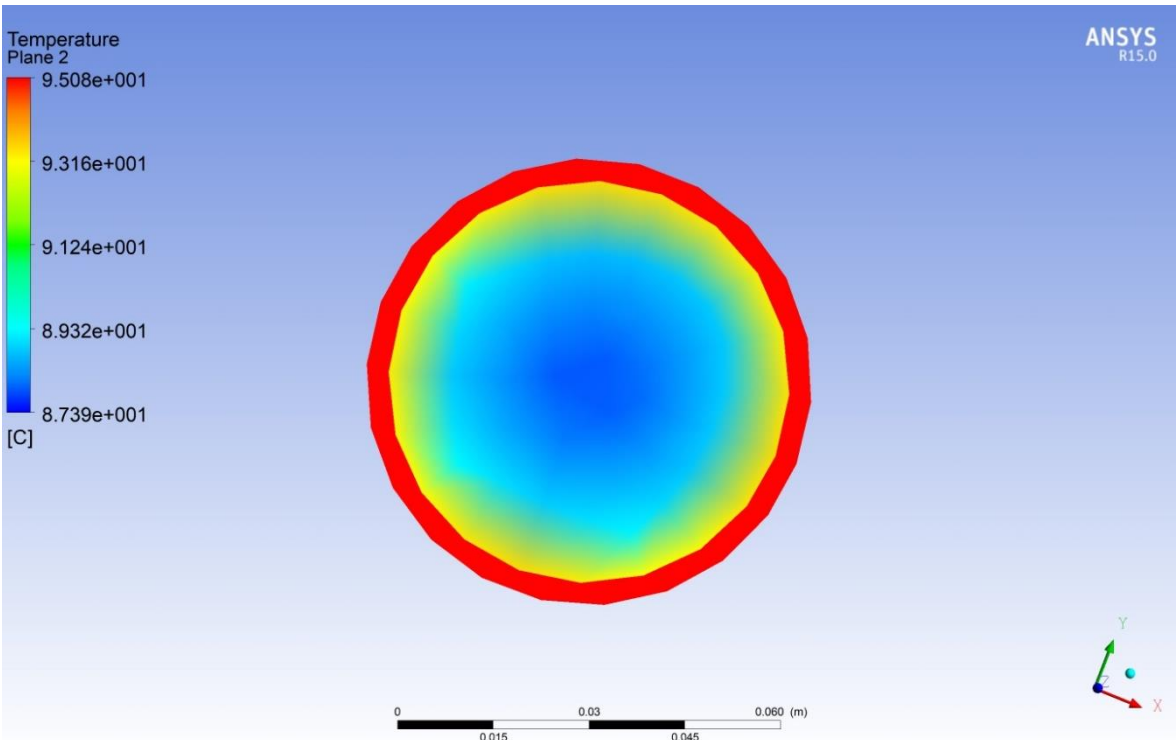
Temperature at 12 pm in T5



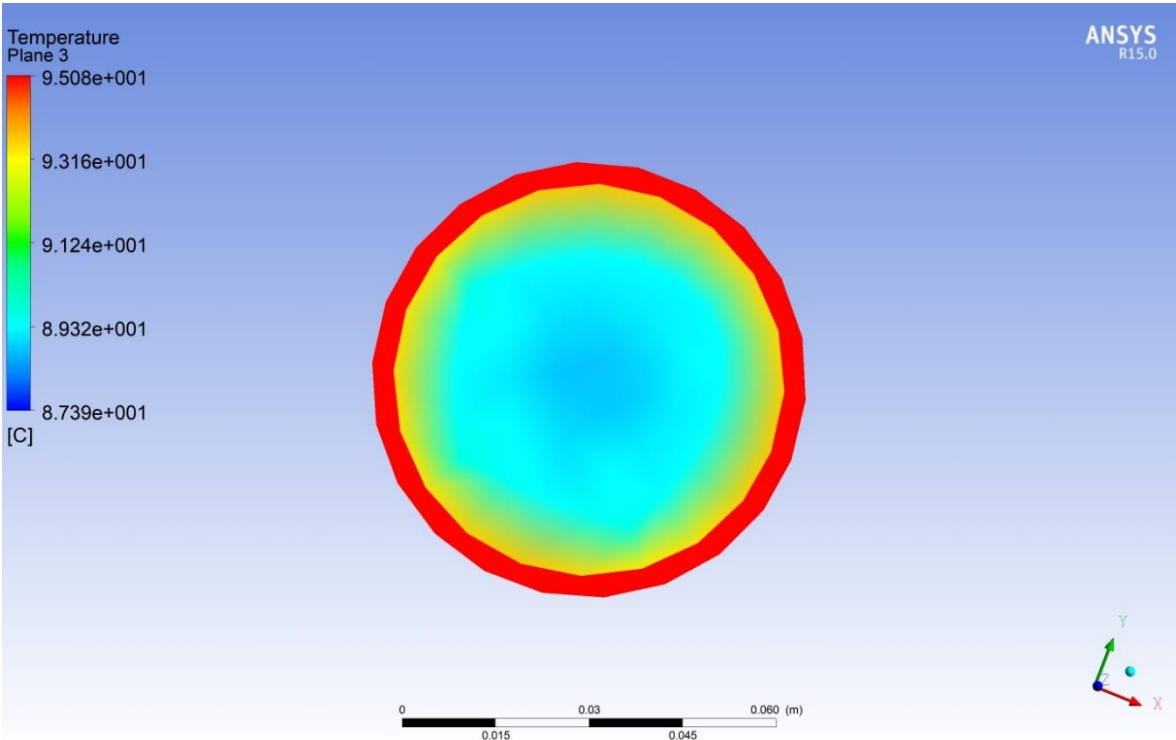
Temperature at 2 pm in T1



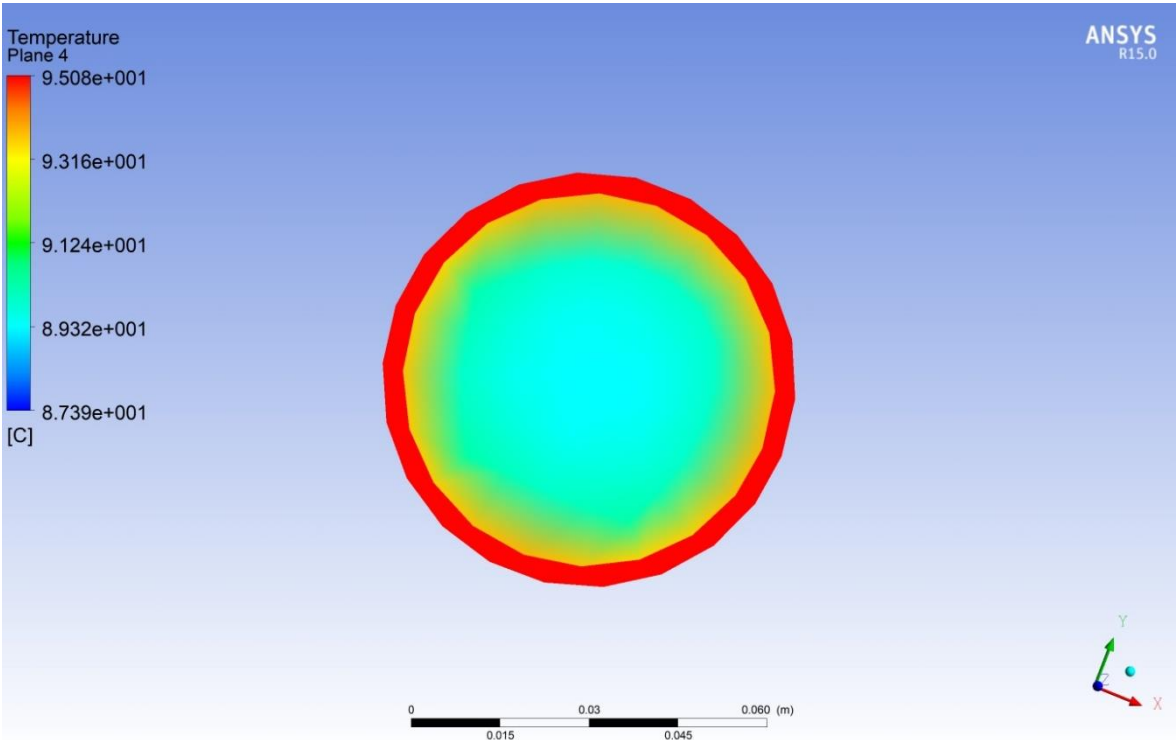
Temperature at 2 pm in T2



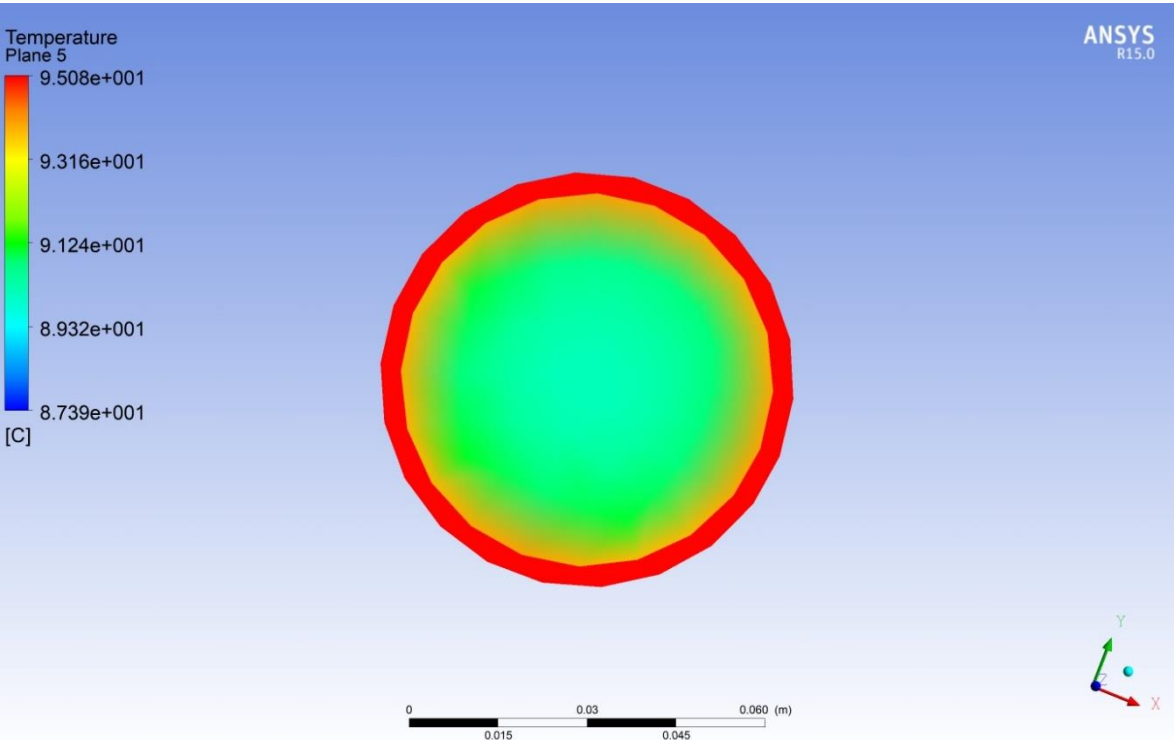
Temperature at 2 pm in T3



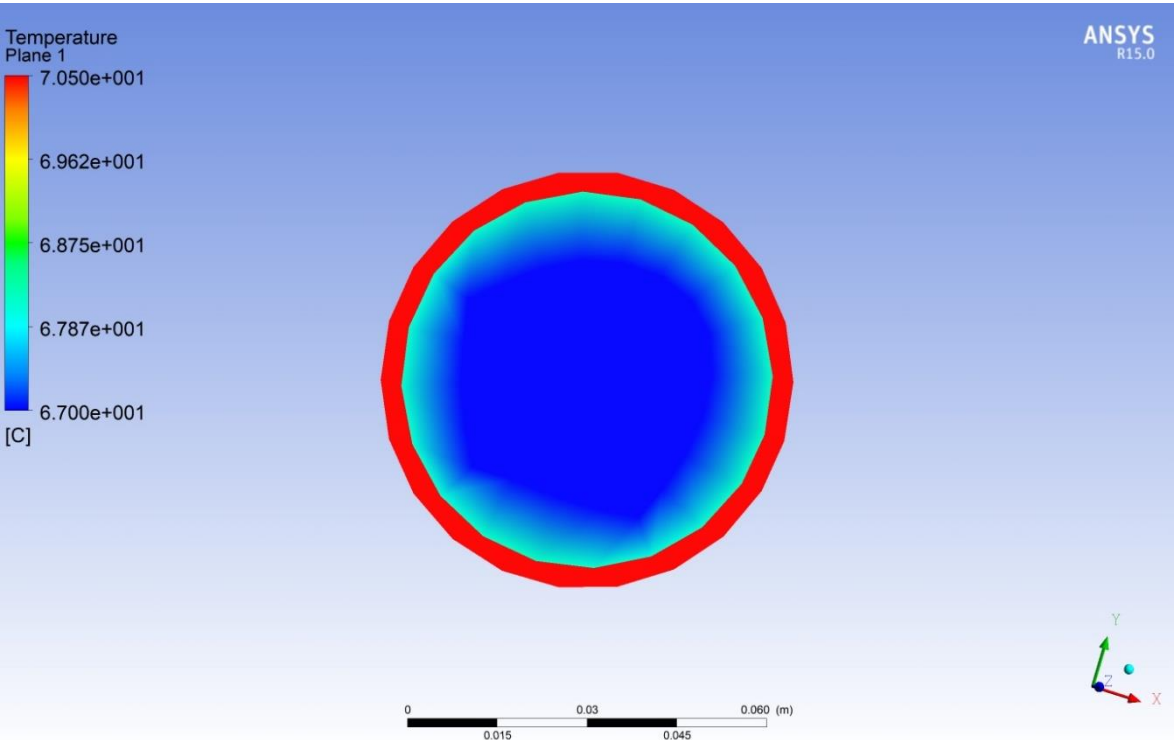
Temperature at 2 pm in T4



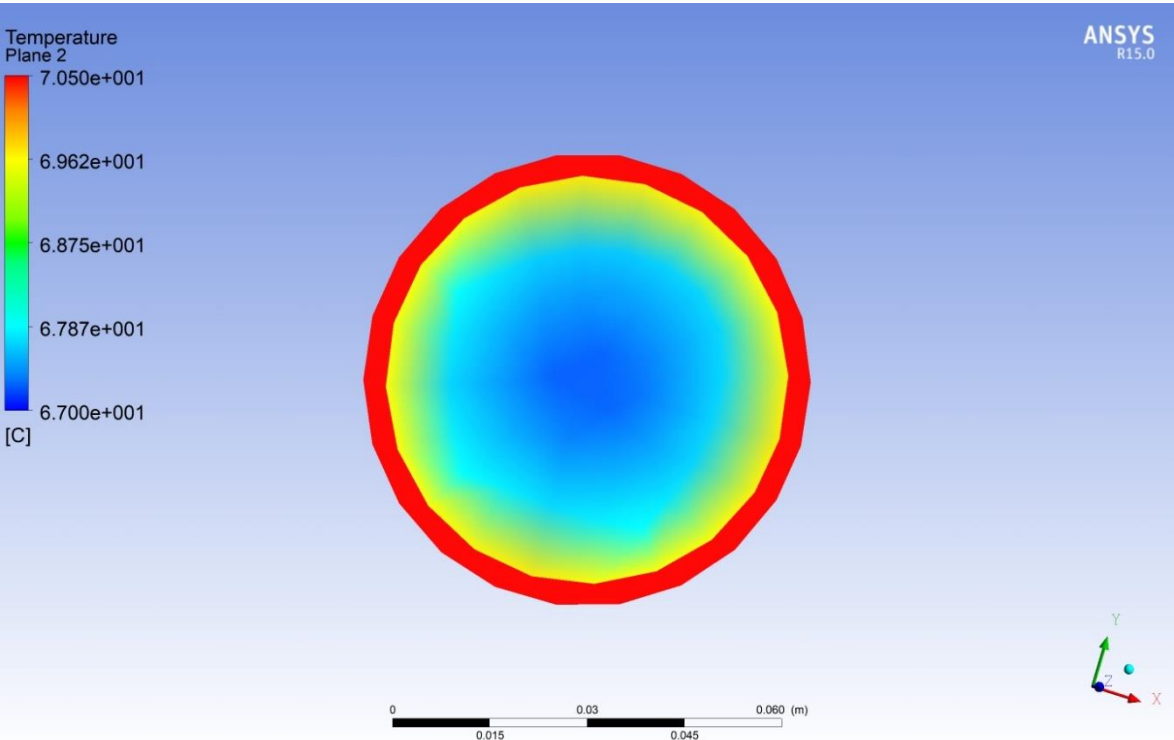
Temperature at 2 pm in T5



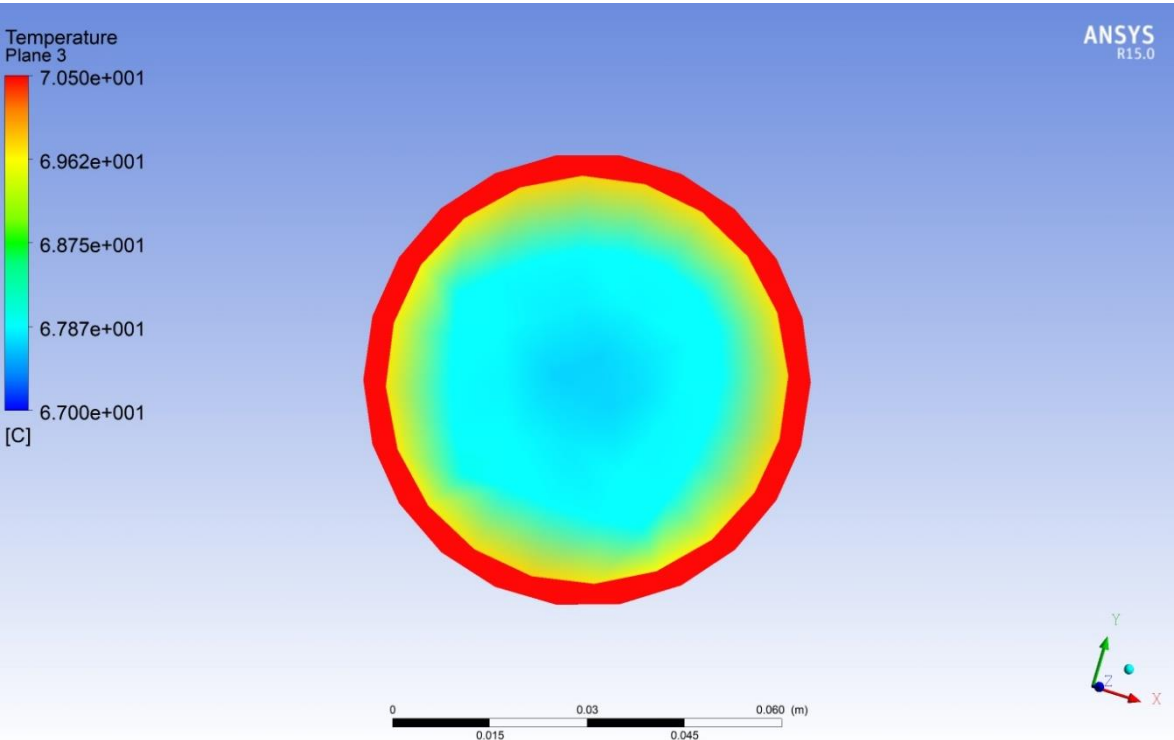
Temperature at 4 pm in T1



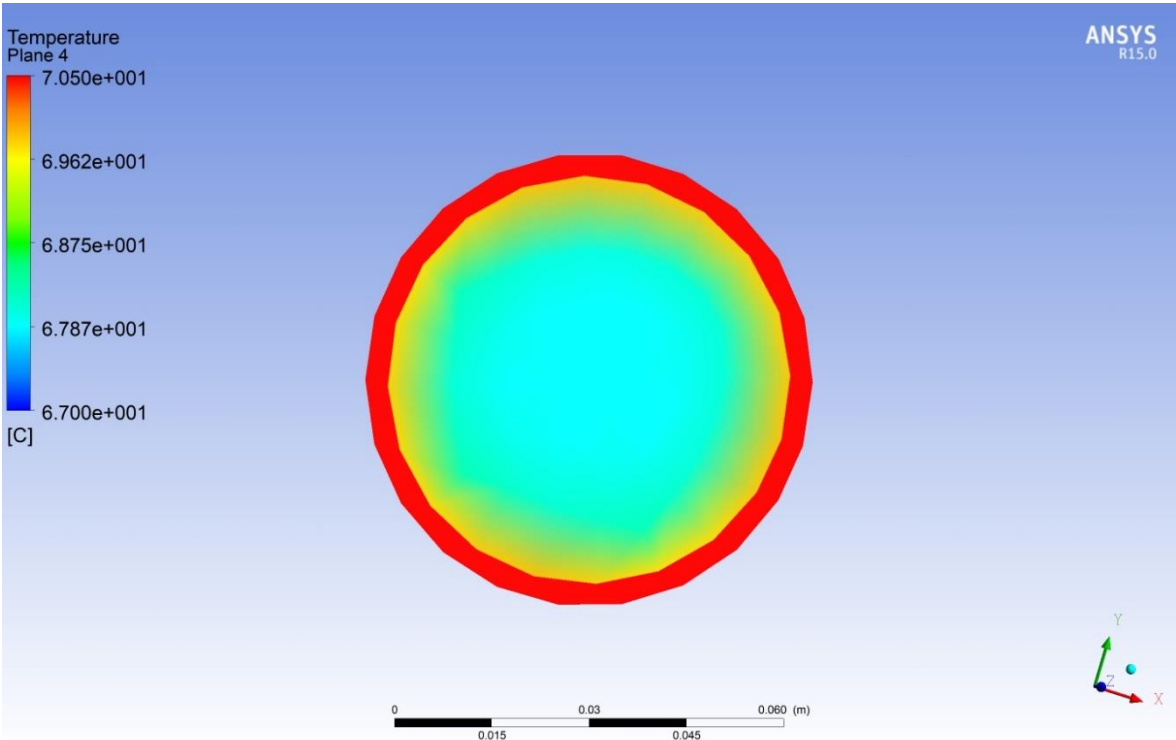
Temperature at 4 pm in T2



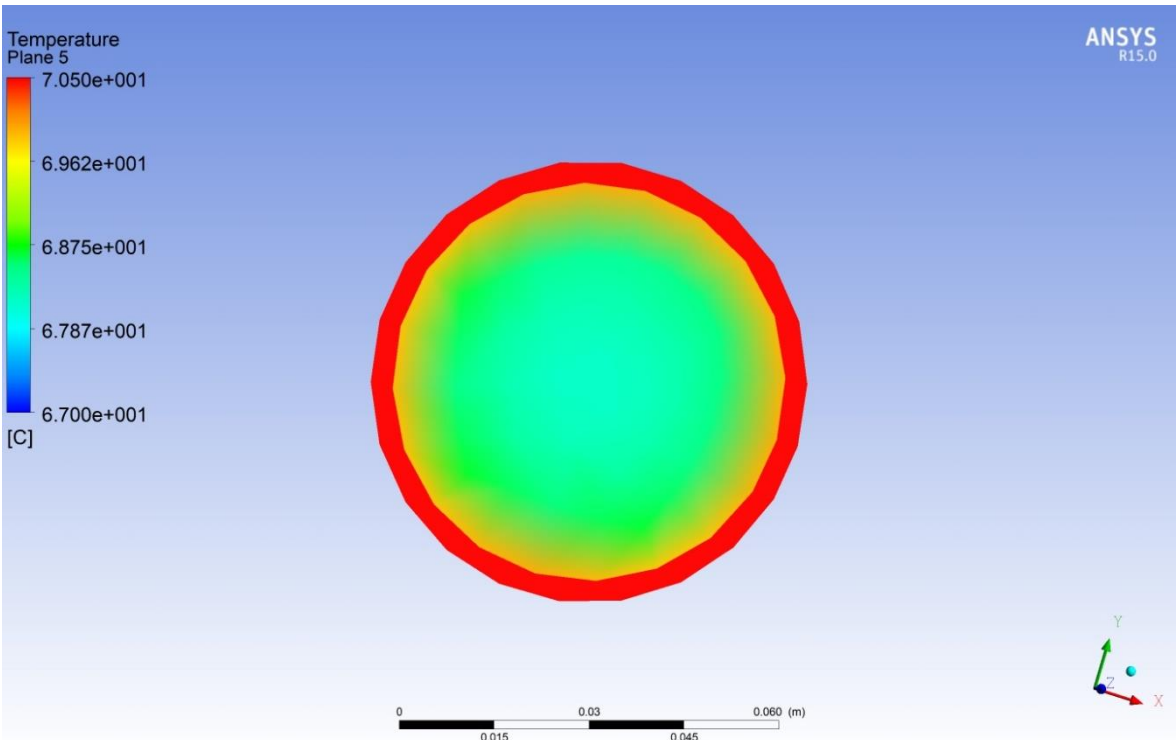
Temperature at 4 pm in T3



Temperature at 4 pm in T4



Temperature at 4 pm in T5

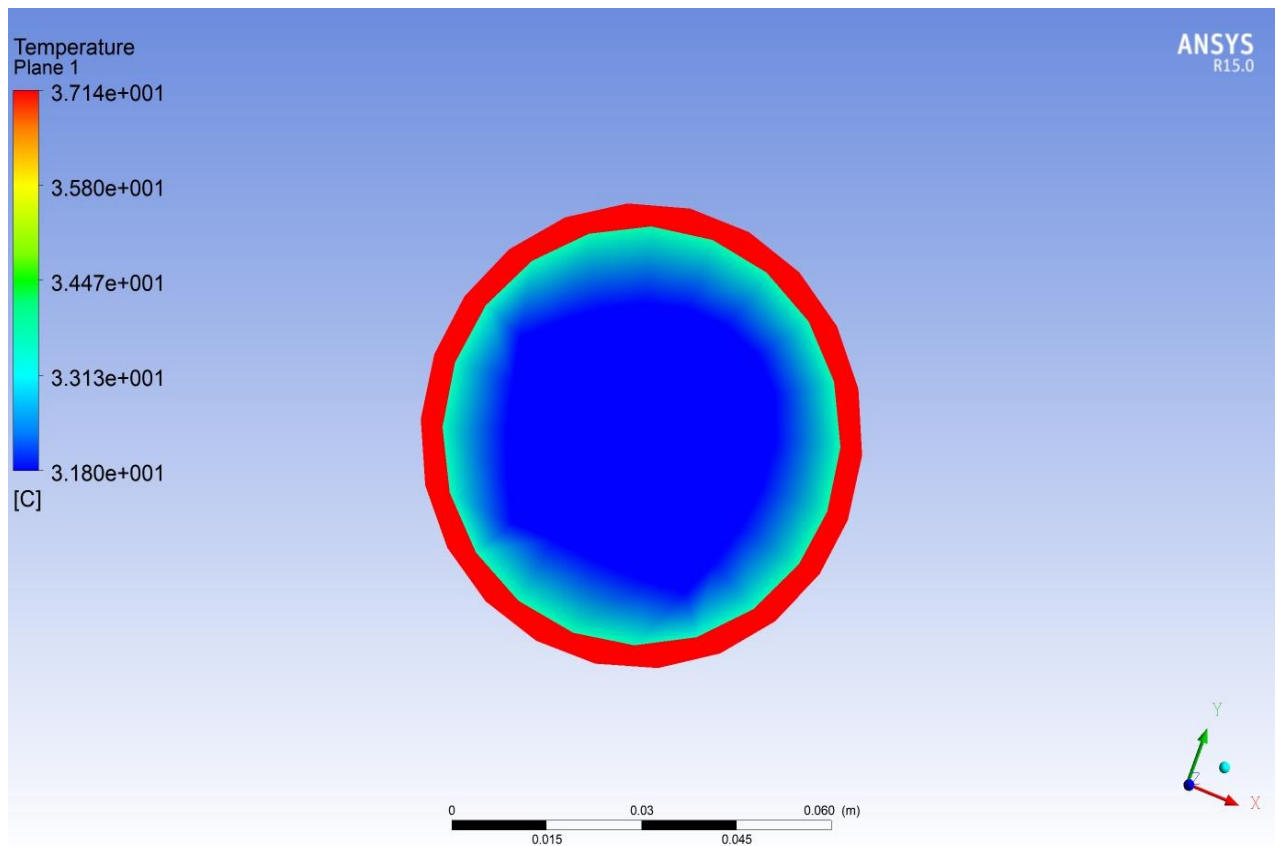


The calculations and readings which are obtained from the heat pipe is later taken for CFD analysis. The figure given below shows the heat distributon in the heat pipe using the CFD analysis.

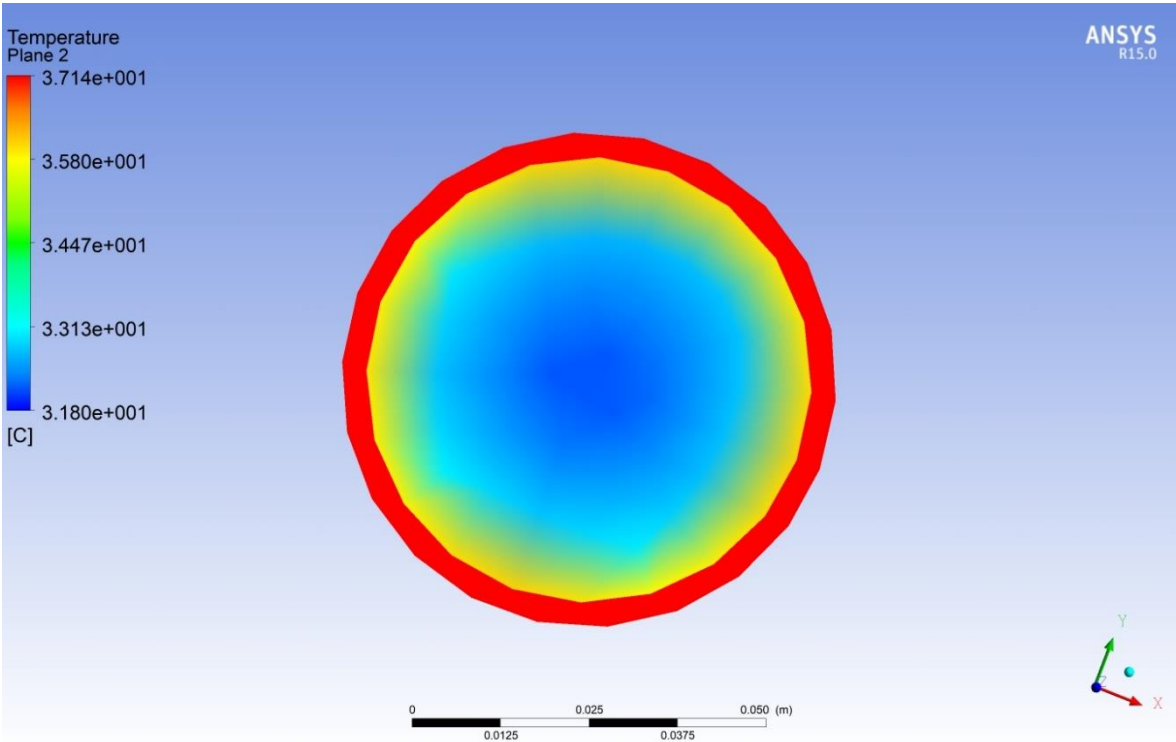
The below CFD analysis represent the Day 20 reading of each points in the pipe at different time

DAY 20

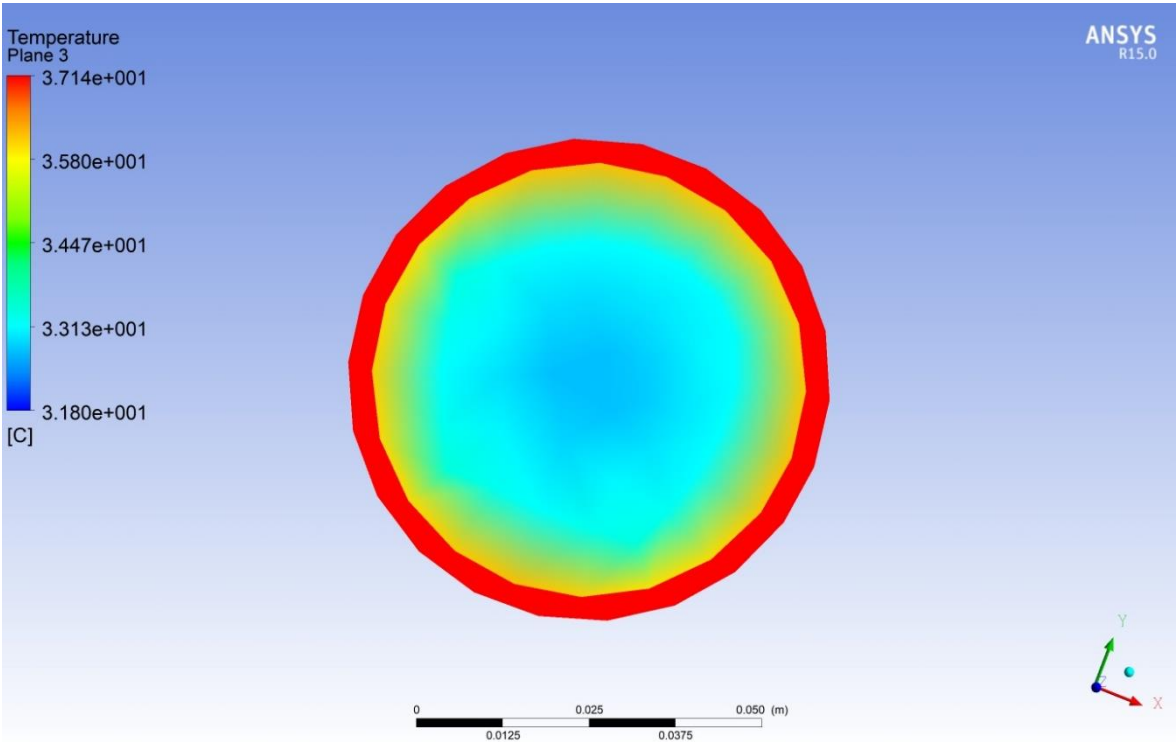
Temperature at 8 am in T1



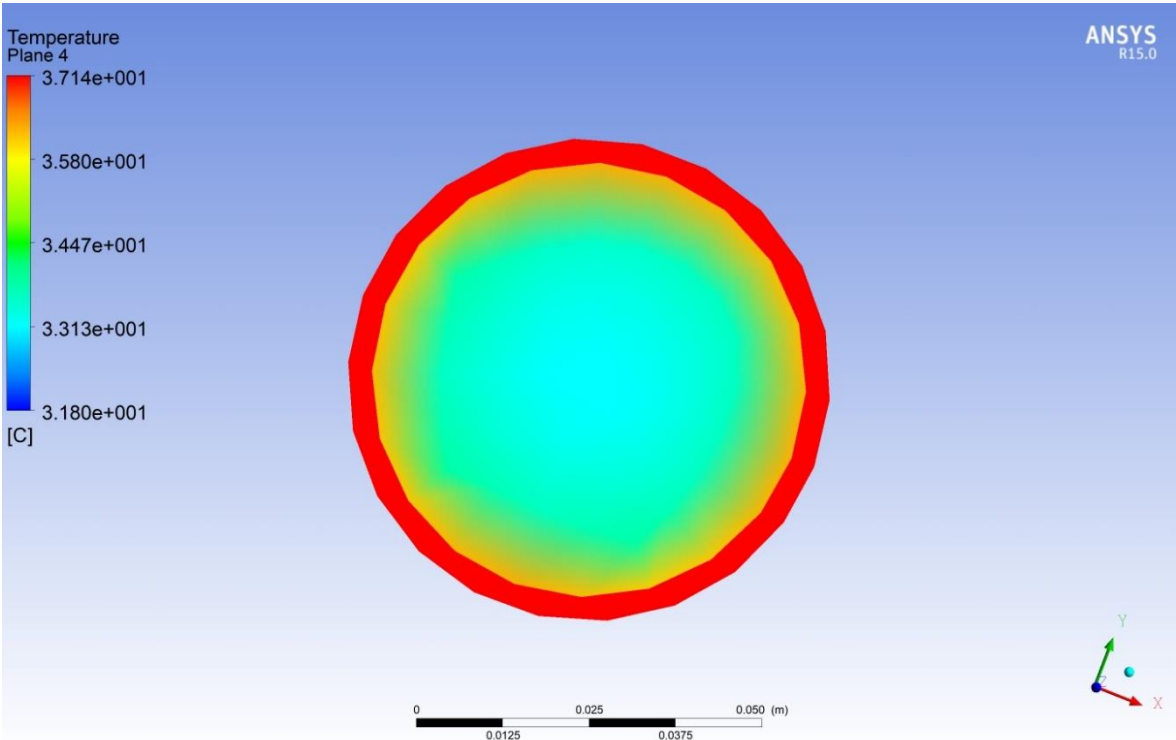
Temperature at 8 am in T2



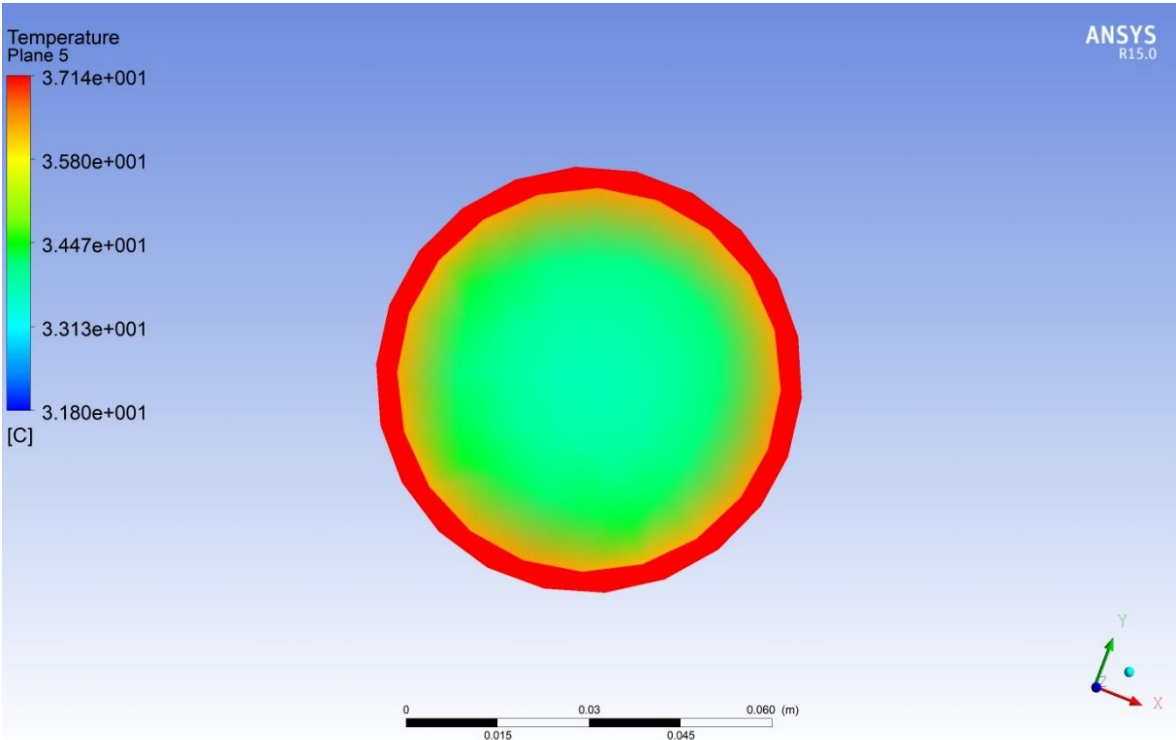
Temperature at 8 am in T3



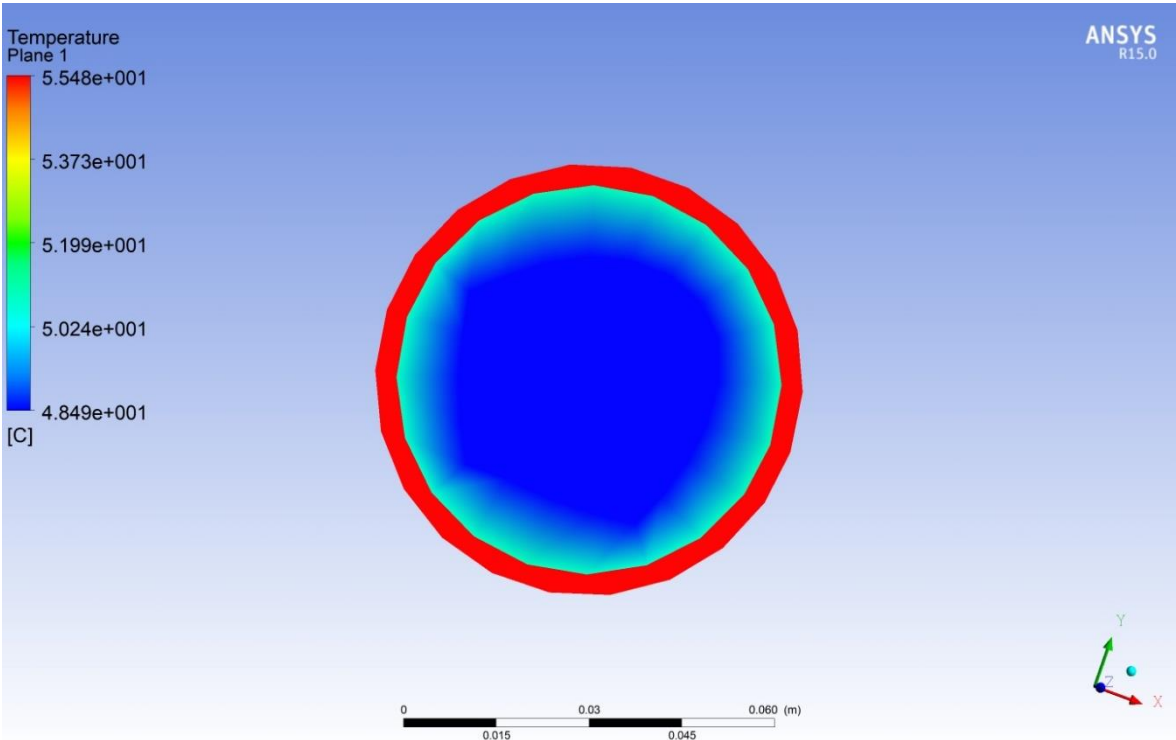
Temperature at 8 am in T4



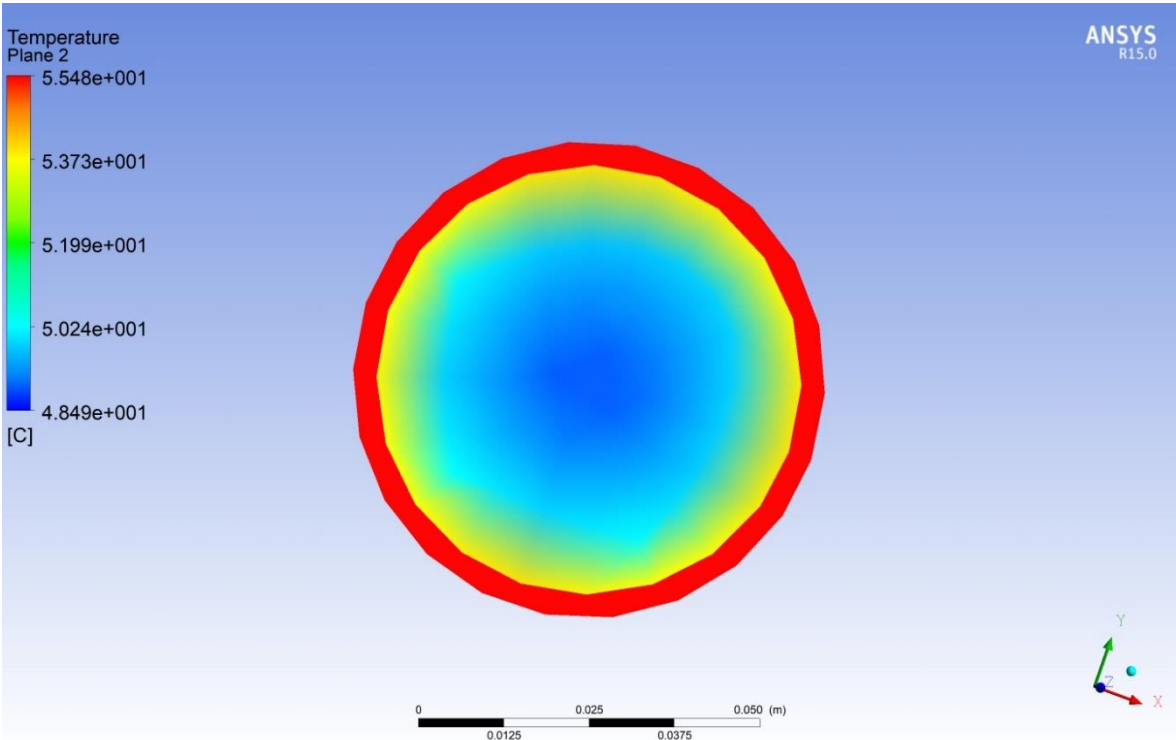
Temperature at 8 am in T5



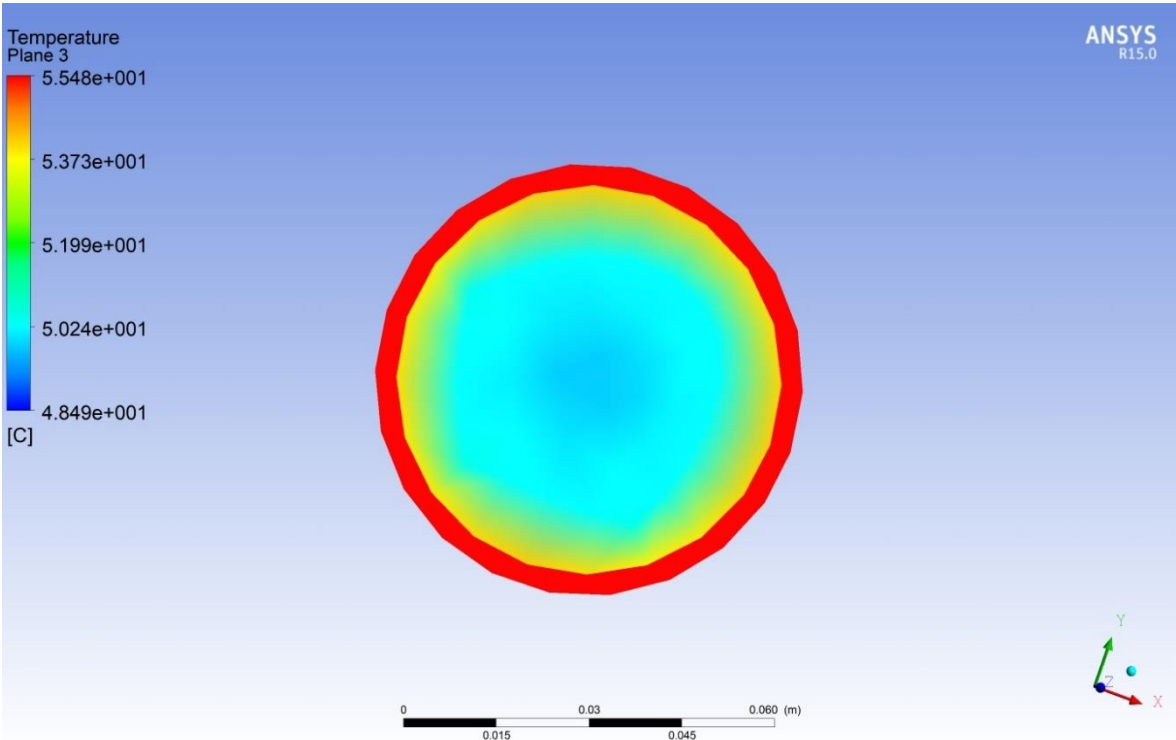
Temperature at 10 am in T1



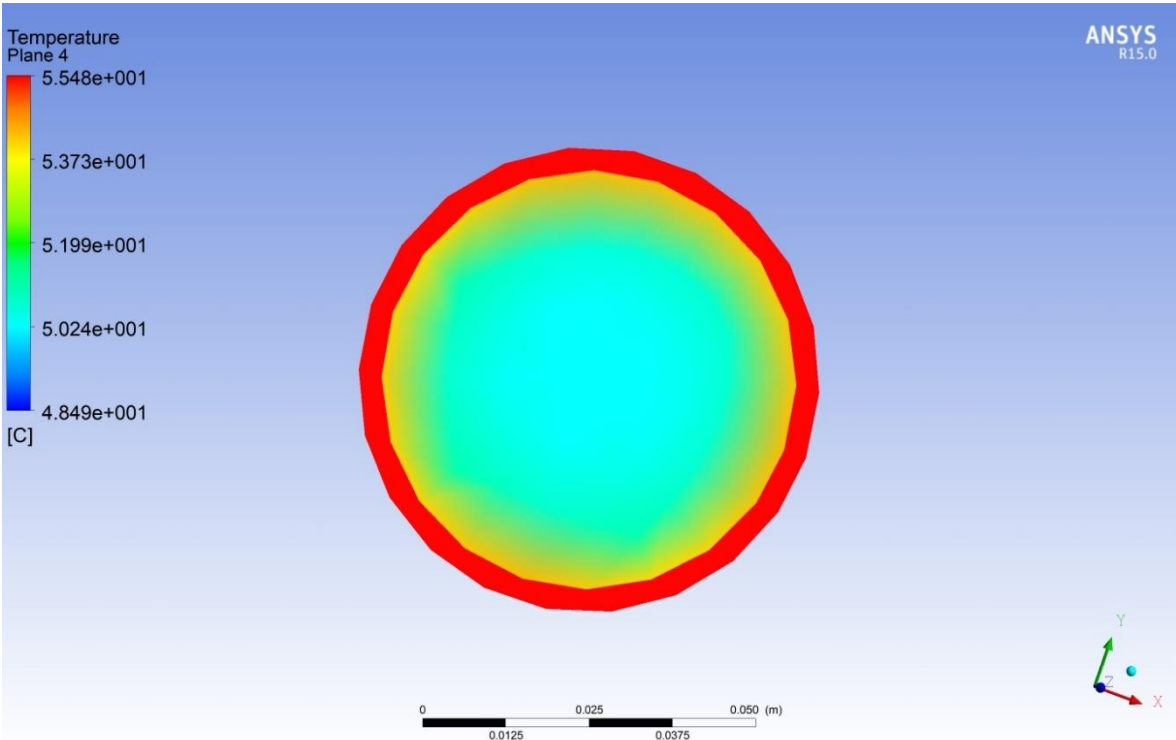
Temperature at 10 am in T2



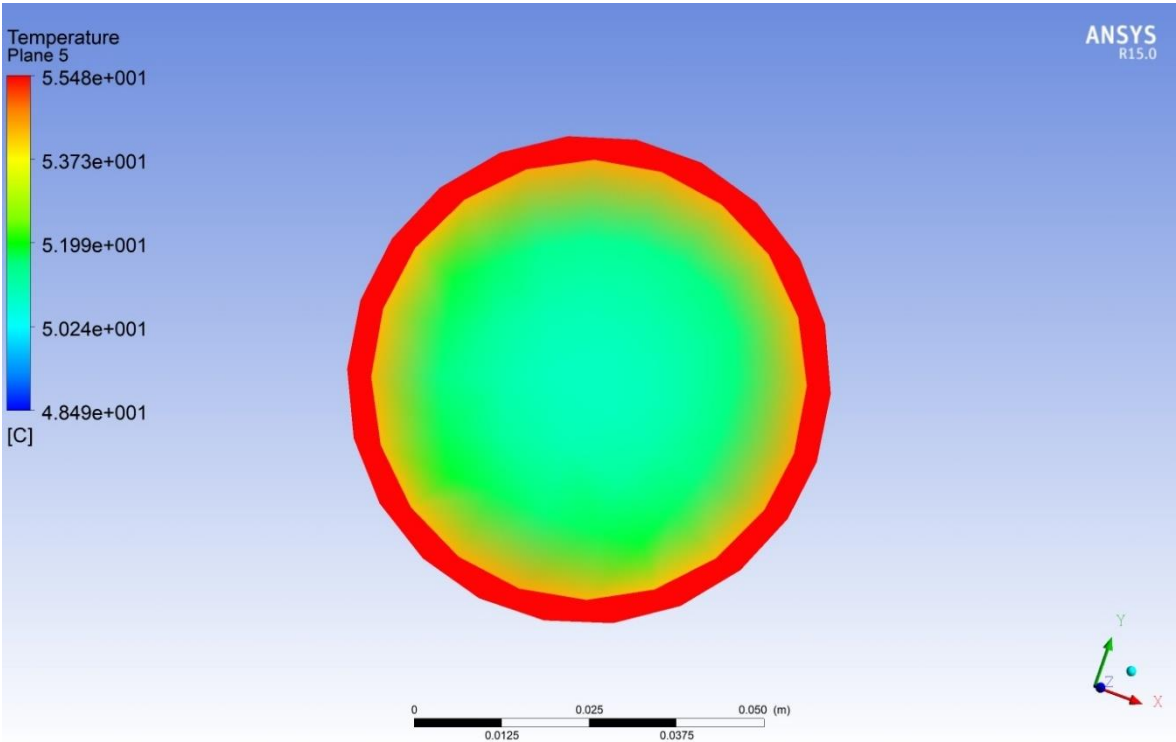
Temperature at 10 am in T3



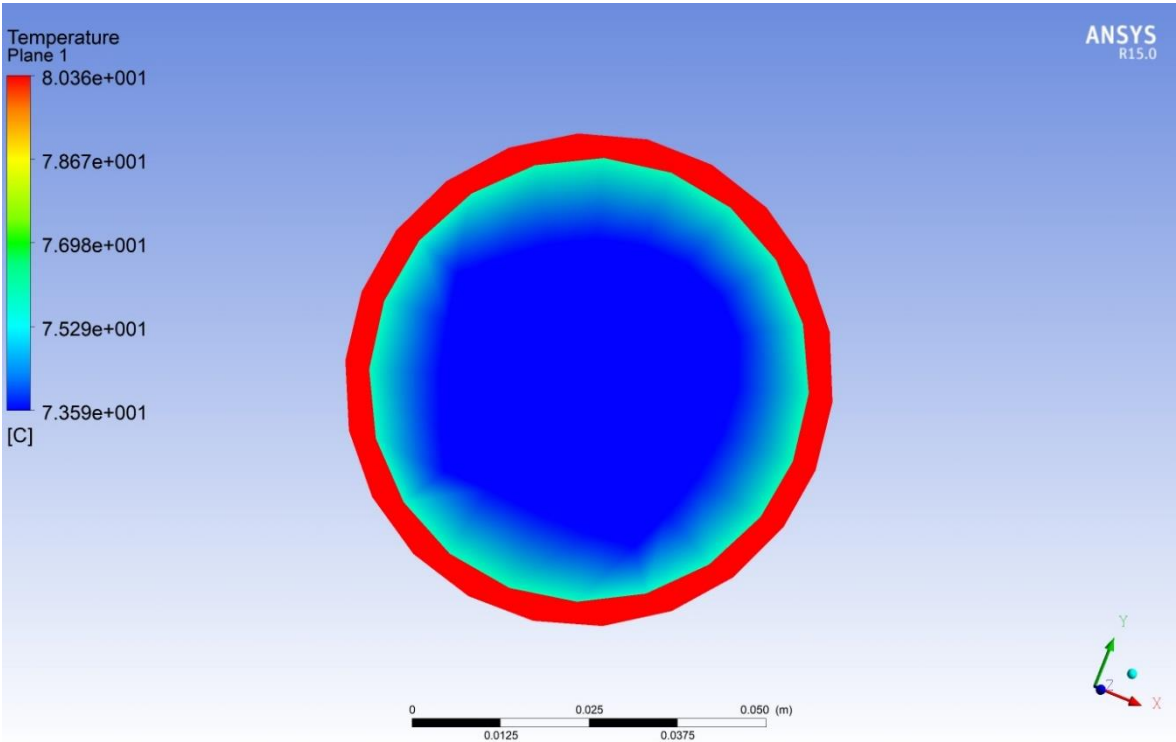
Temperature at 10 am in T4



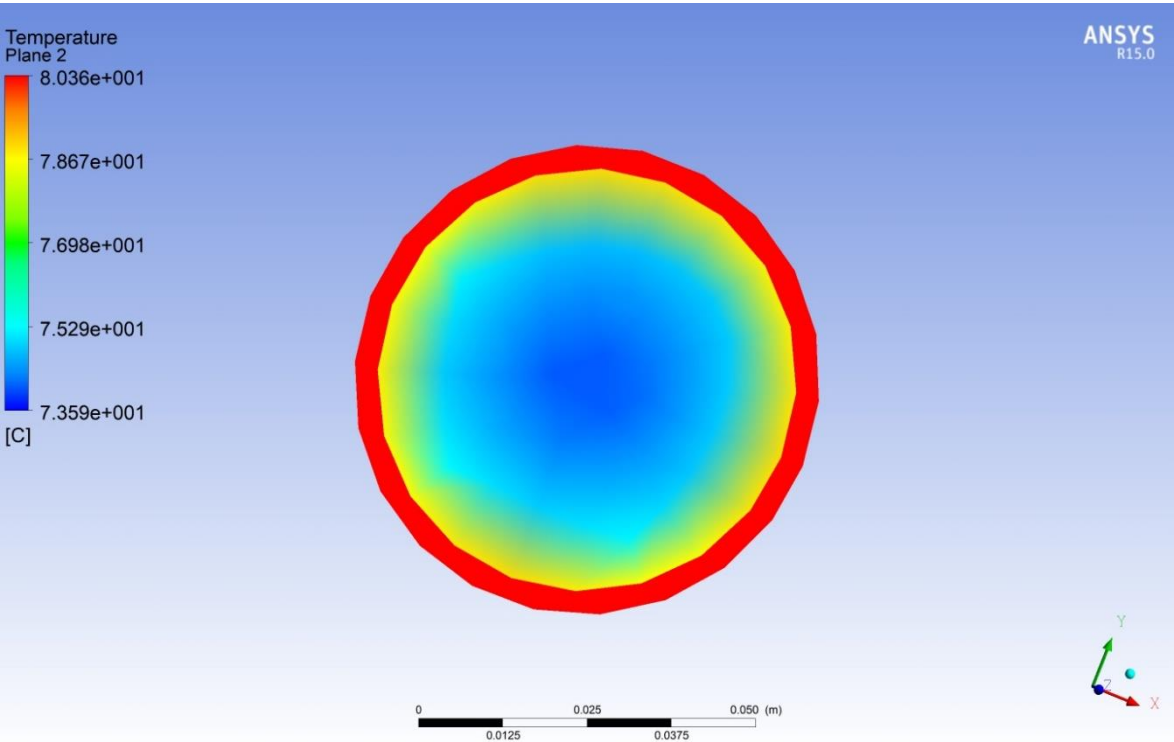
Temperature at 10 am in T5



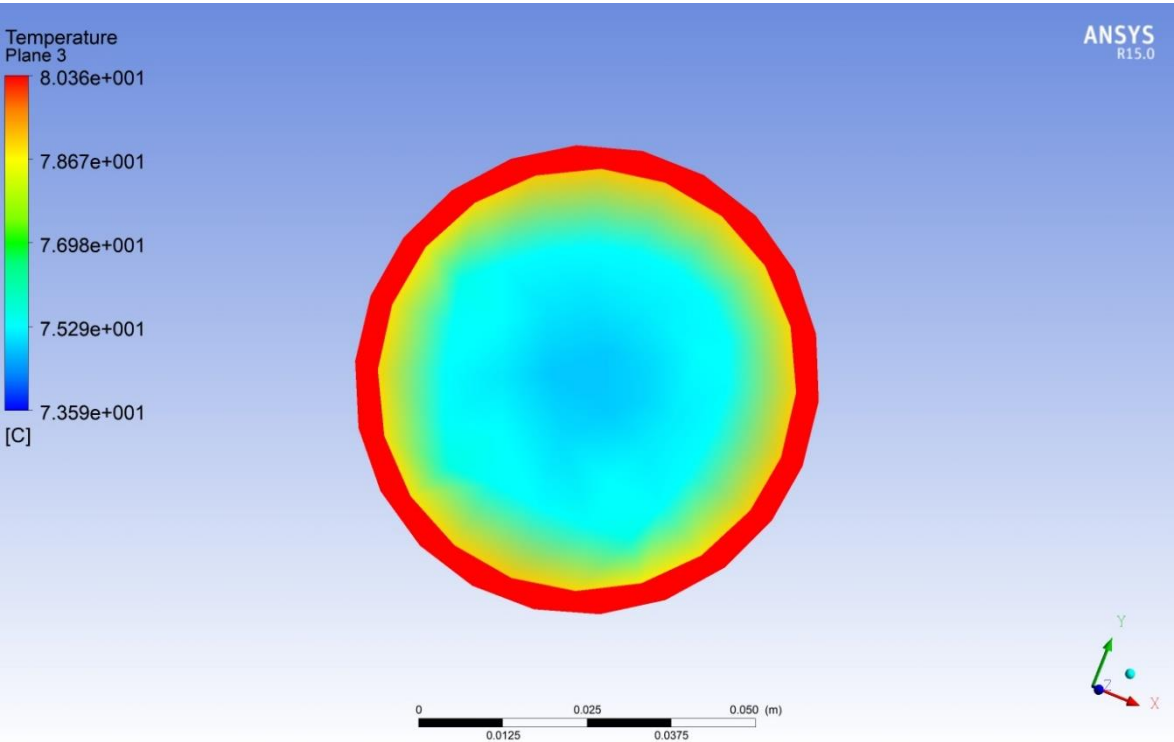
Temperature at 12 pm in T1



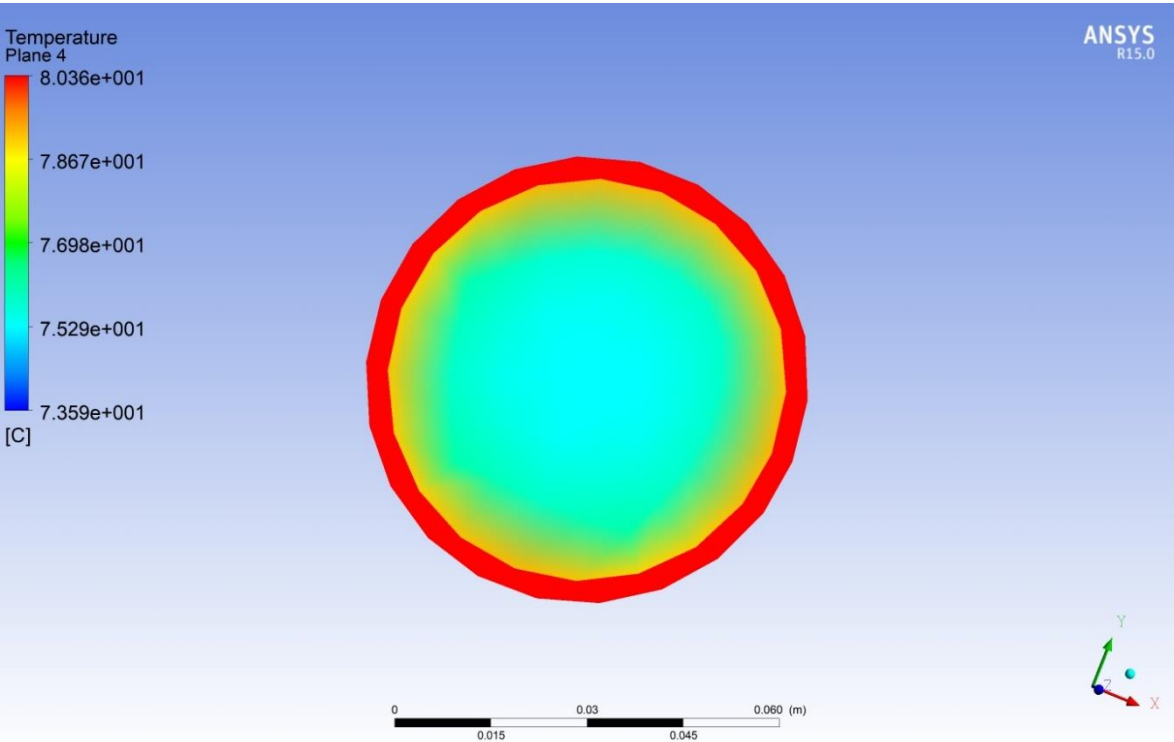
Temperature at 12 pm in T2



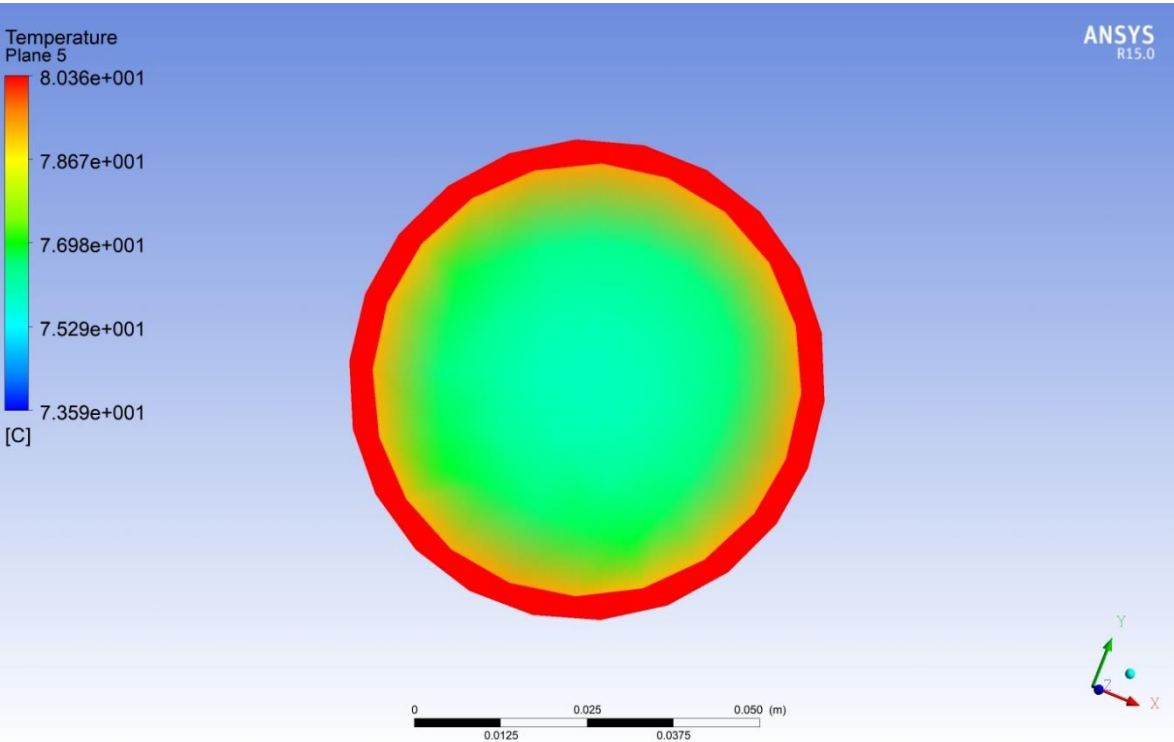
Temperature at 12 pm in T3



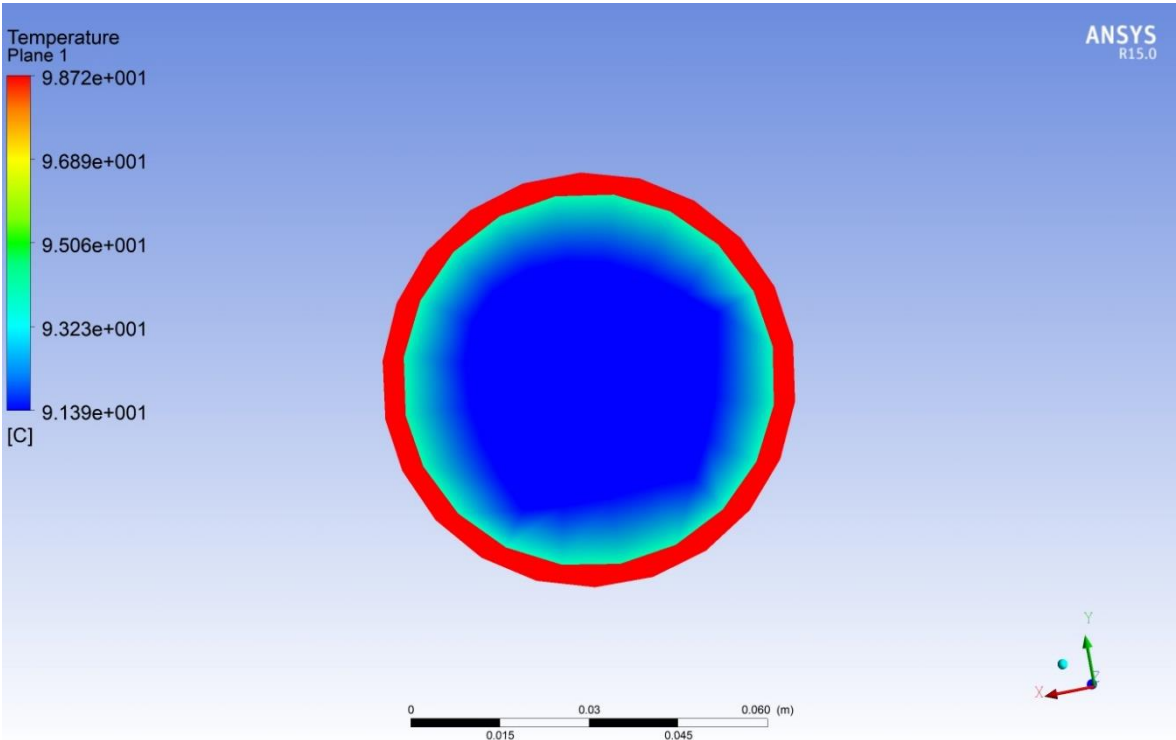
Temperature at 12 pm in T4



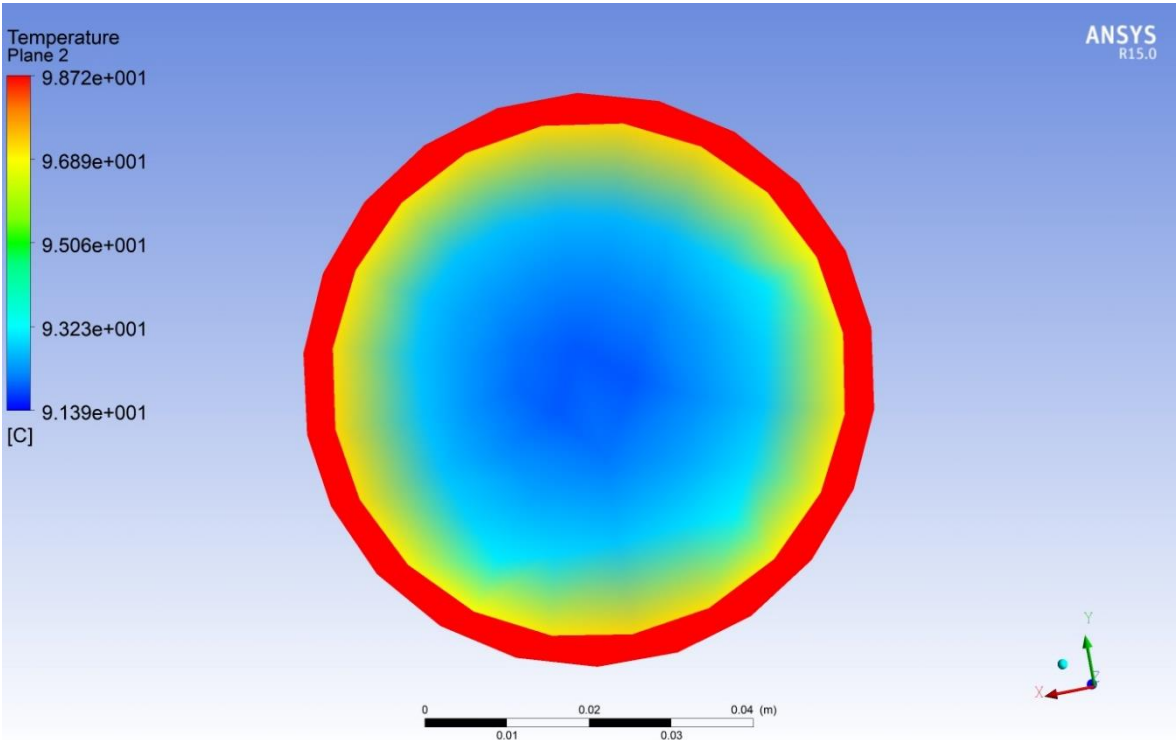
Temperature at 12 pm in T5



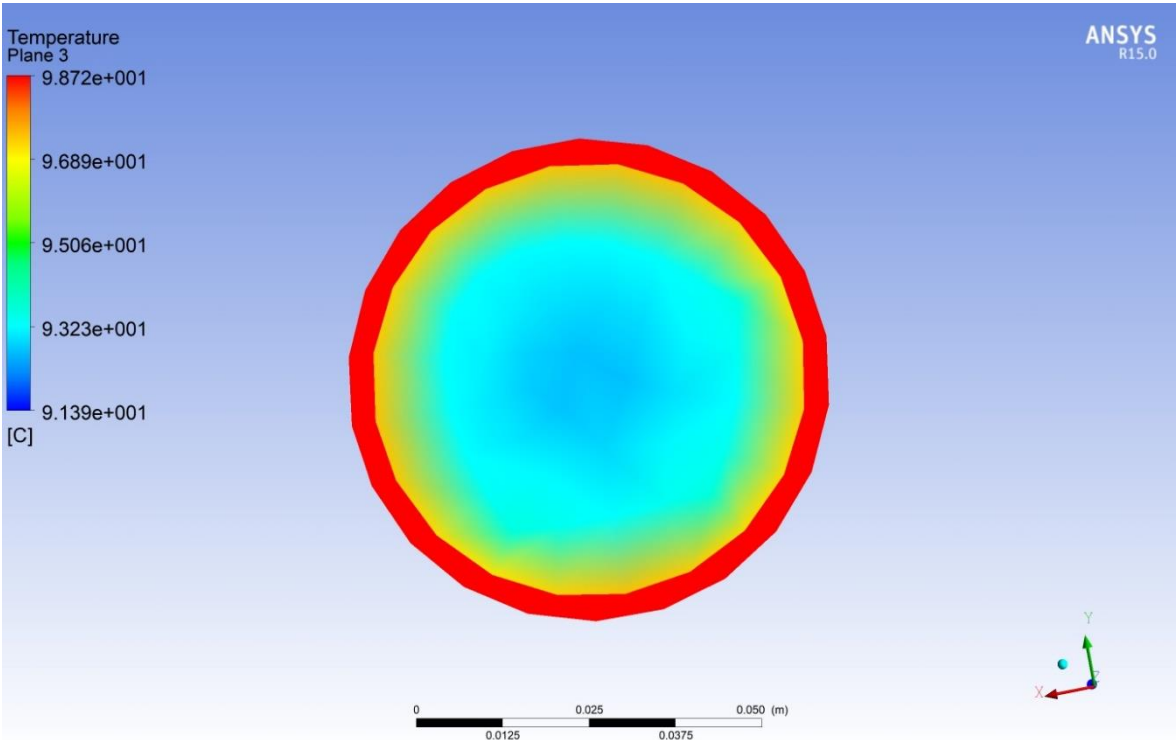
Temperature at 2 pm in T1



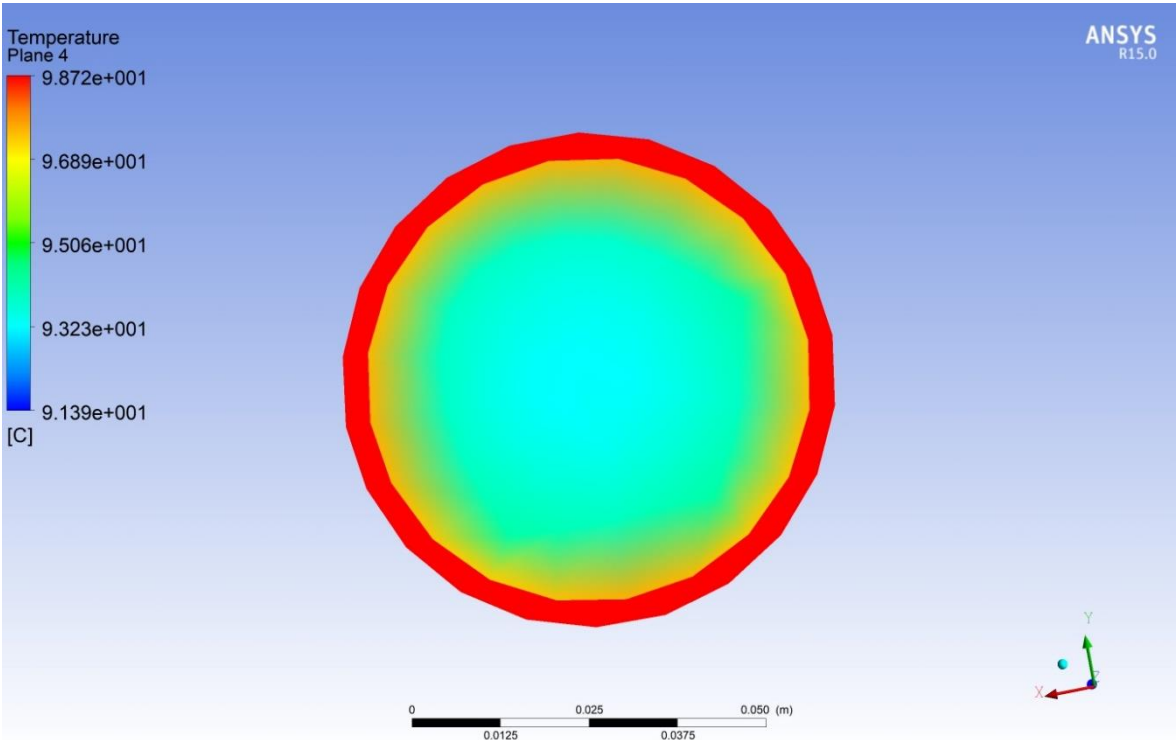
Temperature at 2 pm in T2



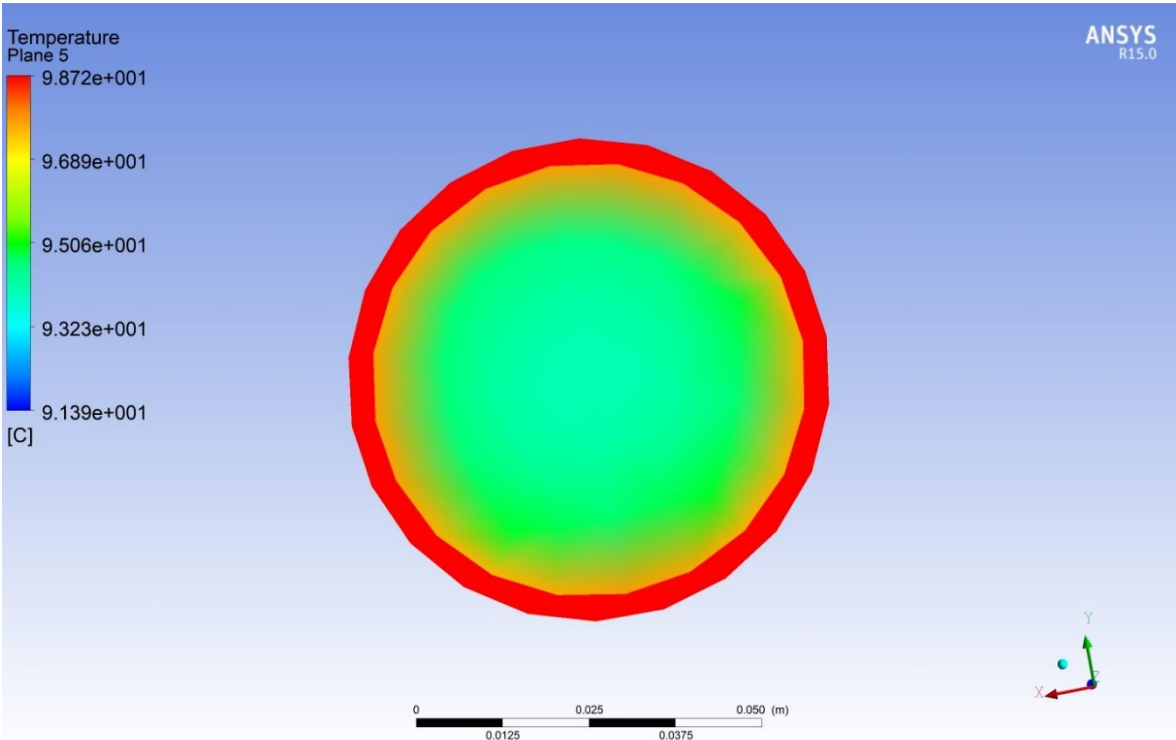
Temperature at 2 pm in T3



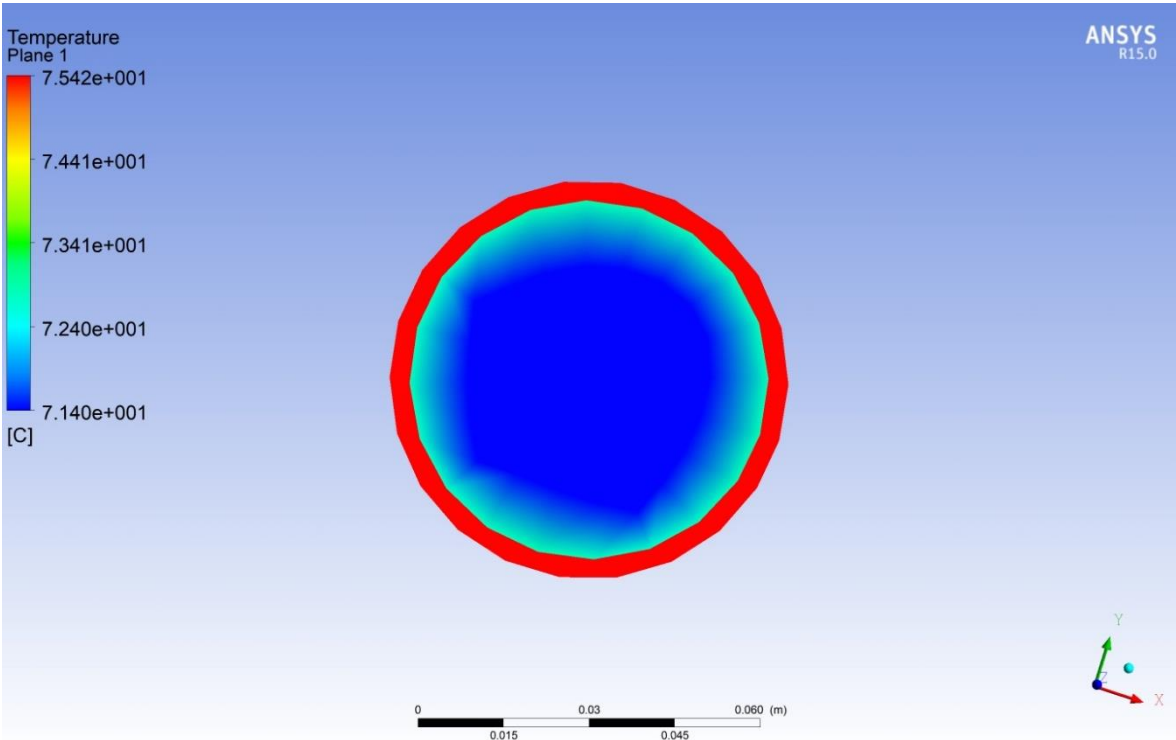
Temperature at 2 pm in T4



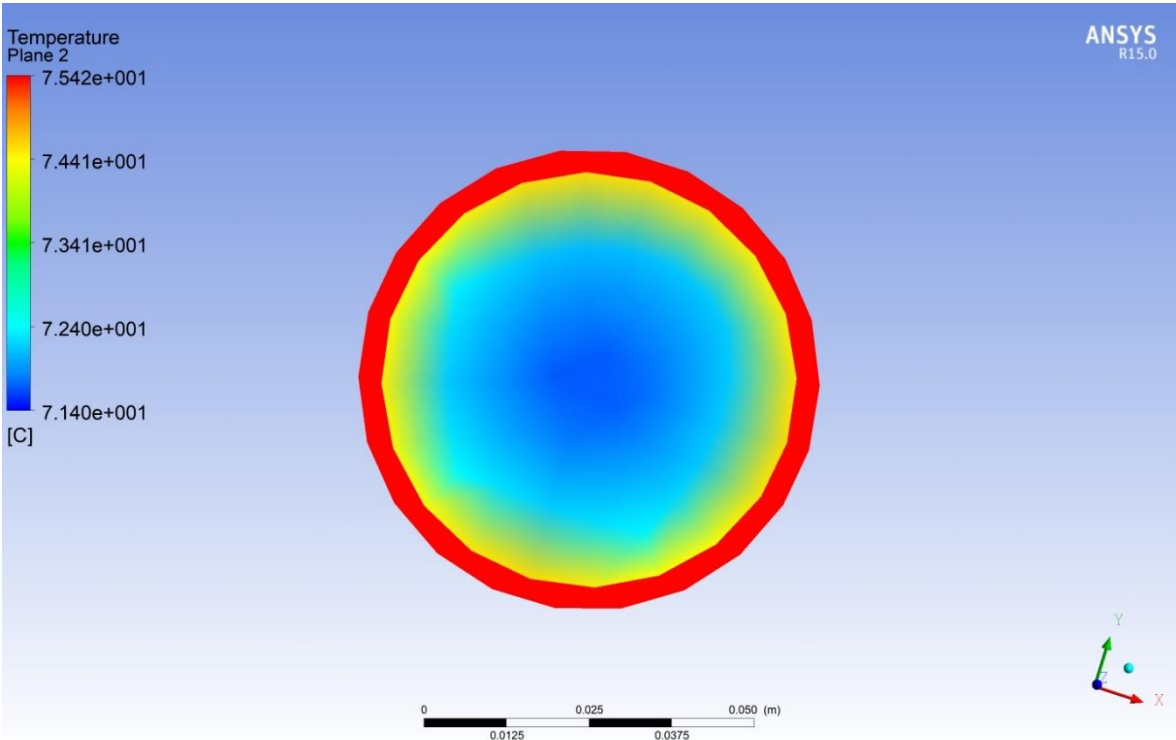
Temperature at 2 pm in T5



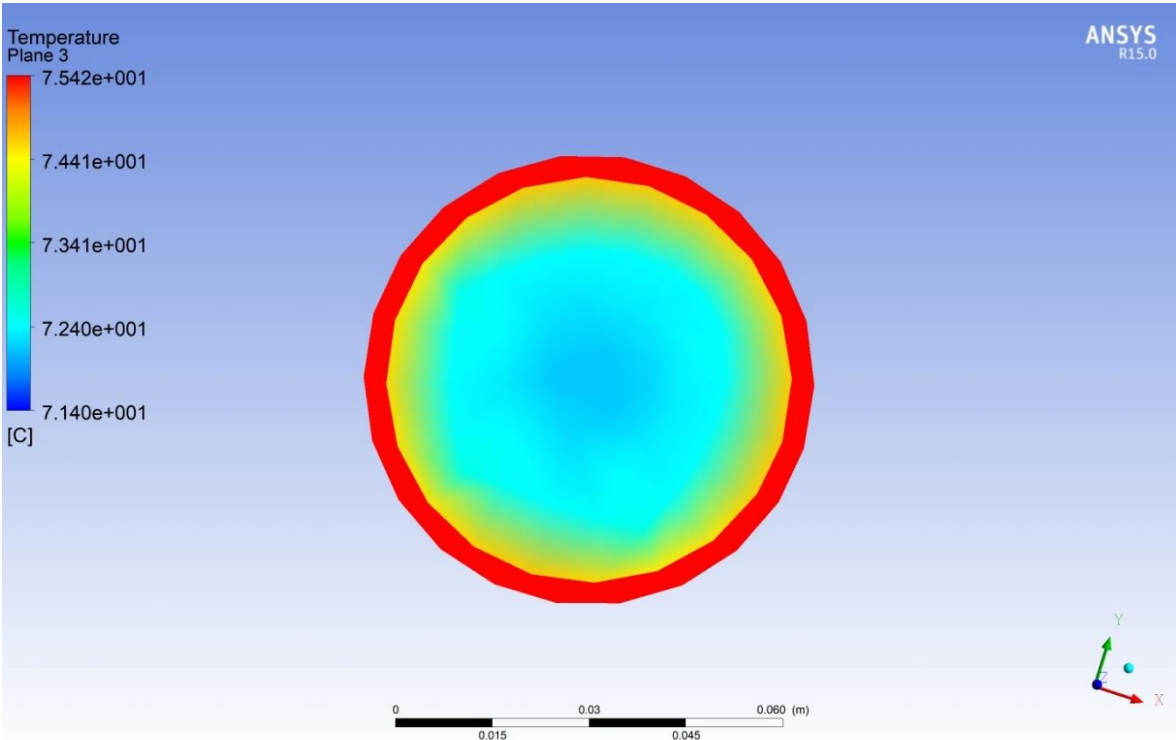
Temperature at 4 pm in T1



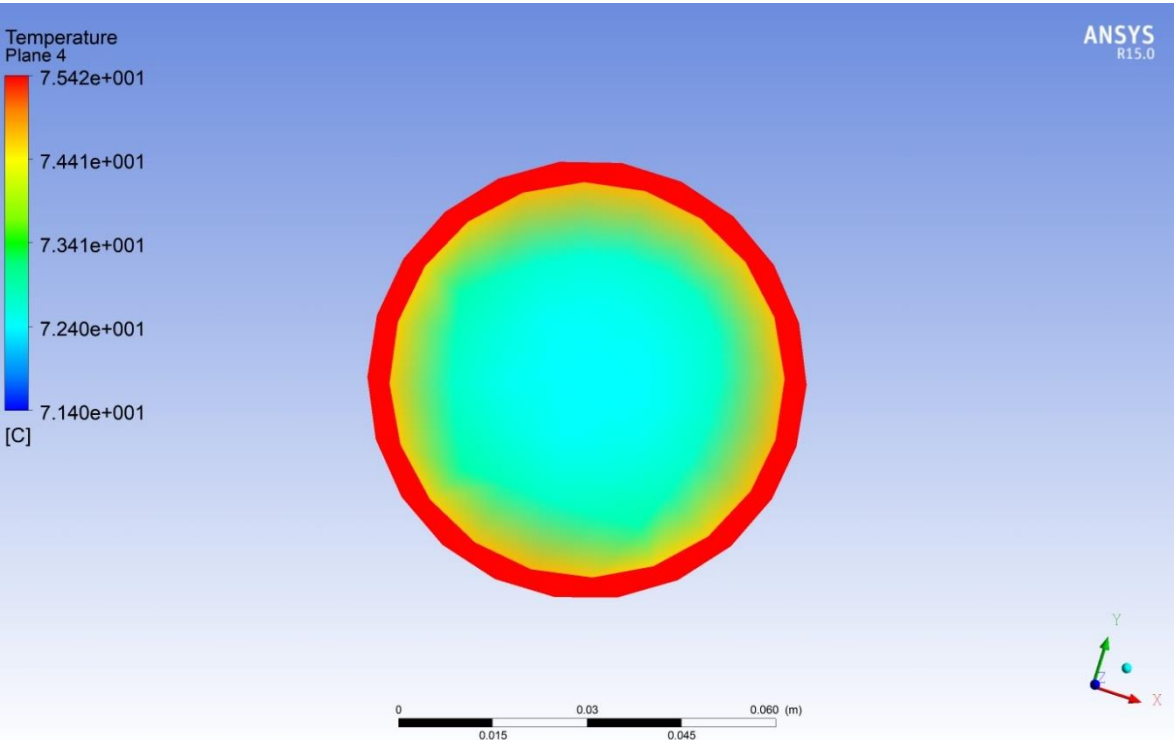
Temperature at 4 pm in T2



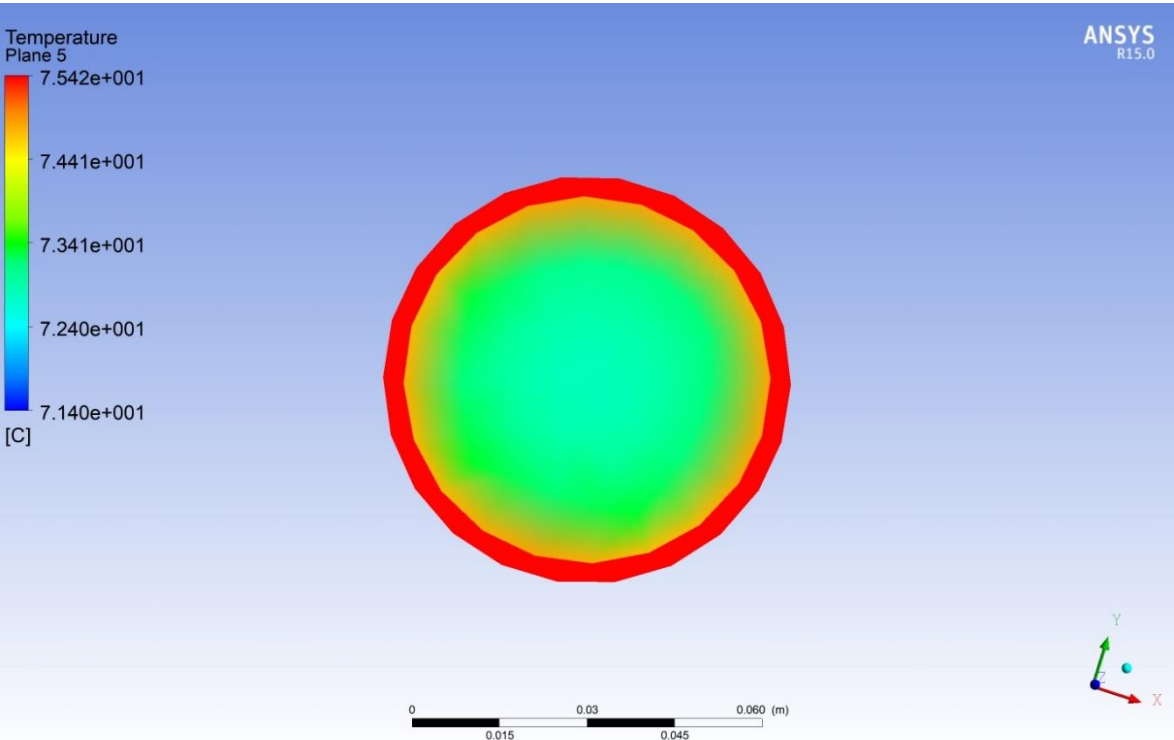
Temperature at 4 pm in T3



Temperature at 4 pm in T4



Temperature at 4 pm in T5

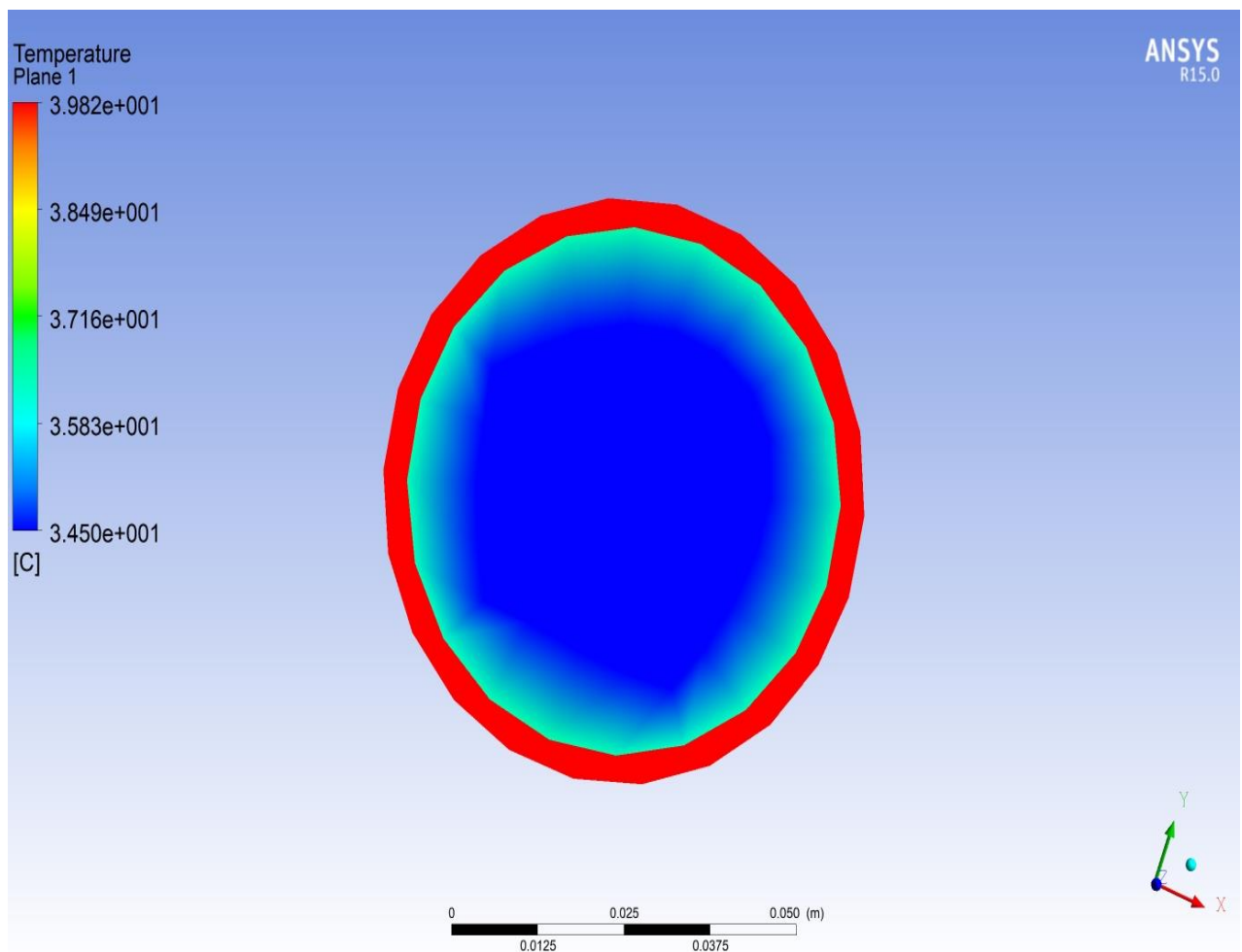


The calculations and readings which are obtained from the heat pipe is later taken for CFD analysis. The figure given below shows the heat distributon in the heat pipe using the CFD analysis.

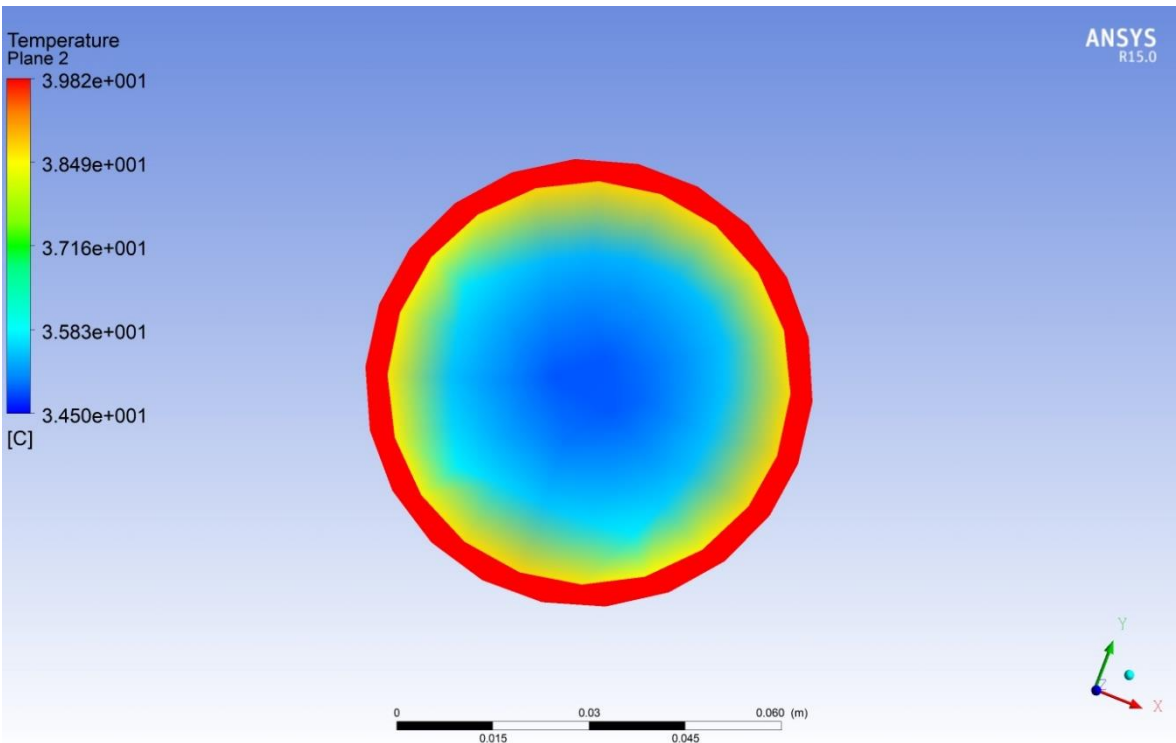
The below CFD analysis represent the Day 25 reading of each points in the pipe at different time

DAY 25

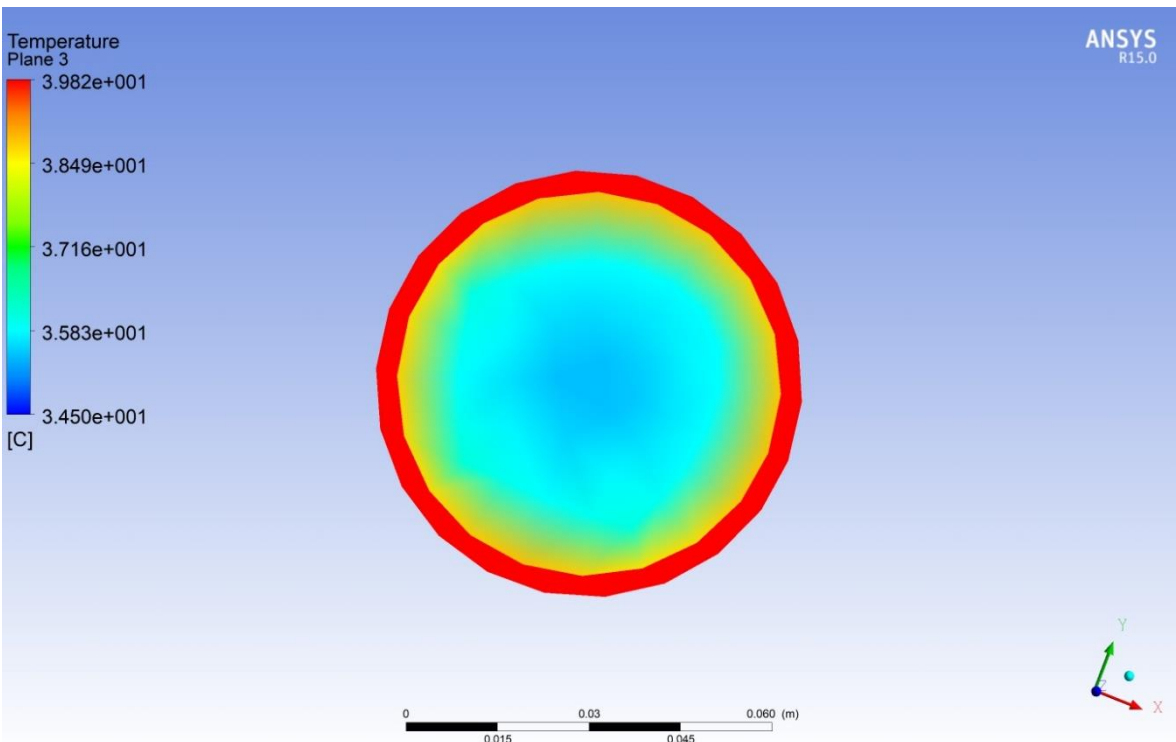
Temperature at 8 am in T1



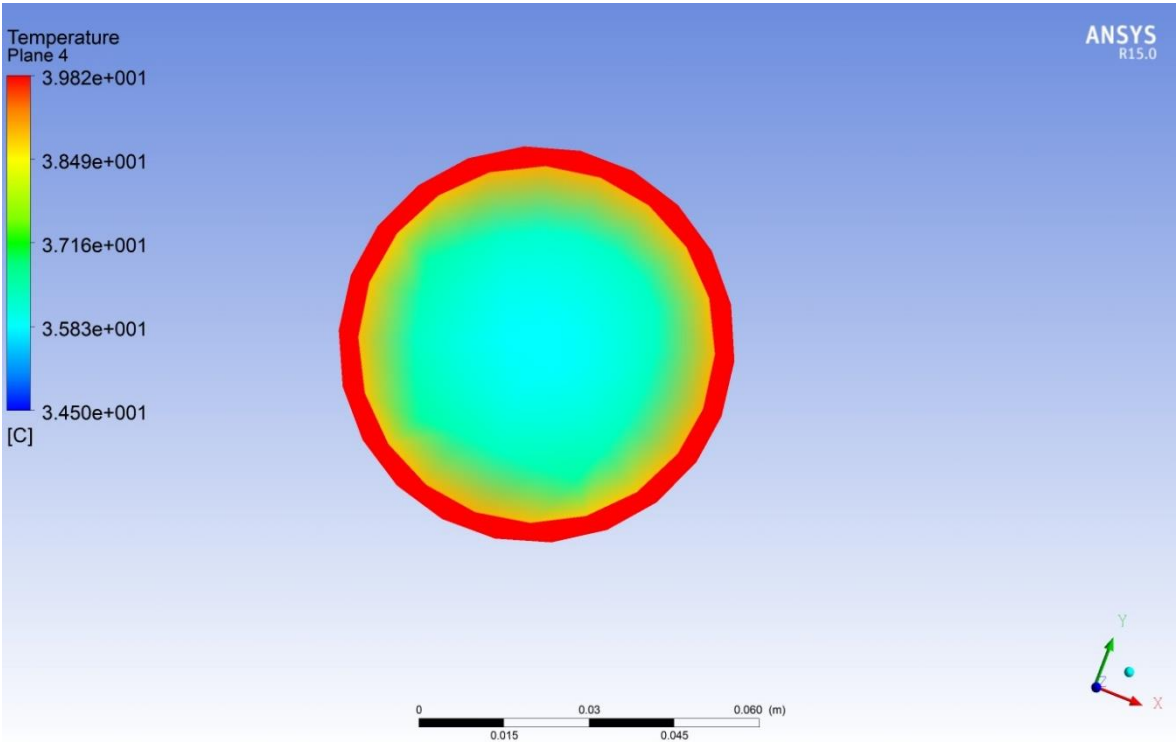
Temperature at 8 am in T2



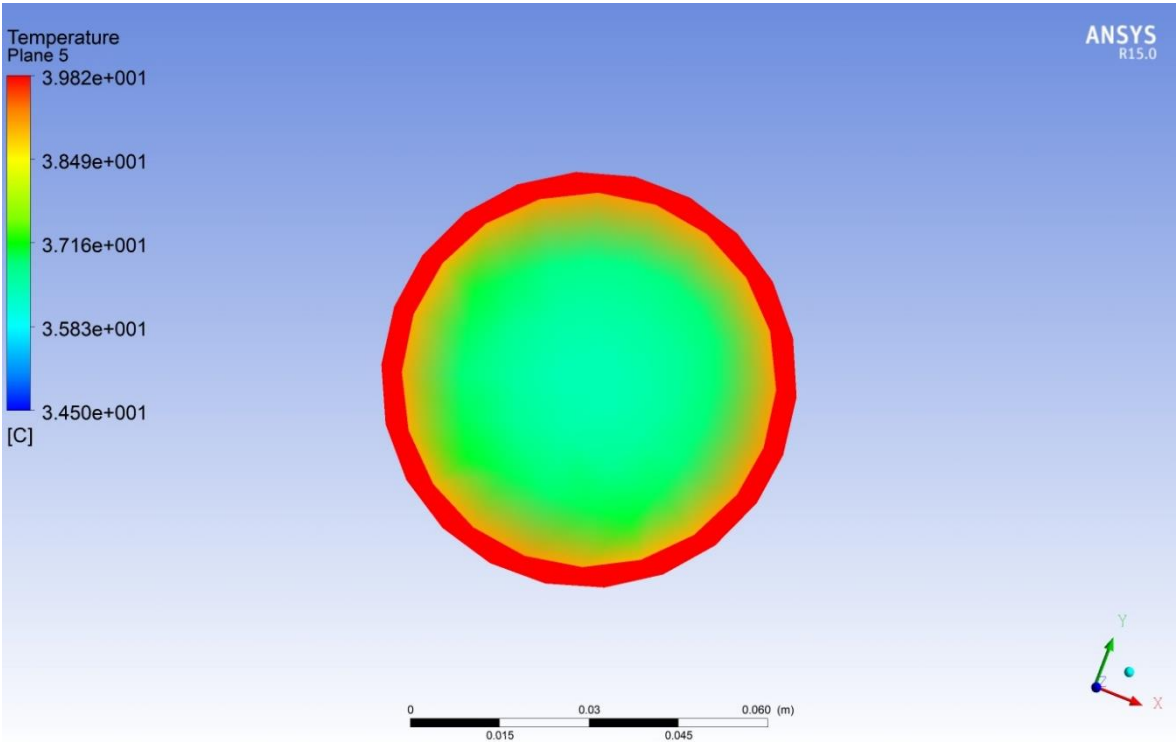
Temperature at 8 am in T3



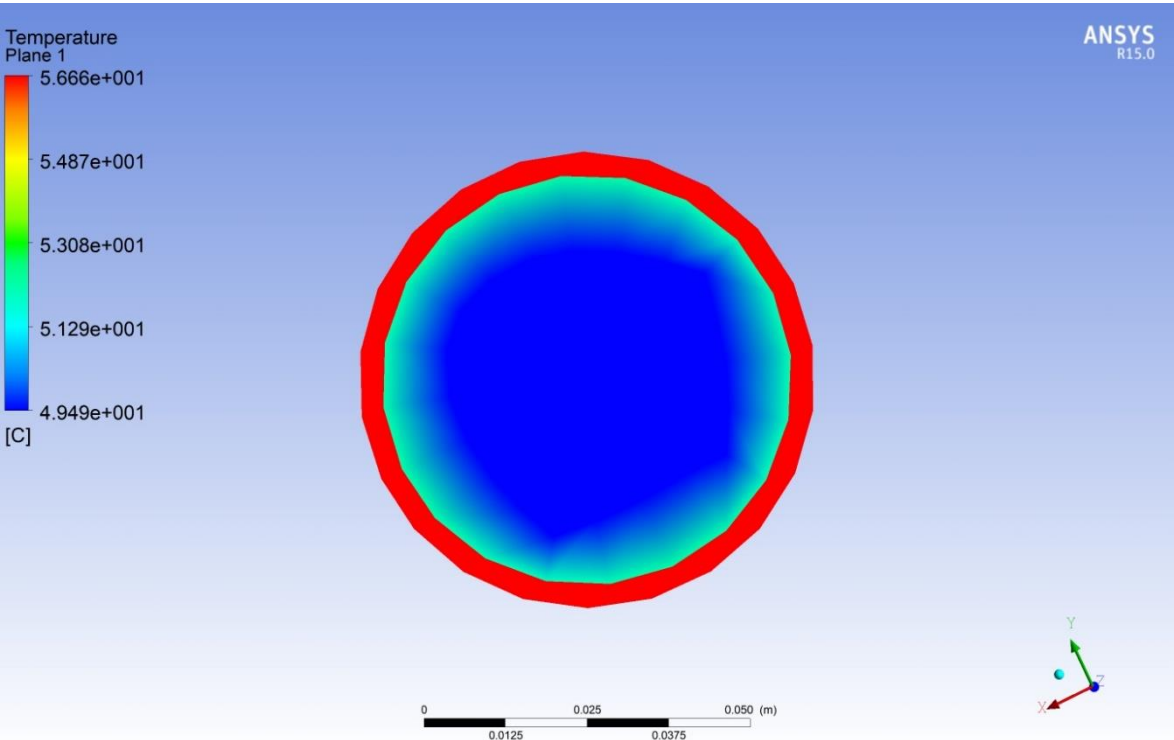
Temperature at 8 am in T4



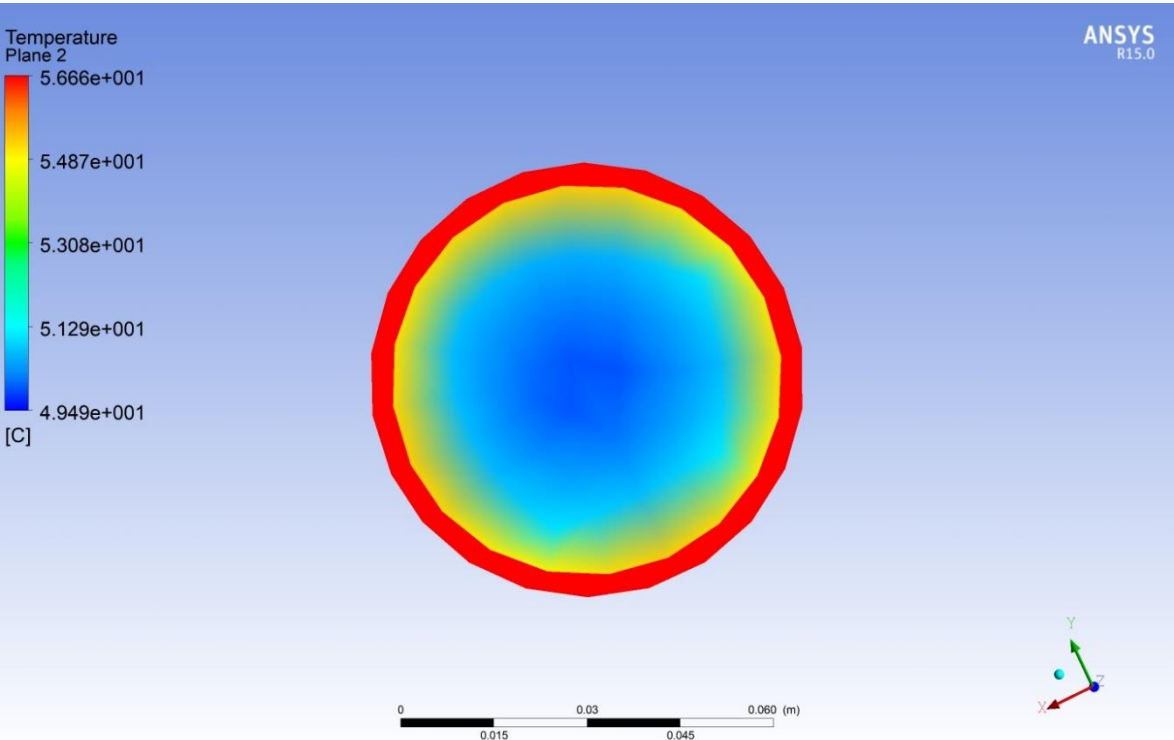
Temperature at 8 am in T5



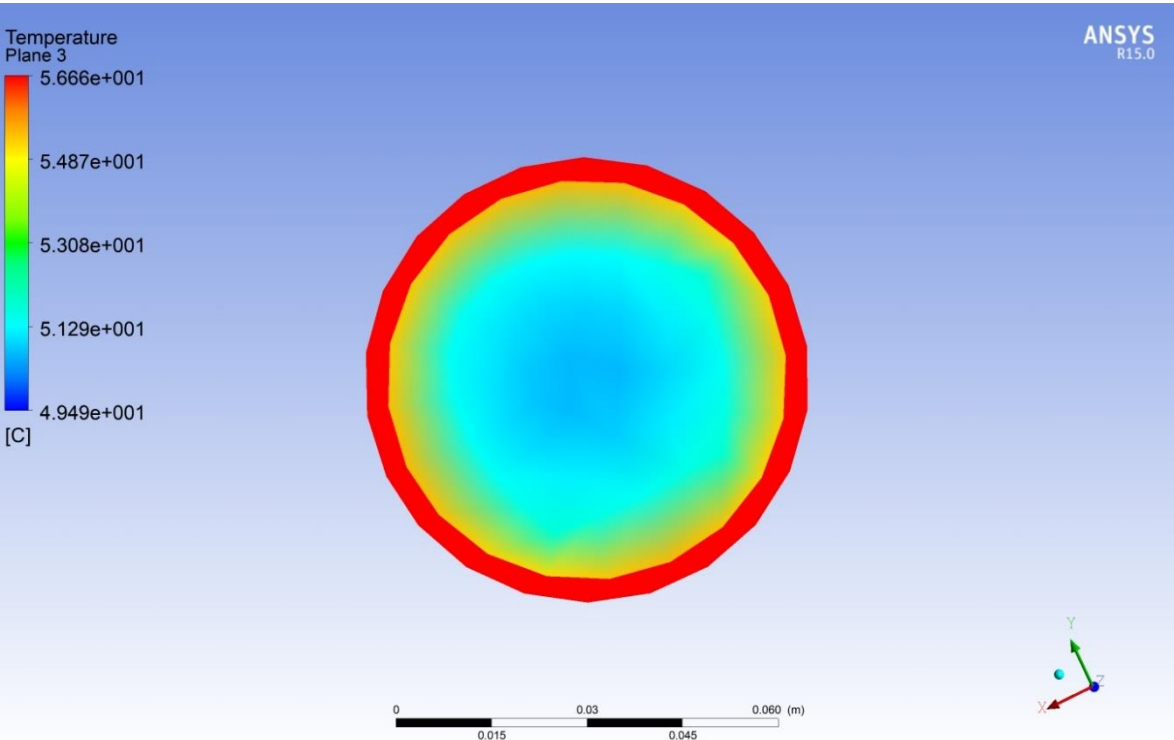
Temperature at 10 am in T1



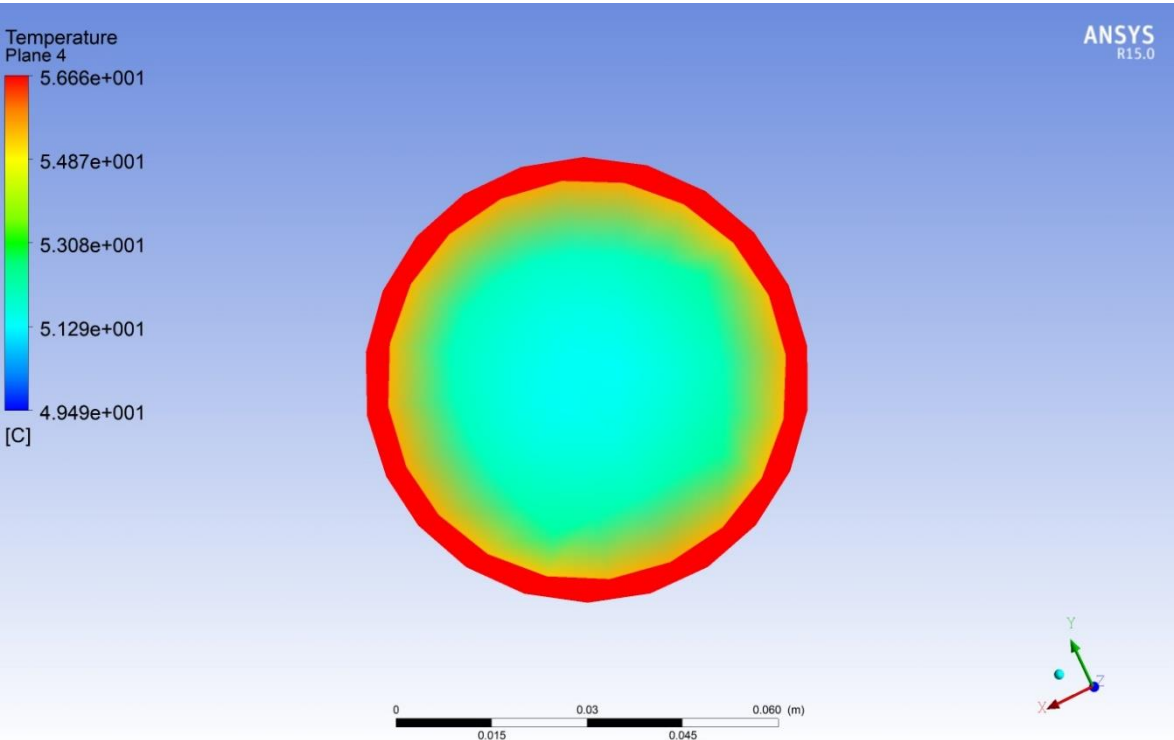
Temperature at 10 am in T2



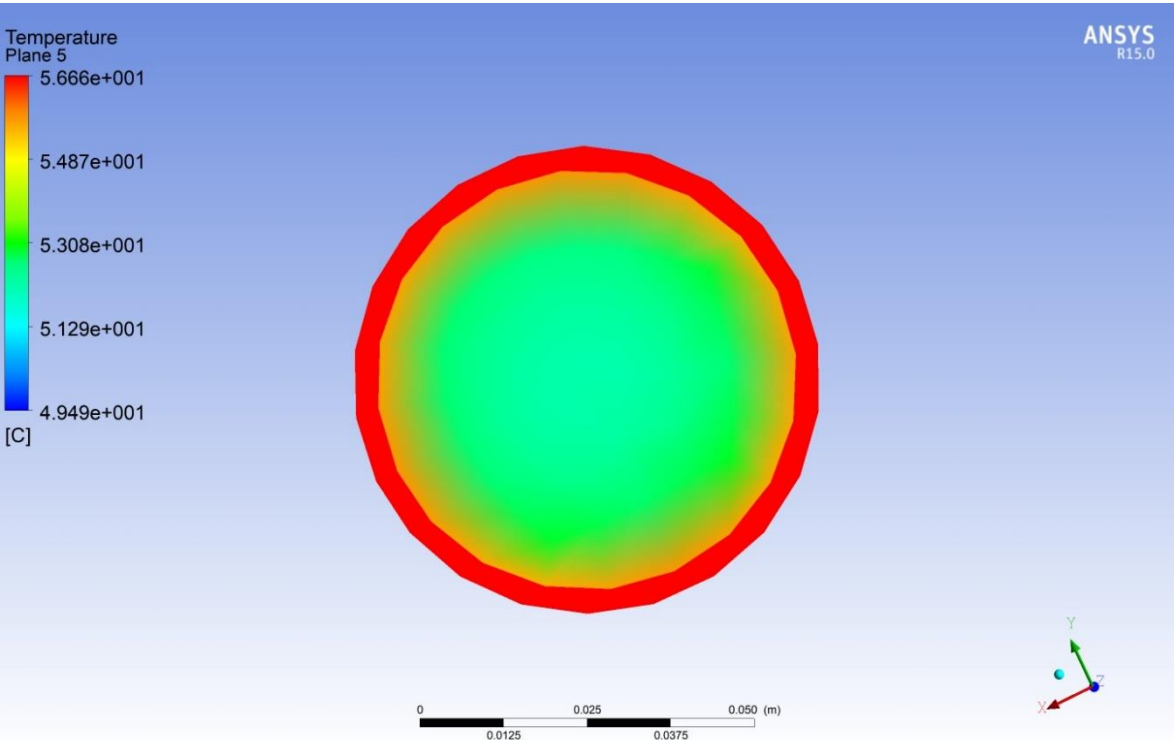
Temperature at 10 am in T3



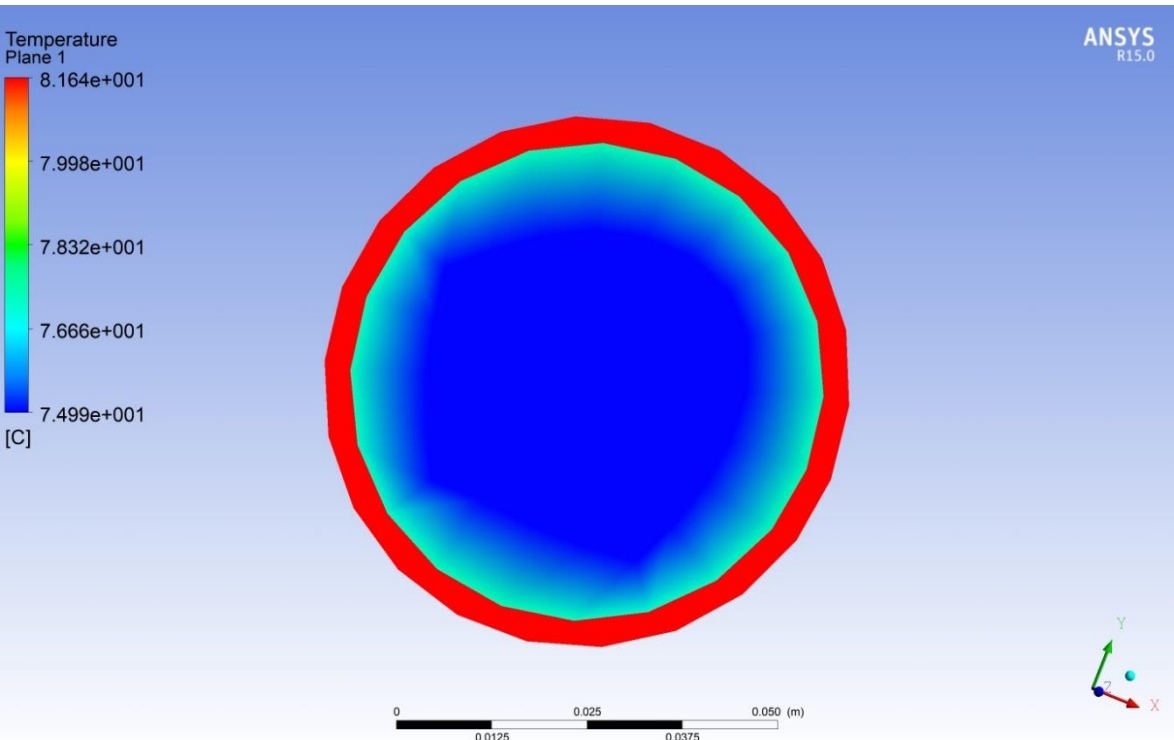
Temperature at 10 am in T4



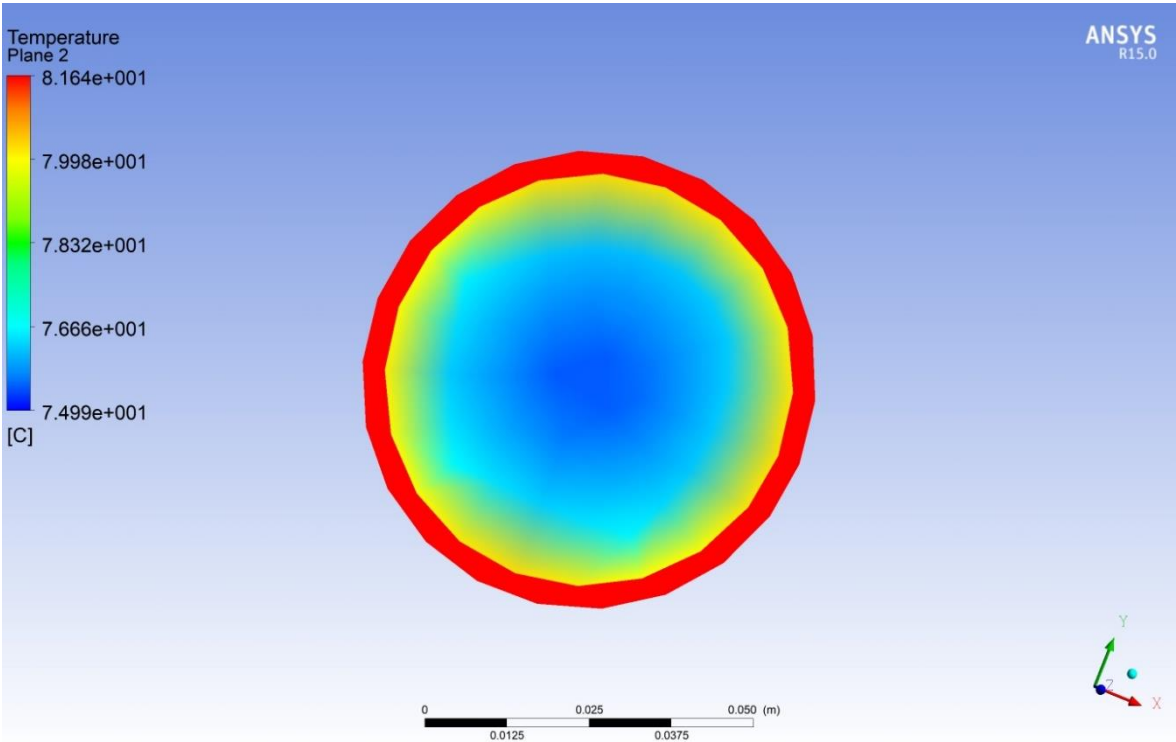
Temperature at 10 am in T5



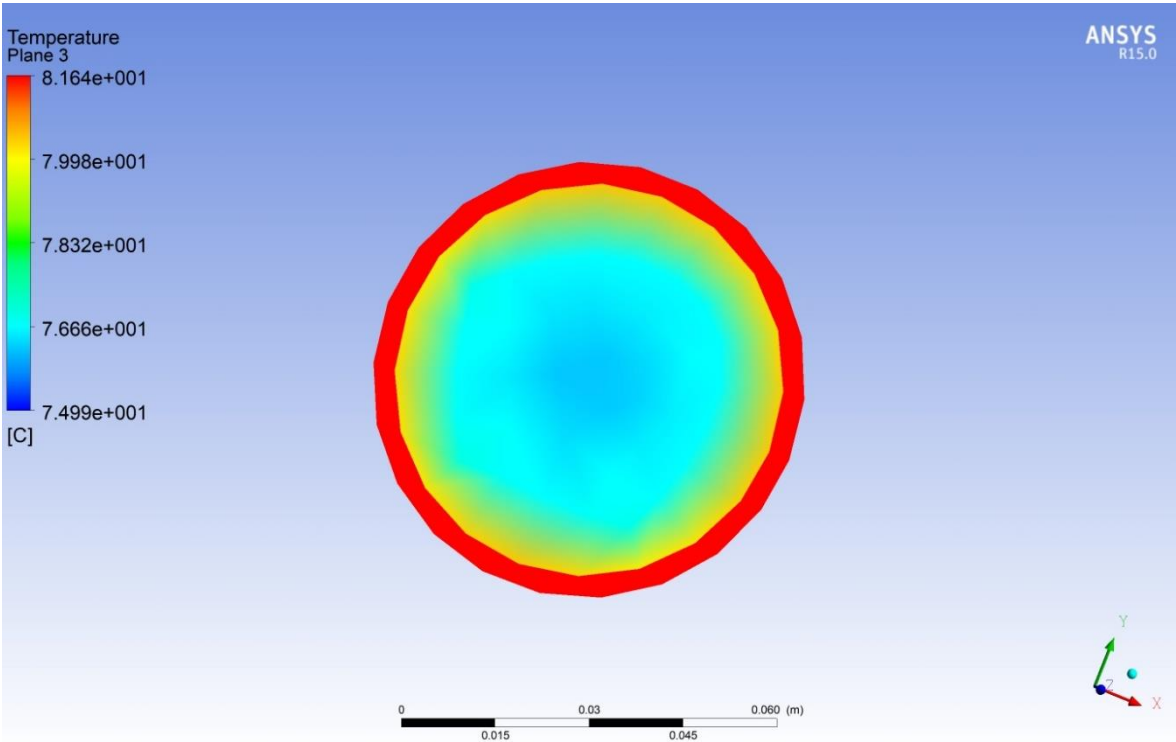
Temperature at 12 pm in T1



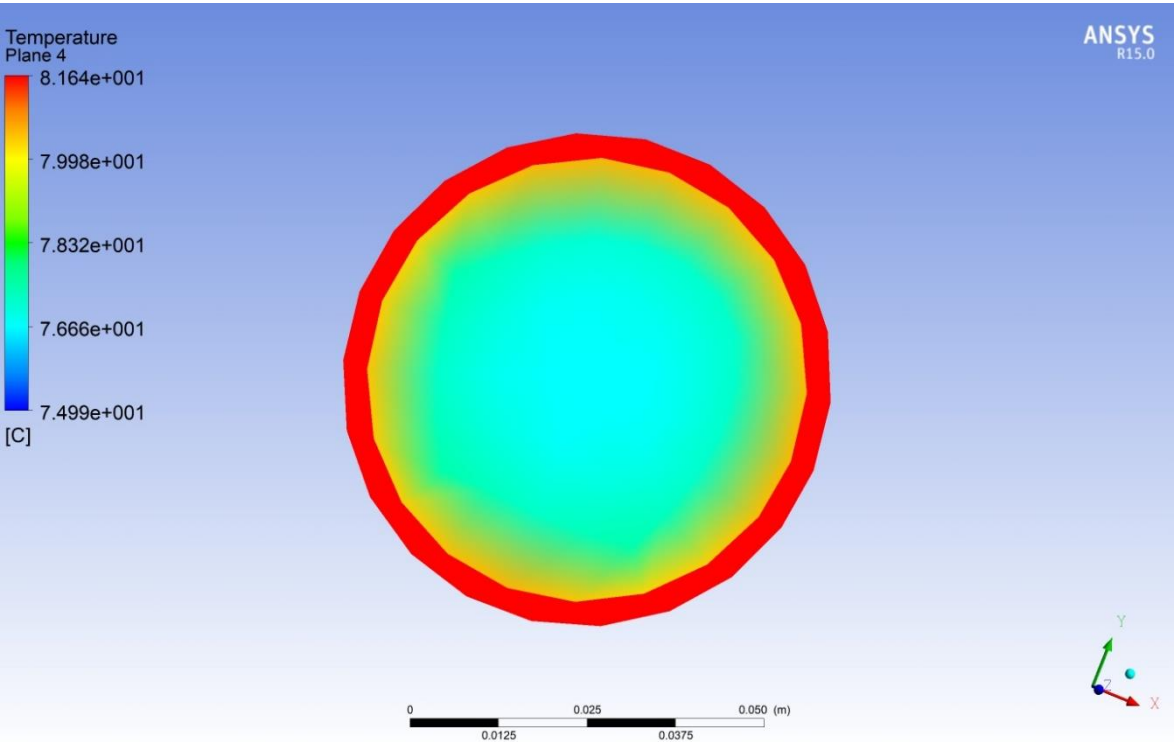
Temperature at 12 pm in T2



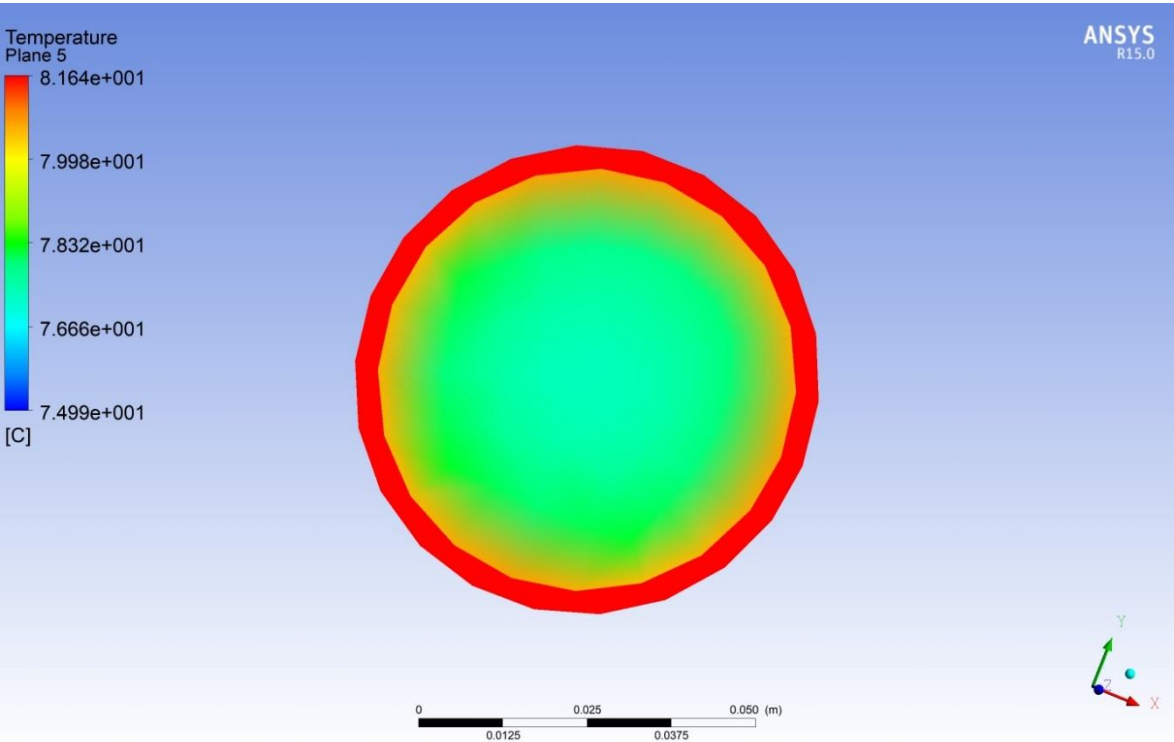
Temperature at 12 pm in T3



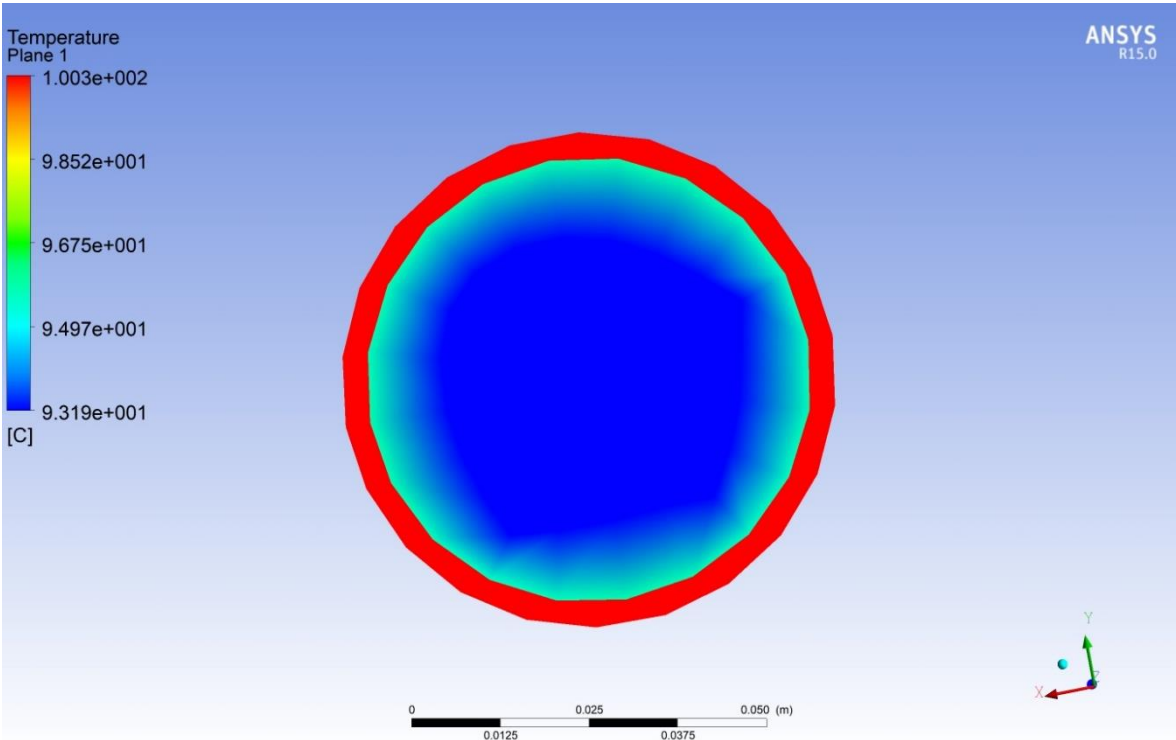
Temperature at 12 pm in T4



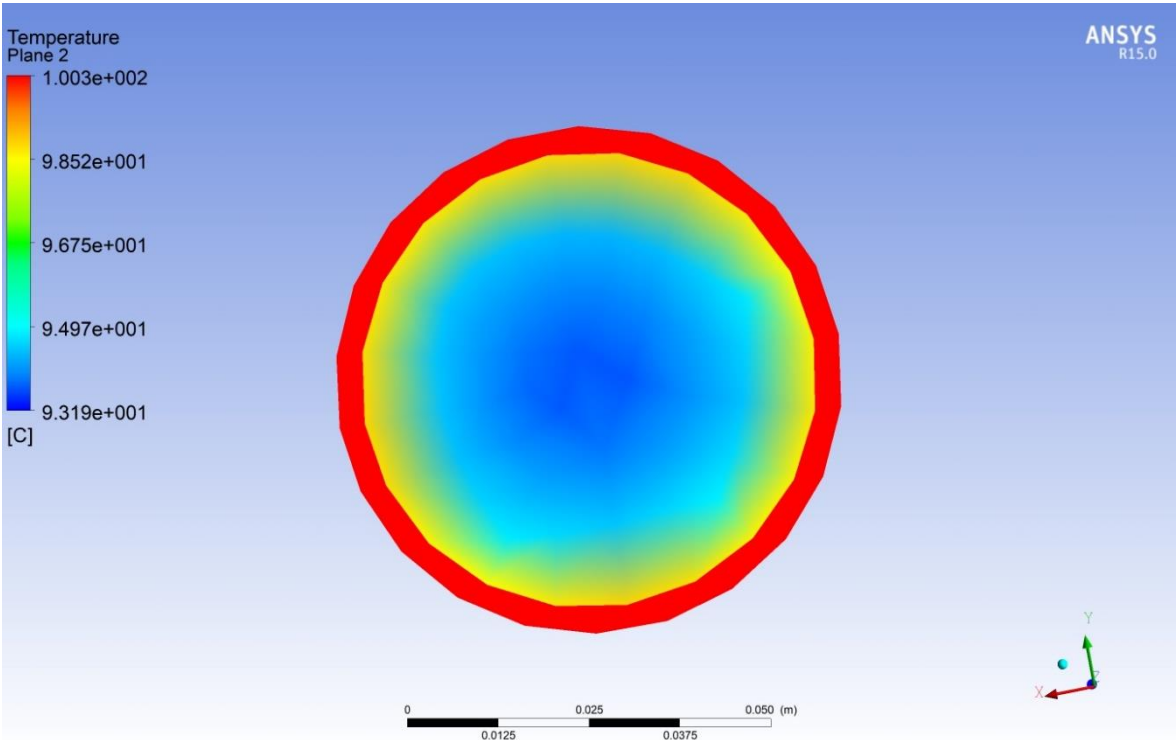
Temperature at 12 pm in T5



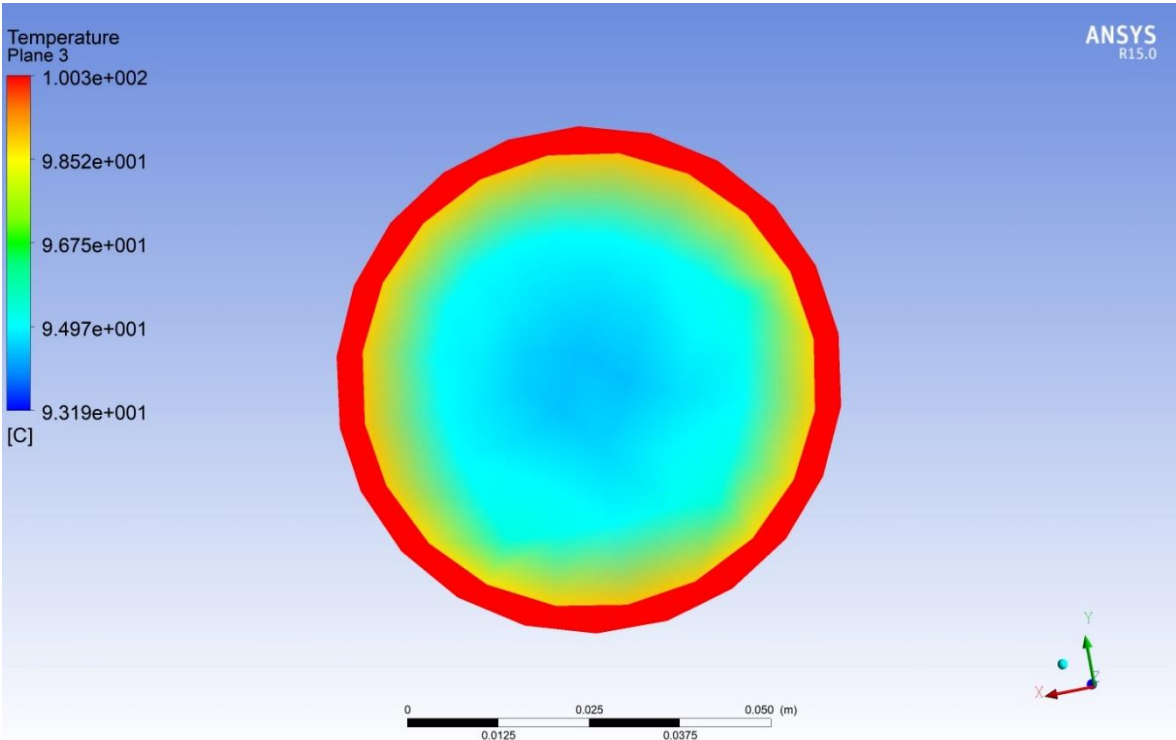
Temperature at 2 pm in T1



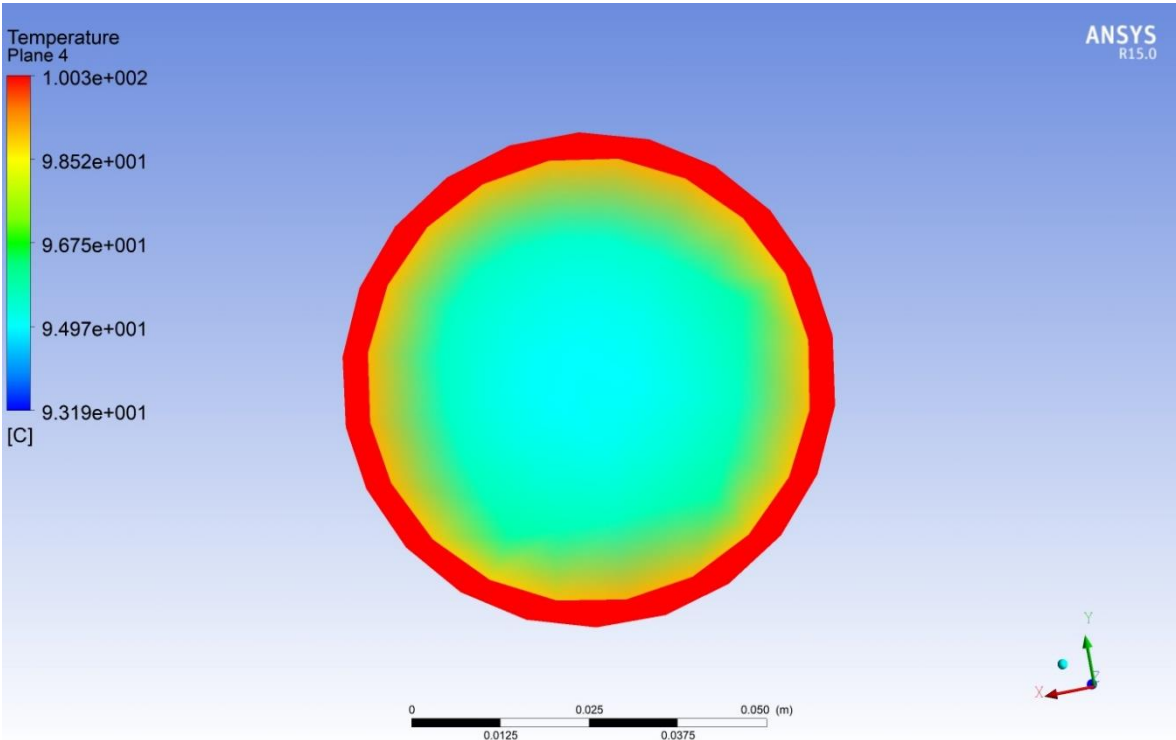
Temperature at 2 pm in T2



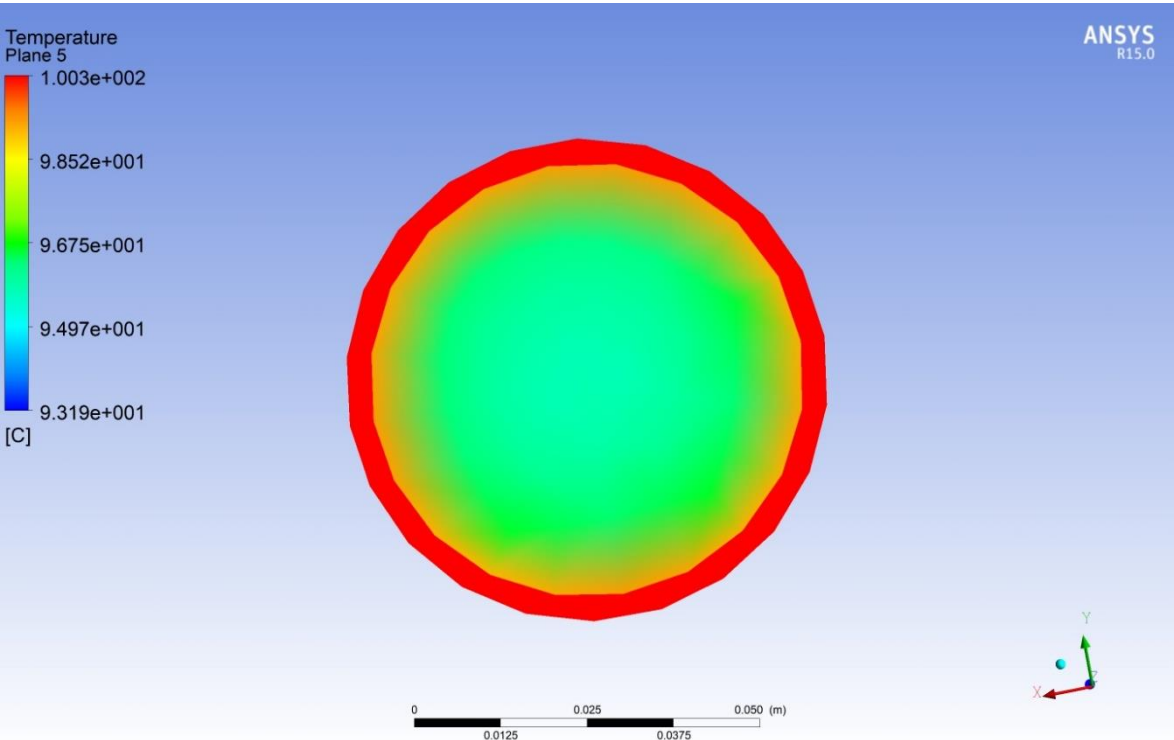
Temperature at 2 pm in T3



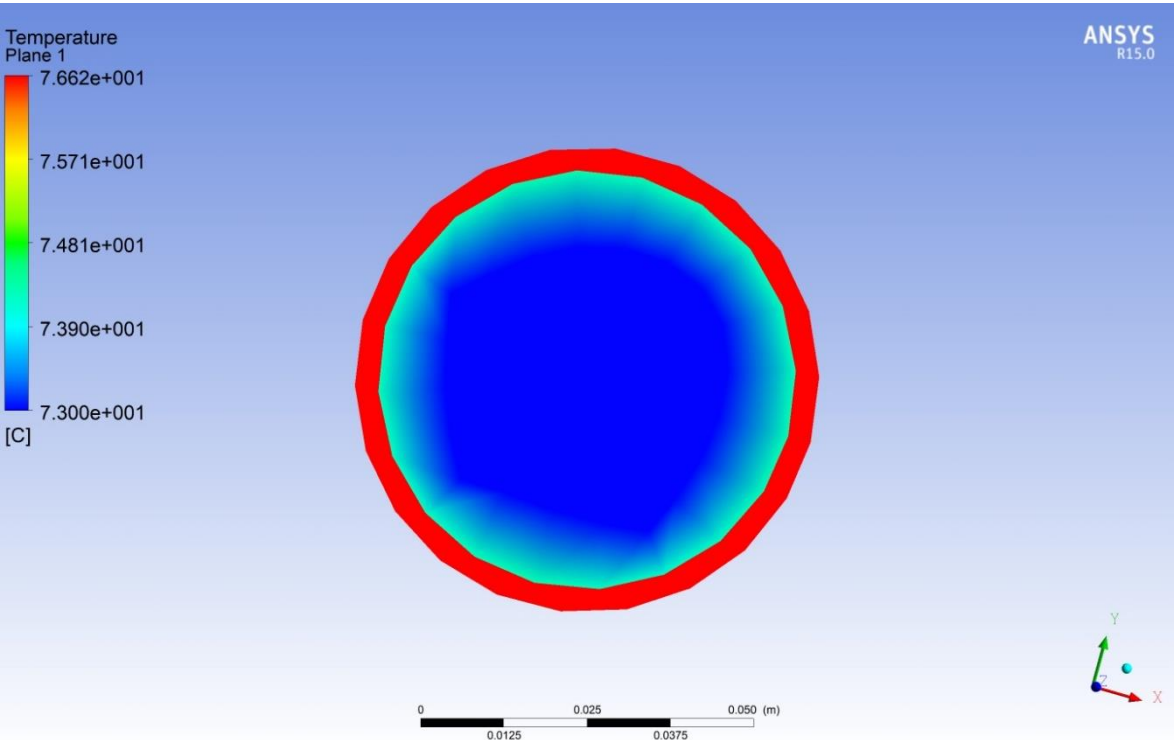
Temperature at 2 pm in T4



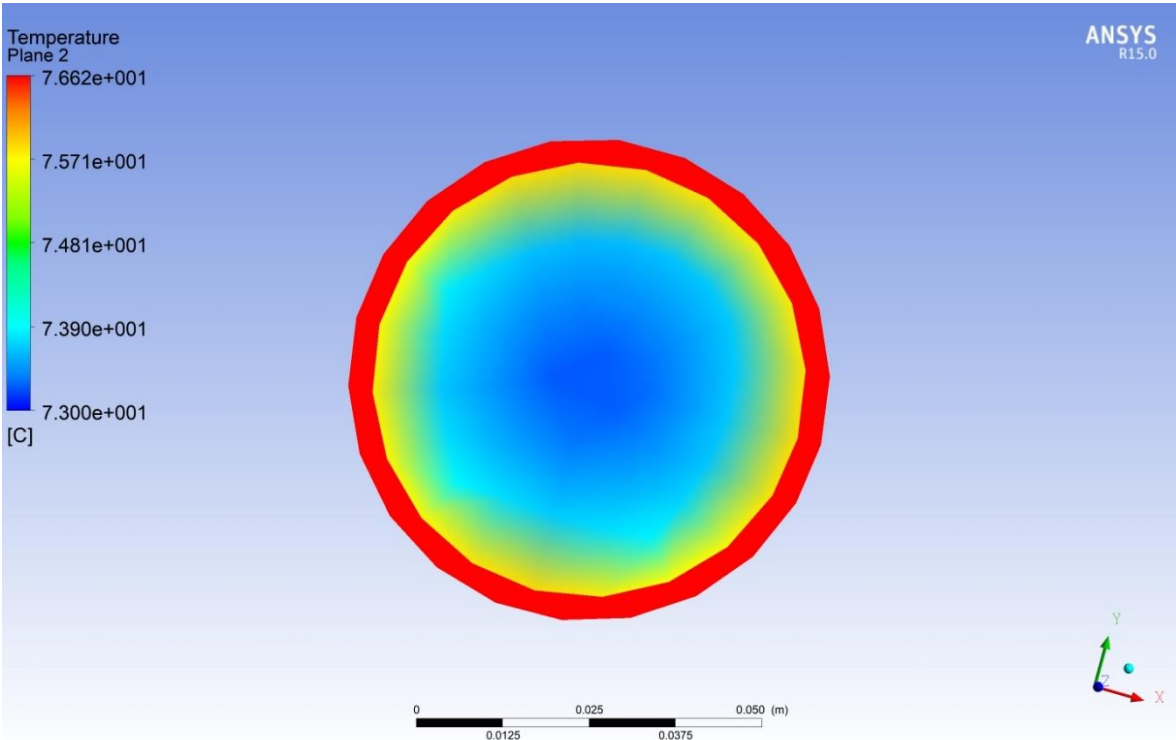
Temperature at 2 pm in T5



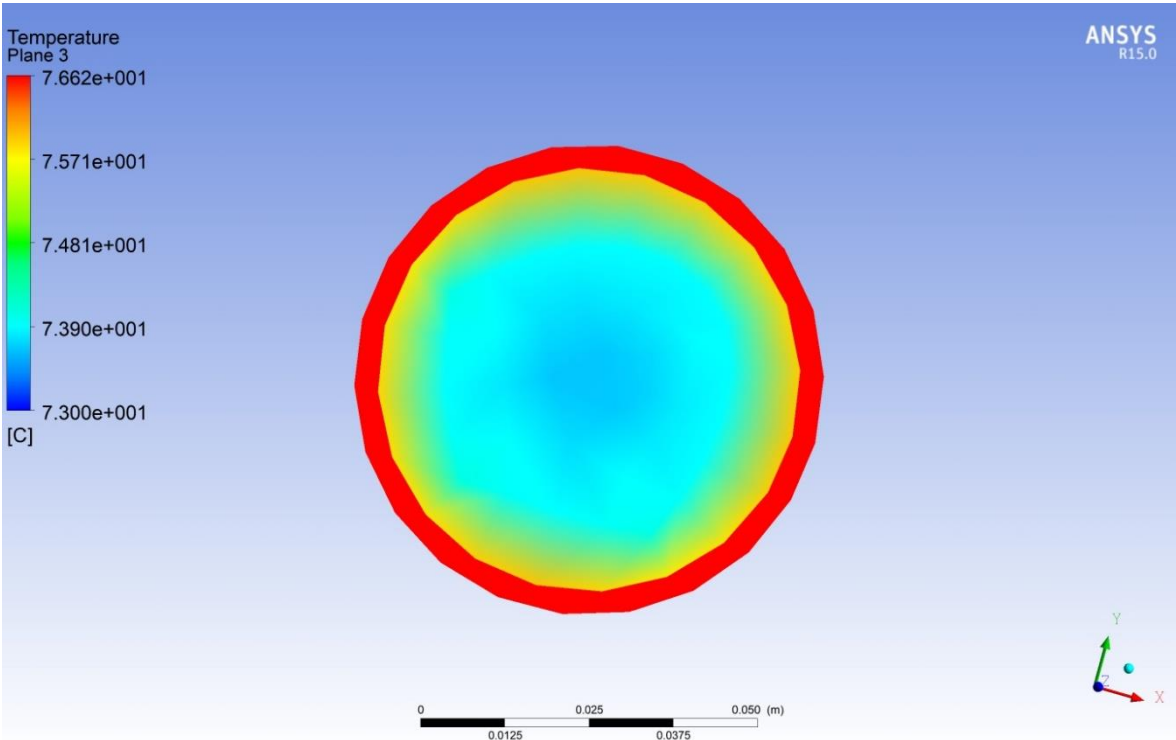
Temperature at 4 pm in T1



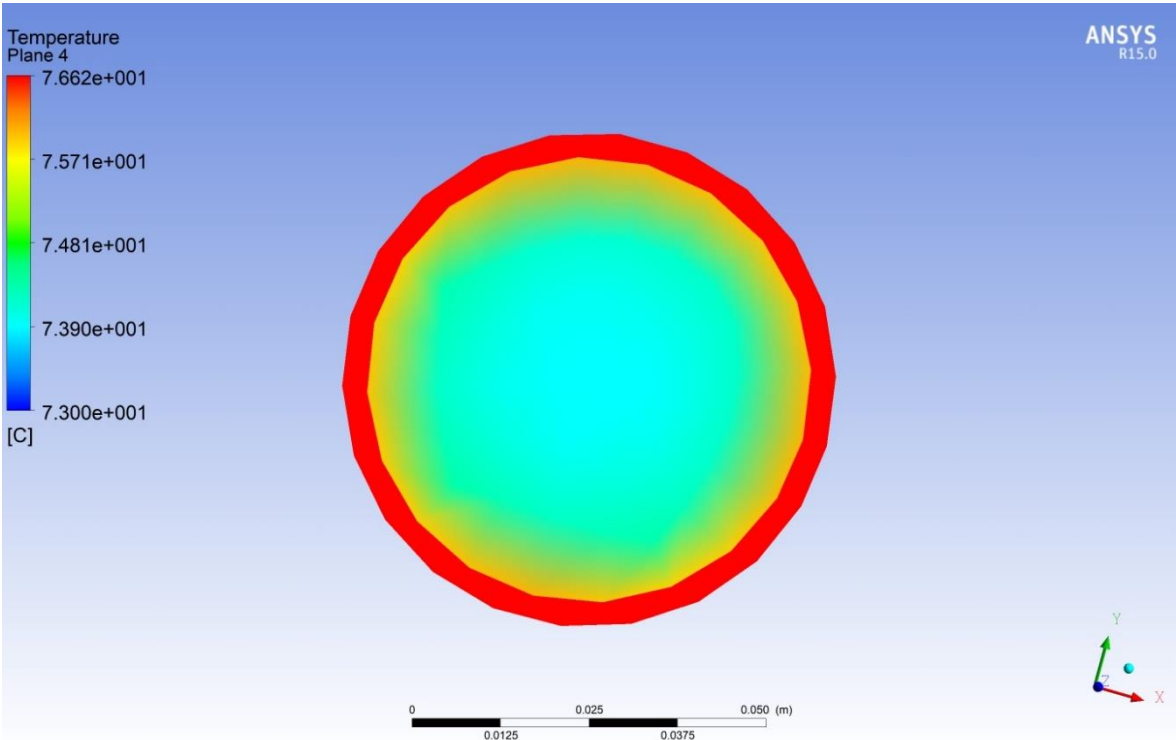
Temperature at 4 pm in T2



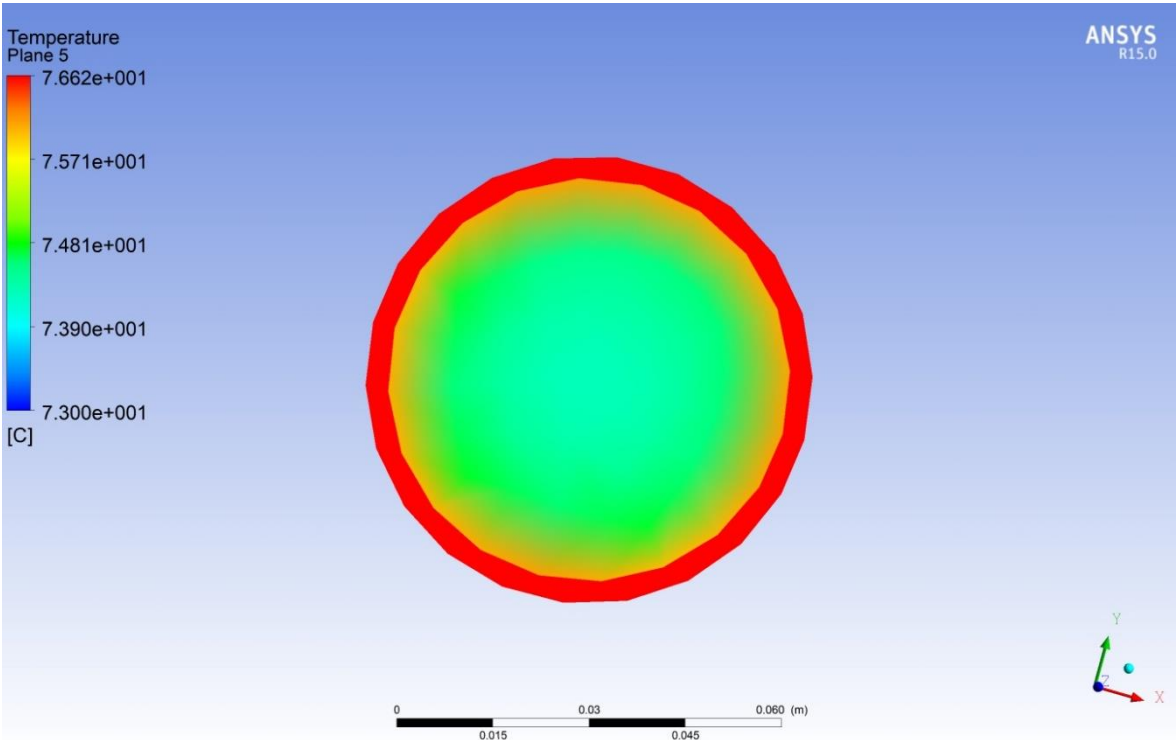
Temperature at 4 pm in T3



Temperature at 4 pm in T4



Temperature at 4 pm in T5







## CHAPTER 6

### SUMMARY AND CONCLUSION

As we know that most of the time materials life depend upon the thermal strain which is cause due to the force. The applied force can be any form of temperature the resultant stress is called thermal stress. It is normal when a object contract or expands due to temperature. The best way to analysis is by use of heat pipe which is more practical and easy way to experiment the nano particles . After the experiment is conducted in the heat pipe it is later taken for analysis using CFD software. CFD is applied to a wide range of research and engineering problems so using the CFD it can show us the proper visual analysis. While comparing the heat pipe with CFD it shows us that the the level of thermal strain in nanao particles

According to the results it shows us that the thermal strain of the therminol 55 is lesser which is proven properly using the heat pipe and later it is visually analysis use the CFD software. By selecting a nanoparticle proper in an application in a real usage it can extremely helps in reduction of thermal strain which will eventually increases the life of the application. Hence the above results may have some small difference under real life working condition



