

CFD ANALYSIS OF NORTH WALL INSULATED GREEN HOUSE SOLAR DRYER WITH NO LOAD CONDITION

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering degree in Mechanical Engineering
By

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of Amaladoss Vinod Castro C (37150009) and Akash I (37150007) who carried out the project entitled **"CFD ANALYSIS OF NORTH WALL INSULATED GREEN HOUSE SOLAR DRYER WITH NO LOAD CONDITION"** under my supervision from August 2020 to March 2021.

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We Amaladoss Vinod Castro C (37150009) and Akash I (37150007) hereby declare that the Project Report entitled “**CFD ANALYSIS OF NORTH WALL INSULATED GREEN HOUSE SOLAR DRYER WITH NO LOAD CONDITION**” done by us under the guidance of **Dr.T.N. VALARMATHI, M.E., Ph.D.** is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Mechanical Engineering.

1.

2.

DATE:

SIGNATURE OF THE CANDIDATE

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ABSTRACT

The seasonal agricultural products could be dried when surplus quantity is produced and it can be consumed when not cultivated.

Drying of food materials consumes more time and needs more energy. So, to reduce the time and energy requirement, Green house solar dryer is one of the cheapest drying methods since it consumes naturally available solar energy.

The use of greenhouse dryer keeps the food safe from dirt, dust and even from adverse weather conditions instead of keeping the food material in open sun light.

The computational fluid dynamics (CFD) is the most powerful tool required to optimize the design and analysis of the greenhouse dryer. The CFD analysis is planned to carried out with north wall insulated greenhouse solar dryer with no load condition.

Temperature profiles under various ambient conditions are to be analyzed to find the most efficient drying conditions.

The scope of this research is mainly to use the available renewable and sustainable energy resources effectively.

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CHAPTER 1

1.1 INTRODUCTION

The world is plunging quickly towards energy emergency with anticipated depletion of petroleum products by 2050. Studies show that lion's share of Indian populace living in the distant doesn't approach power. A definitive method to diminish energy utilization of petroleum derivative and its valuable protection is the far and wide utilization of sun powered energy at every possible opportunity. solar energy is the essential fuel source to our planet and any remaining fuel sources are gotten from it. It is assessed that solar energy got in India goes from 4 to 7 KWh/m² with 300 radiant days. Numerous examinations have uncovered that regardless of whether we use under 1% of the absolute land territory accessible, that can create a Solar force of 3400 TWh/yr. In a tropical nation like India the greater part of the energy requests can be met by straightforward frameworks that can change over Solar energy into fitting structures. By appropriate use of advances, incredible thermodynamic match between the sun powered energy assets and many end-clients can be accomplished.

Solar energy transformation strategies incorporate (i) thermal conversion, (ii) electrical conversion and (iii) photochemical conversion. Solar direct usage of solar energy should be possible by two innovations – Solar photovoltaic (PV) and solar technologies. Solar photovoltaic can utilized for direct transformation of solar energy to power, while solar thermal can be utilized for changing solar energy over to nuclear power or electrical energy. Liquid warming is the most generally utilized solar warm application. Water or air is the most ordinarily utilized liquid in sun powered warm gatherers. Much advancement has been accomplished over the course of the years in Solar water radiator with various advances like flat plate collectors (FPCs), evacuated tube heat pipes (ETCs) and emptied tube heat pipes (ETHPs). In contrast to water, air doesn't have great thermodynamic properties and subsequently the productivity won't be comparable to sun powered water warmers. Be that as it may, solar air radiators are less convoluted than solar water warmers in light of less effect of erosion and spillage. Sun powered air warmers are generally utilized for crop drying, measure warming, wood preparing, space warming and different applications.

Numerous analysts have approached with various developments to improve the presentation of solar air radiators. Exploratory investigations say that the productivity and energy loss of a solar air warmer with free and fixed balances. It was tracked down that fixed blades are more successful than free balances as they produce higher outlet temperature and less pressing factor drop. The exhibition of a constrained convection Solar level plate air warmer with energy stockpiling. Exploratory and hypothetical outcomes show that the mass stream rate and solar radiation are the significant boundaries which decide the exhibition of the gatherer. The investigation on advancing the solar air warmer plan for 10 setups of safeguard plates uncovered that twofold stream design with a solitary coating showed better execution.

The exhibition of Solar technologies with permeable gatherer, for various mass stream rates and diverse kind of materials like glass fleece and steel fleece and tracked down that the productivity increments with expanding mass stream rate. There is additionally expansion in effectiveness of about 10% for glass fleece and 26% for steel fleece. A roof sun powered air heating framework for drying applications was planned by Sreekumar and its presentation was broke down utilizing a Batch drier. The Batch drier was utilized to dry pineapple cuts with beginning dampness substance of about 82% to the ideal degree of under 10% in 8 h. Financial investigation was finished utilizing three strategies, in particular annualized cost, present worth of yearly reserve funds and present worth of total reserve funds. Writing study uncovers the advancement of sun powered air warmers with various alterations in safeguard plate like balances, confounds, permeable plates, expanded harshness, grid plates, wire network, and so on

1.2 SOLAR DRYERS

Solar dryers are devices that use solar energy to dry substances, especially food. There are two general types of solar dryers: Direct and indirect.

1.2.1 Direct

Direct Solar dryers open the substance to be dried out to direct sunlight. Historically, food and attire were dried in the sun by using lines, or laying the things on rocks or on top of tents. In Mongolia cheddar and meat are still generally dried utilizing the highest point of the gear (tent) as a solar dryer. In these frameworks the sun

powered drying is helped by the development of the air (wind) that eliminates the more immersed air away from the things being dried. More as of late, complex drying racks [4] and solar tents were built as solar dryers. One current sort of Solar dryer has a black absorbing surface which gathers the light and converts it to warm; the substance to be dried is set straightforwardly on this surface. These driers may have enclosures, glass covers and/or vents to in order to increase efficiency.

1.2.2 Indirect

In Indirect solar dryers, the dark surface warms approaching air instead of straightforwardly warming the substance to be dried. This warmed air is then disregarded the substance to be dried and exits upwards regularly through a chimney, taking moisture released from the substance with it. They can be exceptionally straightforward, simply a shifted cold casing with dark cloth to a protected block working with active ventilation and a back-up warming system. One of the benefits of the backhanded framework is that it is simpler to ensure the food, or other substance, from defilement whether wind-passed up birds, creepy crawlies, or animals. Also, direct sun can synthetically adjust a few food varieties making them less tantalizing.

CHAPTER 2

2.1 LITERATURE REVIEW

Abhay et al., [1] Drying agrarian food items in an indirect type solar dryer (ITSD) is a subject of incessant research. Heat move rate to the liquid stream in the Solar authority can be upgraded by giving counterfeit harshness on the outside of the absorb err plate. The current work focuses on wind stream and warmth move qualities in a Solar air gatherer gave unpleasantness of square molded rib over the safeguard of ITSD. 2D mathematical reenactments are performed for course through the solar air authority for relevant Reynolds number (Re) which goes from 3800 to 18,000. The Re , relative roughness pitch (P/e), relative unpleasantness stature (e/D) and thermo-water powered execution boundary (THPP) are picked as plan factors. The overseeing conditions for tempestuous stream field are addressed utilizing RNG $k-\epsilon$ turbulence model. The reproduction results are contrasted and smooth conduit which shows that the channel with roughened surface improves the warmth move and friction factor (for) by 2.13 and 3.54 occasions, individually. The solar air gatherer with harshness of square molded rib with $P/e = 7.14$ gives better THPP of 1.45 at Re of 15000. It is tracked down that the extra drying chamber temperature of 4 K and warmth gain of 106% when the dryer is moved up to roughened surface from smooth surface.

Adnan, et al. [2] Perfect and practical energy age is a generous need for creating world. Solar energy is a widely used sustainable power asset and it tends to be used for both power and nuclear power age. Sun powered warm applications could be used in different cycles like space warming and drying. In this examination, two savvy and straightforward organized solar air radiators were planned and made. The primary warmer is an empty cylinder type radiator. Second warmer has similar essential properties however iron lattices were included the stream channel to broaden its warmth move surface region. The lattice adjusted cylinder type warmer was produced in regards to mathematical reenactment discoveries utilizing Ansys Fluent programming. The two warmers were coordinated with a drying chamber and drying tests were directed at three air mass stream rates (0.014, 0.011 and 0.009 kg/s). The most extreme quick warm effectiveness in iron lattice changed solar warmer was gotten as 74.71%. Using network change improved warm productivity of the cylinder type warmer up to 11%. Likewise, the most elevated estimations of the normal energy proficiency of the drying framework were accomplished as 50.85% too in iron lattice adjusted sun powered helped dryer. It is seen that this rounded SAH configuration is promising taking into account sustainable hot air age with its basic and savvy structure

since it incorporates no packaging, no protection material and manufactured from sheet metal.

Arina Mohd et al. [3] Drying is a significant interaction in numerous ventures to decrease dampness content inside the item to a protected cutoff to lessen misfortunes or as a prerequisite for the downstream cycles. It's likewise contributed in decreasing the taking care of and capacity cost. In convective drying, temperature and speed of the drying air have been distinguished as the significant components that affecting the drying pace of the item. New sun powered drying have been produced for sericite mica drying measure. The goals of this paper are to reproduce and examine the impact of item plan and distinctive working condition on the temperature and wind stream dissemination inside the drying office of the recently evolved Solar dryer. Business CFD programming, Ansys Fluent was utilized in the examination. The outcomes from CFD recreations shows that the crisscross bed course of action produces higher and more uniform wind current contrasted with the straight bed game plan. Three potential working conditions for the sun powered dryer have been recognized and reenacted which are nursery impact with aloof ventilation, nursery impact with dynamic ventilation and nursery impact with discontinuous dynamic ventilation. CFD reproduction results show that the working condition with discontinuous dynamic ventilation produce the most noteworthy temperature for both inside the drying chamber and inside the sericite mica which is up to 59.8 and 55.6oC individually.

Osage, et al. [4] introduced work, double-pass indirect solar dryer (DPISD) and twofold pass circuitous solar dryer with network safeguard alteration (DPISDMA) have been planned, dissected, made and tried. The fundamental point of this examination is improving the warm effectiveness of twofold pass solar air gatherer by incorporating iron cross sections. Pepion organic product (Solana muriatic L.) examples in two thicknesses have been utilized in the exploratory investigation. Additionally, CFD examination of both solar air authorities and drying chamber and quality measurements like phenolic, absolute flavonoid substance and cancer prevention agent movement have been directed. Mathematical reenactment and trial results showed that utilizing network adjustment has positive effect on the presentation of the authority. The most elevated estimation of the normal effectiveness of the dryer was gotten in DPISDMA for the meager example thickness as 23.08%. As per quality investigations, the trials which done in DPISDMA gave the best outcomes with most noteworthy estimations of TPC, TFC and cell reinforcement movement esteems ($p < 0.05$).

Purusothaman et al. [5] Creative innovations are expected to make the existence simple.

The advancements are best utilized utilizing inexhaustible wellspring of energy. Nursery solar dryer is a gadget utilized for drying reason. Computational liquid elements investigation reproduction is performed on nursery solar dryer when presented to a surrounding temperature on a hot radiant day with the expectation of complimentary convection and constrained convection measures. The mass stream rate and the thickness of polycarbonate rooftop sheet material differ. The normal temperature of the dryer is dissected utilizing recreation. The most extreme temperature acquired by constrained convection is 71°C for 0.025 kg/s mass stream rate, which is 41% more than that got by regular convection.

Purusothaman et al. [6] The seasonal agricultural products could be dried when surplus quantity is produced and it can be consumed when not cultivated. Drying of food materials consumes a much time and energy. Green house dryer is the cheapest drying methods since it consumes naturally available solar energy. The use of greenhouse dryer keeps the food safe from dirt, dust and even from adverse weather conditions instead of keeping the food material in open sun light. The computational fluid dynamics is most powerful tool required to optimize the design and analysis is carried out with different roof structure greenhouse solar dryer like hemispherical, trapezium and triangle. The dryer analysis was carried out with free and forced convection for Triangle, hemispherical and trapezoidal and also analyzed the performance with no load condition. Temperature profiles under various ambient conditions were analyzed to find the most efficient dryer. The result concludes that trapezoidal roof shape greenhouse dryer has maximum temperature than other shapes of greenhouse solar dryer.

Sanghi, Achint et al. [7] A computational liquid elements model was created to reenact the corn drying measure in a solar bureau dryer. Occurrence solar radiation was demonstrated utilizing a double band range to reproduce the retention of shortwave radiation by corn and record for the nursery impact brought about by coating materials. The exhibition of the dryer was mimicked at reasonable and cloudy climate conditions. The model permitted perception of temperature, stickiness, and air speed profiles in the dryer. The model was approved with trial results, which showed an over prediction of temperature (8.5%) and stickiness (21.4%). The test dampness profile proposes that there was stagnation in the wind current of the dryer, which was precisely anticipated by the model. The model was utilized to reenact the dryer's presentation under cloudy conditions, and the anticipated dampness evacuation was 32% not exactly the mimicked reasonable climate case.

Senthil Kumar et al. [8] Dynamic usage of solar energy for warming and drying is need of

the day for a few homegrown and business applications. Demonstrating and examination of a commonplace Solar harvest dryer cum water warmer has been introduced in this paper. A slim layered bed solar dryer with water warmer was demonstrated in strong works programming. CFD investigation is completed to assess warm and wind current execution. An exhibition examination by insightful displaying was surrendered by energy balance conditions for working liquids and solar dryer segments. The consequences of insightful technique and CFD examination were related. The ideal presentation boundaries of the framework were shown up with differed stream rate information.

2.2 CONCLUSIONS FROM THE LITERATURE REVIEW

- Solar driers are gaining importance due to the striving measures towards sustainable development
- The potential of solar energy is high at Chennai where the average solar radiation crosses 1200 W/m².
- The performance of the solar dryer depends on the type of roof, insulation and the air movement in the dryer.

CHAPTER 3

3.1 AIM

- The work is to compare the performance of the solar drier with triangular and parabolic roof tops.
- To find the effectiveness of north wall insulation on the performance of the solar drier.

3.2 SCOPE OF THE PROJECT

- Drying rate is faster under forced convection than natural convection mode.
- Convective heat transfer coefficient is more than open sun drying mode.
- Green house drying reduce moisture content in very less time.
- Green house agricultural dryers are much higher quality and more effective than open sun drying
- Temperature profiles under various ambient conditions are to be analyzed to find the most efficient drying conditions.
- The scope of this research is mainly to use the available renewable and sustainable energy resources effectively.

CHAPTER 4

EXPERIMENTAL METHOD

4.1 METHOD OF ANALYSIS

Step 1: Literature review and the conclusions

Step 2: To design a triangular and parabolic roofed Greenhouse solar dryer

Step 3: To develop and 3D model for Green house solar dryer

Step 4: Analyze the performance of the dryer based on the maximum temperature at a given time and location using ANSYS Fluent.

Step 5: Simulate the performance of the solar dryer at Satyabhama University from 9am to 5pm.

Step 6: Simulate the performance of the system with triangular and parabolic roof.

Step 7: Simulate the performance of the system with and without north wall insulation.

Step 8: Comparison of the system based on the max temperature obtained at the specified time duration.

4.2 FLOW CHART

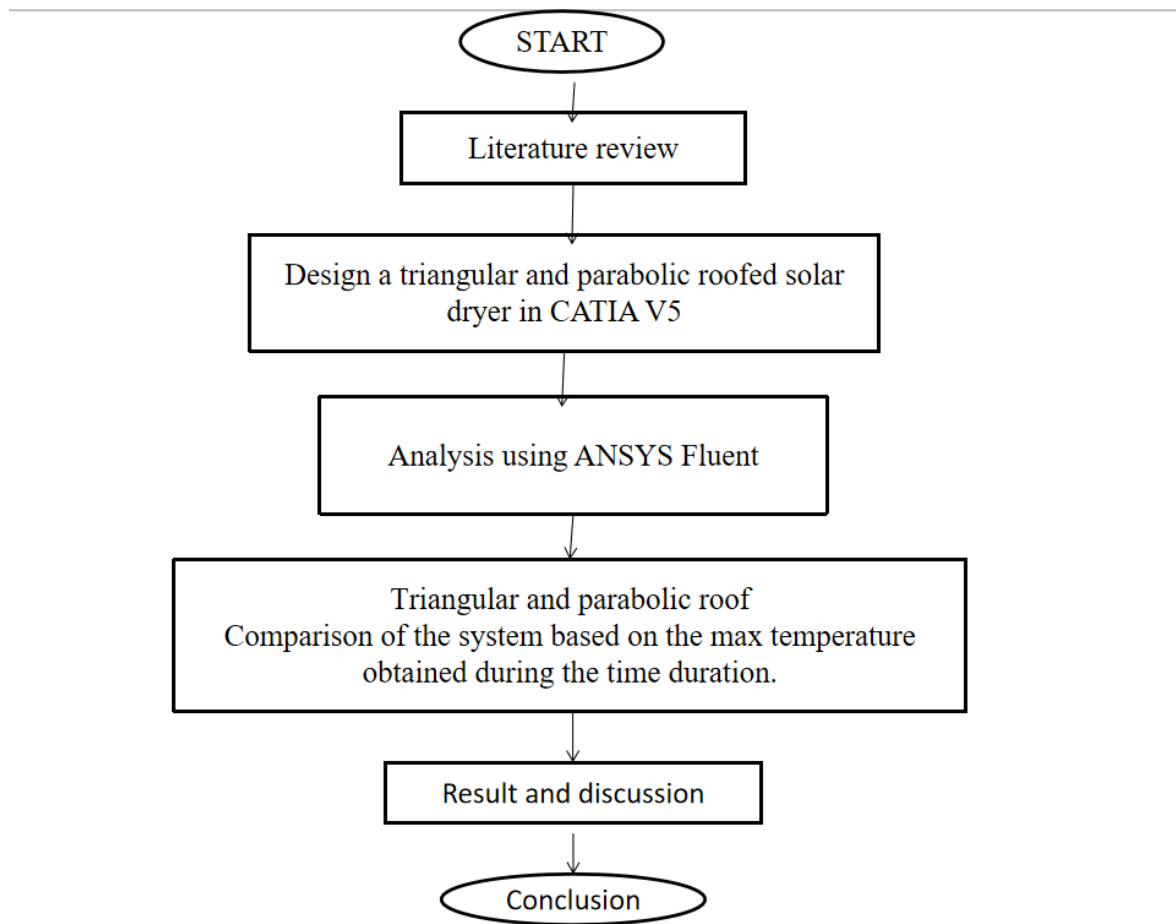


Fig. 4.1 Flowchart of work

4.3 CFD ANALYSIS OF GREENHOUSE DRIER

CFD is method to solve complex problems involving fluid flow. The computer simulation that is the analysis was done using Ansys-Fluent. When we performed this analysis, we found out the variation of parameters as we did in the case of theoretical treatment.

The CFD Analysis was done in the following steps:

- Modelling
- Meshing
- Pre processing
- Solver/Processing
- Post processing

The model created by above dimensions was meshed in mesh mode of Ansys component systems. Meshing is all about converting an infinite number of particles model of finite number of particles. The details of mesh are Physics preference: CFD, Solver preference: Fluent. Mapped face Meshing was used with the face. Then Body Sizing, the element size was chosen 0.05m. The number of nodes were calculated.

The next step of the CFD after meshing is preprocessing. In preprocessing appropriate boundary conditions are applied to the meshed model. The preprocessing was done in Ansys Fluent.

The next step is solver. In solver the solution is initialized and calculation is preceded with the desired number of iterations. It is the most important step of CFD analysis. Using Ansys-Fluent, it is possible to solve the governing equation related to the flow physical properties.

4.3.1 Advantages of CFD

- Computational fluid dynamics (CFD) is the science of predicting fluid flow, heat transfer, mass transfer, chemical reactions, and related phenomena by solving the mathematical equations which govern these processes using a numerical process
- Relatively low cost - CFD simulations are relatively inexpensive, and costs are likely to decrease as computers become more powerful.
- Speed- CFD simulations can be executed in a short period of time.
- Ability to simulate real conditions – CFD provides the ability to theoretically simulate any physical condition.
- Comprehensive information – CFD allows the analyst to examine a large number of locations in the region of interest, and yields a comprehensive set of flow parameters for examination.

4.4 GREENHOUSE DRIER WITH TRIANGULAR ROOF TOP

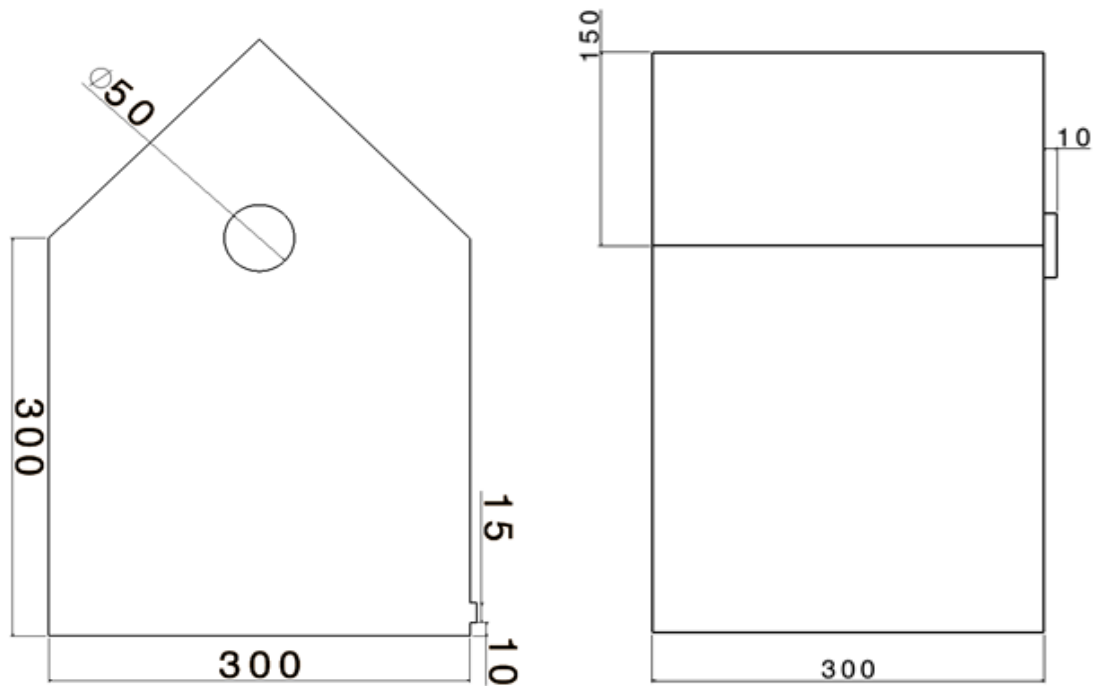


Fig.4.2 Front and side views of the greenhouse dryer with triangular roof

Mesh Characteristics

Mesh

Nodes- 36577

Elements – 191689

Element Type – Tetrahedral Elements

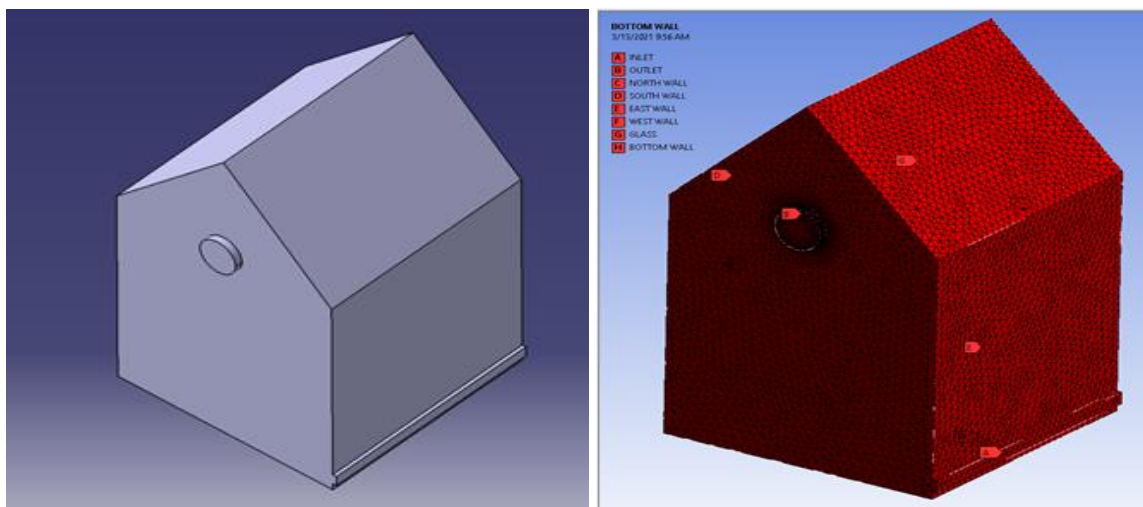


Fig.4.3 CATIA V5 Model and ANSYS MESH Model of the greenhouse with triangular roof top

4.5 GREENHOUSE DRIER WITH PARABOLIC ROOF

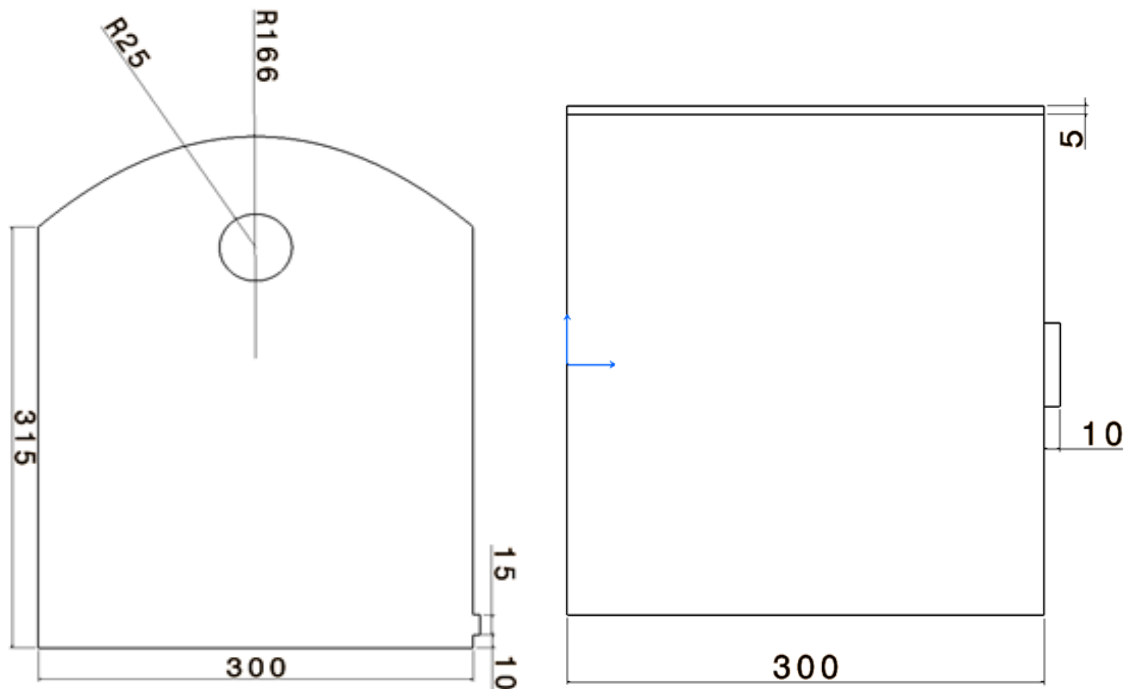


Fig. 4.4 Front and side view of the greenhouse drier with parabolic roof

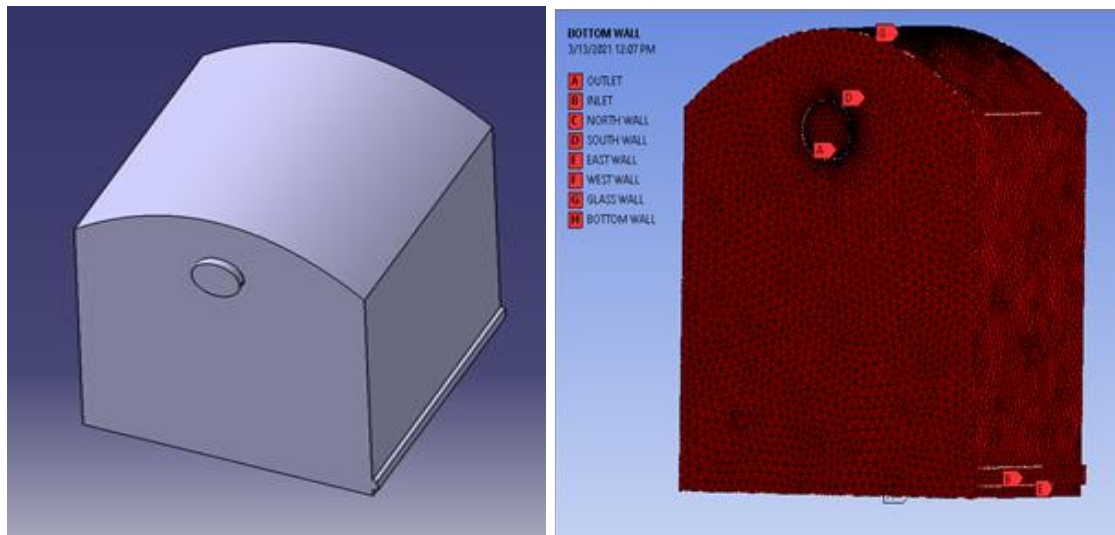


Fig. 4.5 CATIA V5 Model and ANSYS MESH Model of the greenhouse with parabolic roof

Mesh Characteristics

Mesh

Nodes- 38975

Elements – 203566

Element Type – Tetrahedral Elements

4.6 INLET AND BOUNDARY CONDITIONS

Table 4.1 Inlet and Boundary Conditions

Parameters	Values
	Longitude 80.2184° E, Latitude 12.8725° N
Inlet air velocity	2 m/s
Inlet air temperature	27 °C
Roof shape Material	Triangular and parabolic Glass

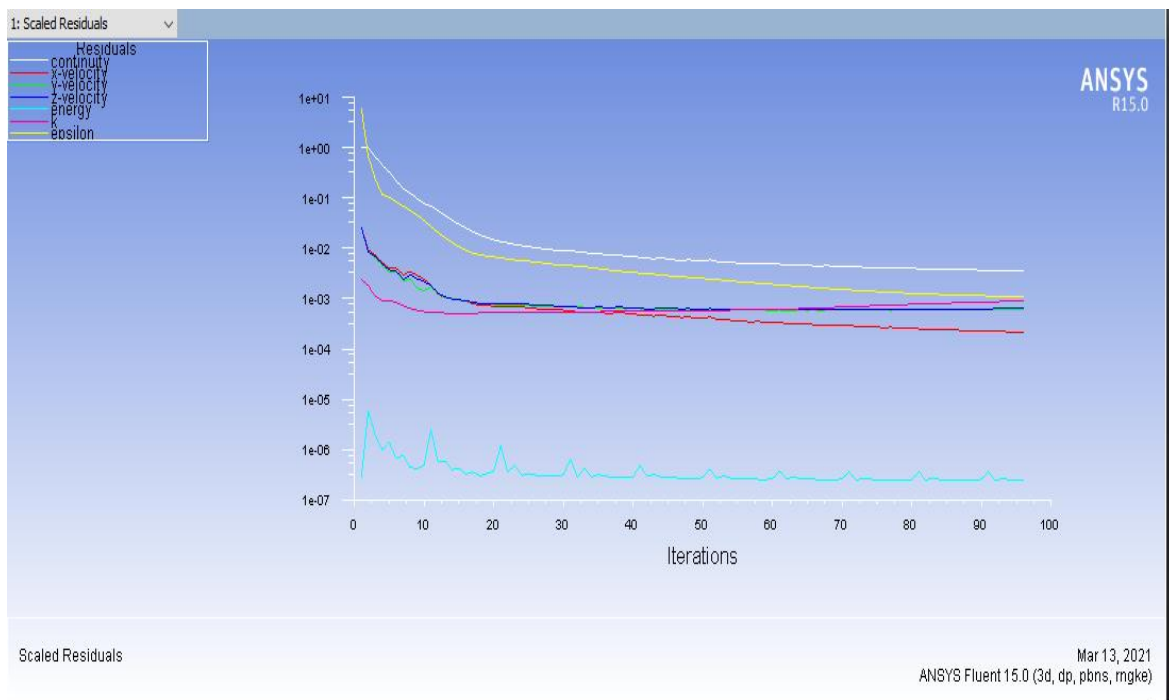


Fig. 4.6 Convergence

Chapter 5

5.1 RESULTS AND DISCUSSION

5.1.1 Simulation results of triangular roof without north wall insulation

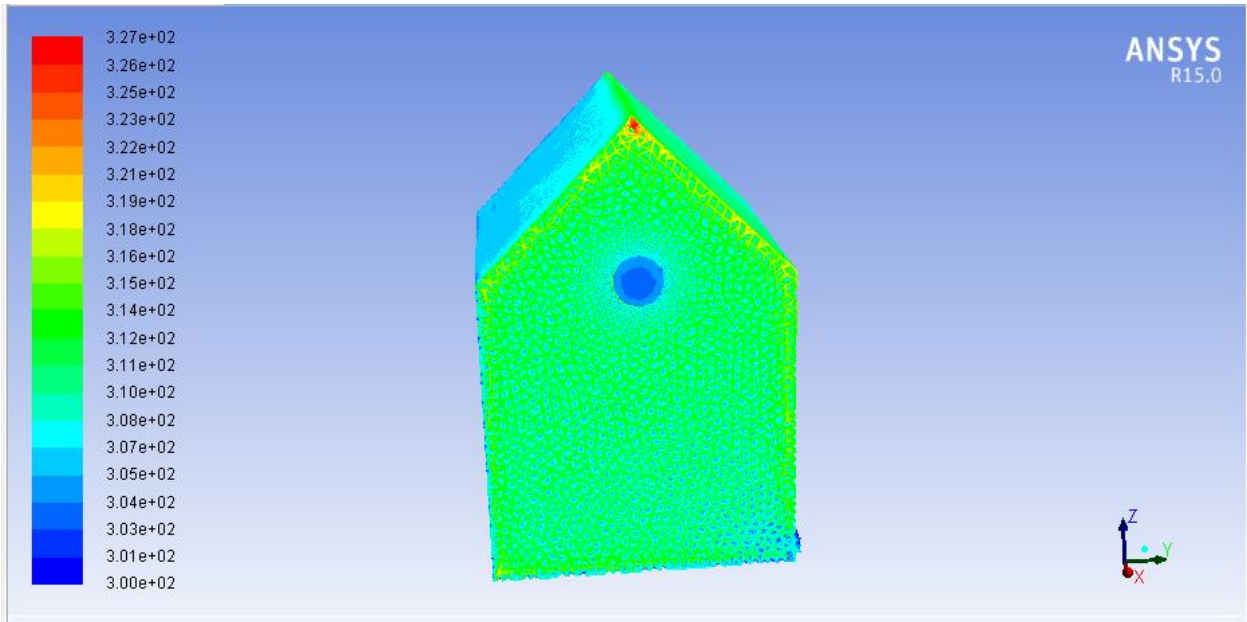


Fig 5.1 Temperature contour for triangular roof at 9am

The dryer is designed and analyzed with same volume with triangle roof. The dimensions of triangle are 300x300 as shown in Fig 5.1. The system was analyzed without the north wall insulate at 9AM. The hole of diameter 15mm is placed for forced convection with an exhaust outlet. The outlet exhaust is at the top and the inlet is at the bottom openings with an inlet velocity of 2 m/s. It is noticed that maximum temperature achieved is 32.7°C due to the linear contact area with highest solar radiation on roof is larger. The inside temperature of the dryer is more than outside temperature as the heat is collected inside the dryer due to greenhouse effect. There is a gradual rise in the temperature from top to bottom of the plane. This is due to the solar radiation passes through the glass which acts like a transparent, allowing the radiation from sun into dryer. As a result, heat is collected in dryer by convection and exhaust fan is used to removes the air from the dryer slowly thereby increase the temperature of the dryer.

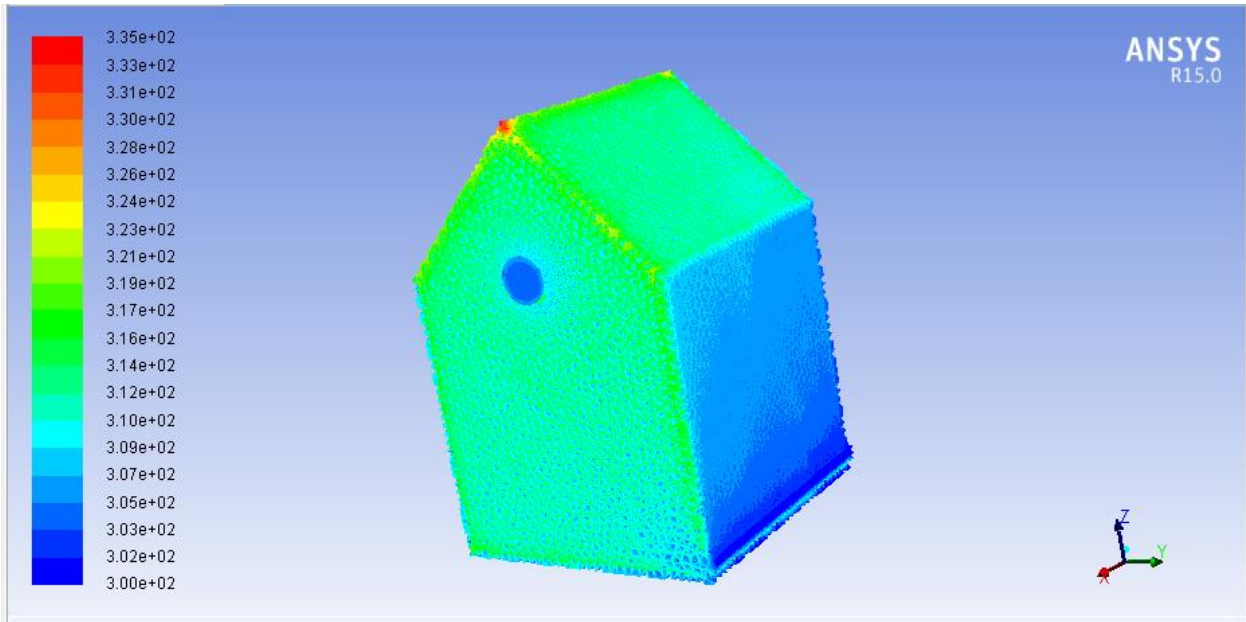


Fig 5.2 Temperature contour for triangular roof at 11am

The dryer is planned and examined with same volume with triangle rooftop. The elements of triangle are 300x300 as demonstrated in Fig 5.2 The system was analyzed without the north wall insulate at 11AM. the hole of the diameter 15mm is placed for forced convection with an exhaust convection. The power source exhaust is at the top and the delta is at the base openings with a gulf speed of 2 m/s. It is seen that most extreme temperature accomplished is 33.5°C because of the straight contact territory with most noteworthy sun powered radiation on rooftop is bigger. Within temperature of the dryer is more than outside temperature as the warmth is gathered inside the dryer because of greenhouse impact. There is a continuous ascent in the temperature start to finish of the plane. This is because of the sun powered radiation goes through the glass which acts like a straightforward, permitting the radiation from sun into dryer. Accordingly, heat is gathered in dryer by convection and exhaust fan is utilized to eliminates the air from the dryer gradually subsequently increment the temperature of the dryer.

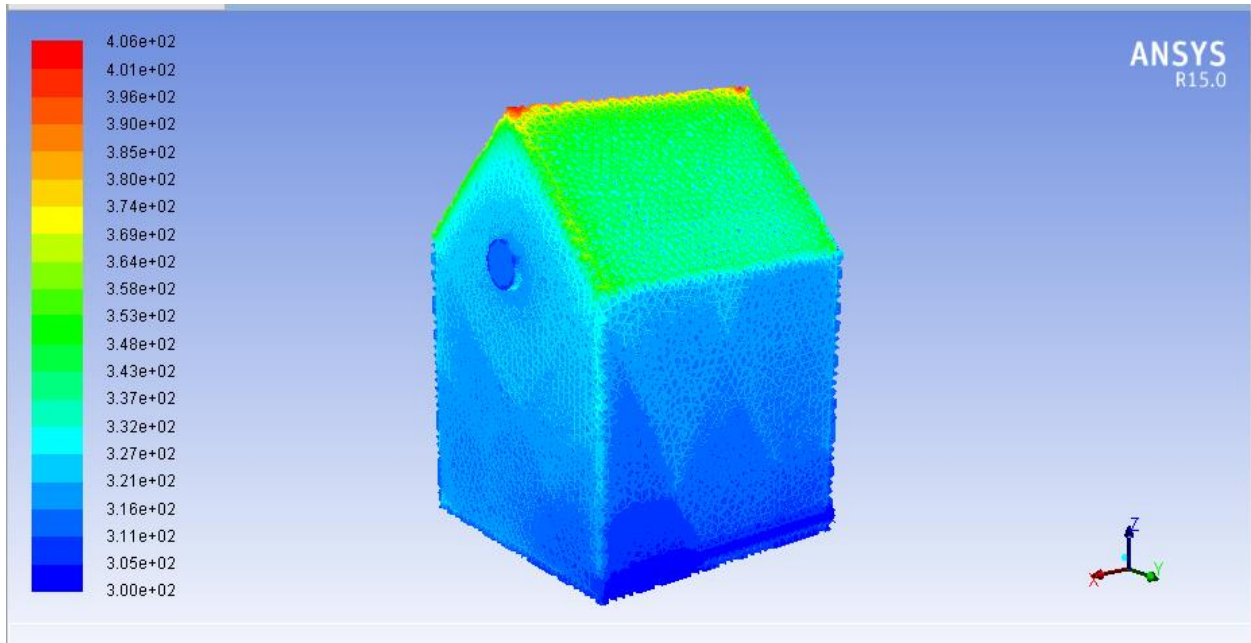


Fig 5.3 Temperature contour for triangular roof at 1pm

The dryer is planned and examined with same volume with triangle rooftop. The components of triangle are 300x300 as demonstrated in Fig 5.3. The system was analyzed without the north wall insulate at 1PM. The hole of diameter 15mm is placed for forced convection with an exhaust outlet. The power source exhaust is at the top and the channel is at the base openings with an inlet velocity of 2 m/s. It is seen that greatest temperature accomplished is 40.6°C because of the direct contact zone with most elevated sun powered radiation on rooftop is bigger. Within temperature of the dryer is more than outside temperature as the warmth is gathered inside the dryer because of greenhouse impact. There is a continuous ascent in the temperature start to finish of the plane. This is because of the sunlight-based radiation goes through the glass which acts like a straightforward, permitting the radiation from sun into dryer. Accordingly, heat is gathered in dryer by convection and exhaust fan is utilized to eliminates the air from the dryer gradually in this way increment the temperature of the dryer.

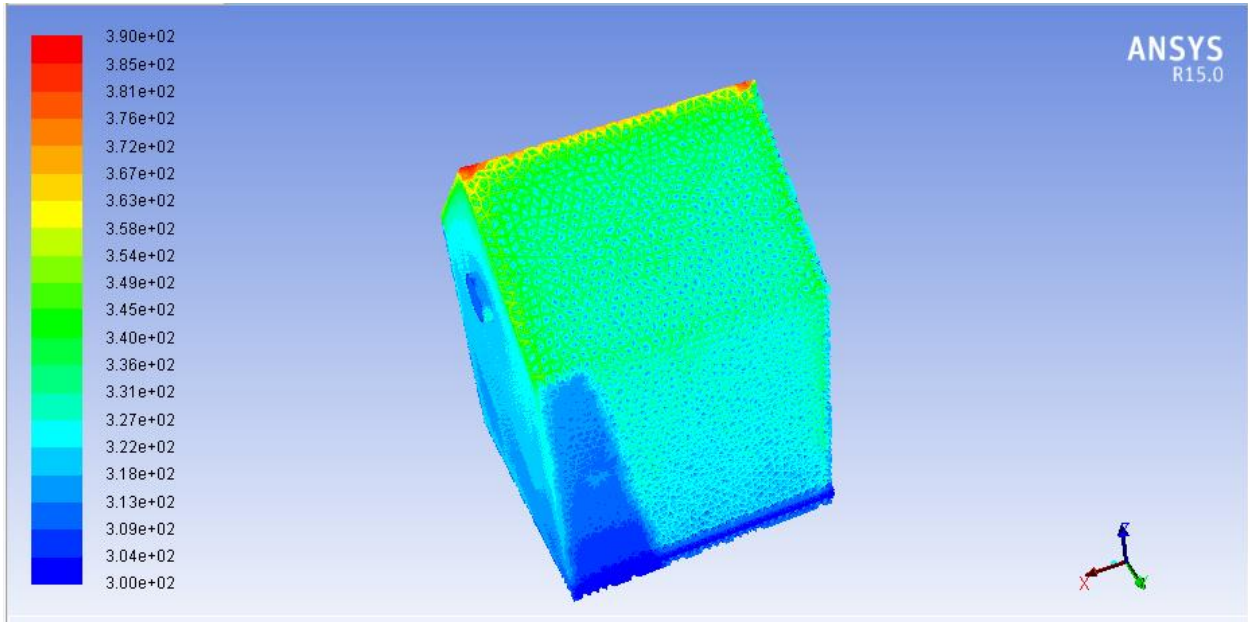


Fig 5.4 Temperature contour for triangular roof at 3pm

The dryer is planned and investigated with same volume with triangle rooftop. The components of triangle are 300x300 as demonstrated in Fig 5.4. The system was analyzed without the north wall insulate at 3PM. the hole of diameter 15mm is placed for forced convection with an exhaust outlet. The power source exhaust is at the top and the bay is at the base openings with a bay speed of 2 m/s. It is seen that greatest temperature accomplished is 39.0°C because of the straight contact region with most noteworthy sun-based radiation on rooftop is bigger. Within temperature of the dryer is more than outside temperature as the warmth is gathered inside the dryer because of greenhouse impact. There is a continuous ascent in the temperature start to finish of the plane. This is because of the sun-based radiation goes through the glass which acts like a straightforward, permitting the radiation from sun into dryer. Therefore, heat is gathered in dryer by convection and exhaust fan is utilized to eliminates the air from the dryer gradually accordingly increment the temperature of the dryer.

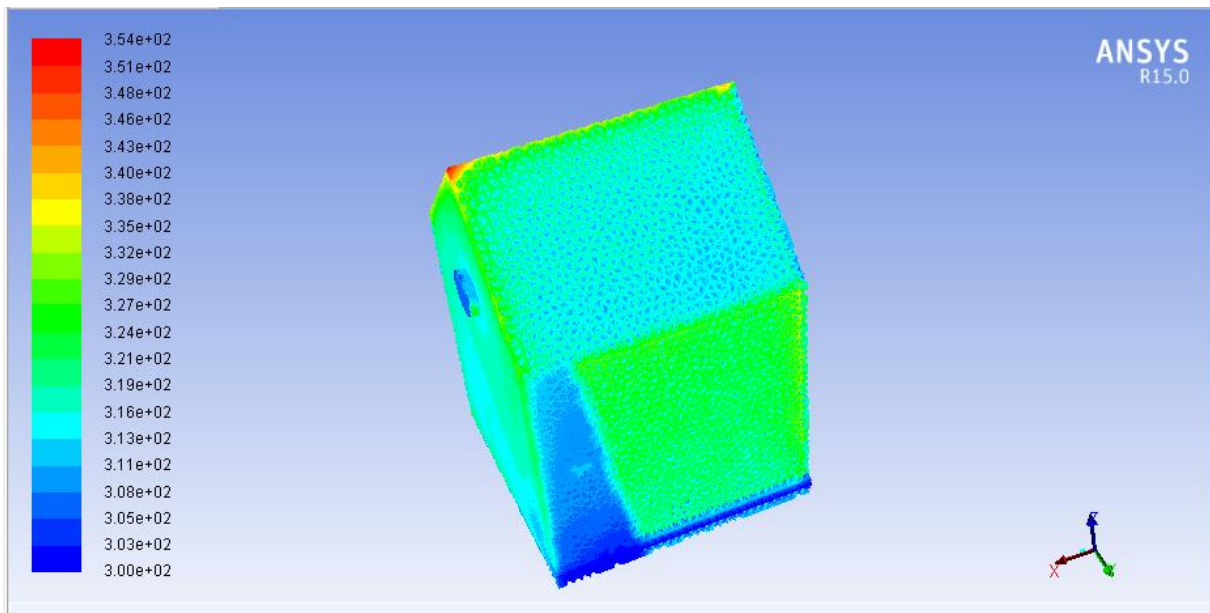


Fig 5.5 Temperature contour for triangular roof at 5pm

The dryer is designed and analyzed with same volume with triangle roof. The dimensions of triangle are 300x300 as shown in Fig 5.1 The system was analyzed without the north wall insulate at 5PM The hole of diameter 15mm is placed for forced convection with an exhaust outlet. The outlet exhaust is at the top and the inlet is at the bottom openings with an inlet velocity of 2 m/s. It is noticed that maximum temperature achieved is 35.4°C due to the linear contact area with highest solar radiation on roof is larger. The inside temperature of the dryer is more than outside temperature as the heat is collected inside the dryer due to greenhouse effect. There is a gradual rise in the temperature from top to bottom of the plane. This is due to the solar radiation passes through the glass which acts like a transparent, allowing the radiation from sun into dryer. As a result, heat is collected in dryer by convection and exhaust fan is used to removes the air from the dryer slowly thereby increase the temperature of the dryer.

5.1.2 Simulation results of triangular roof with north wall insulation

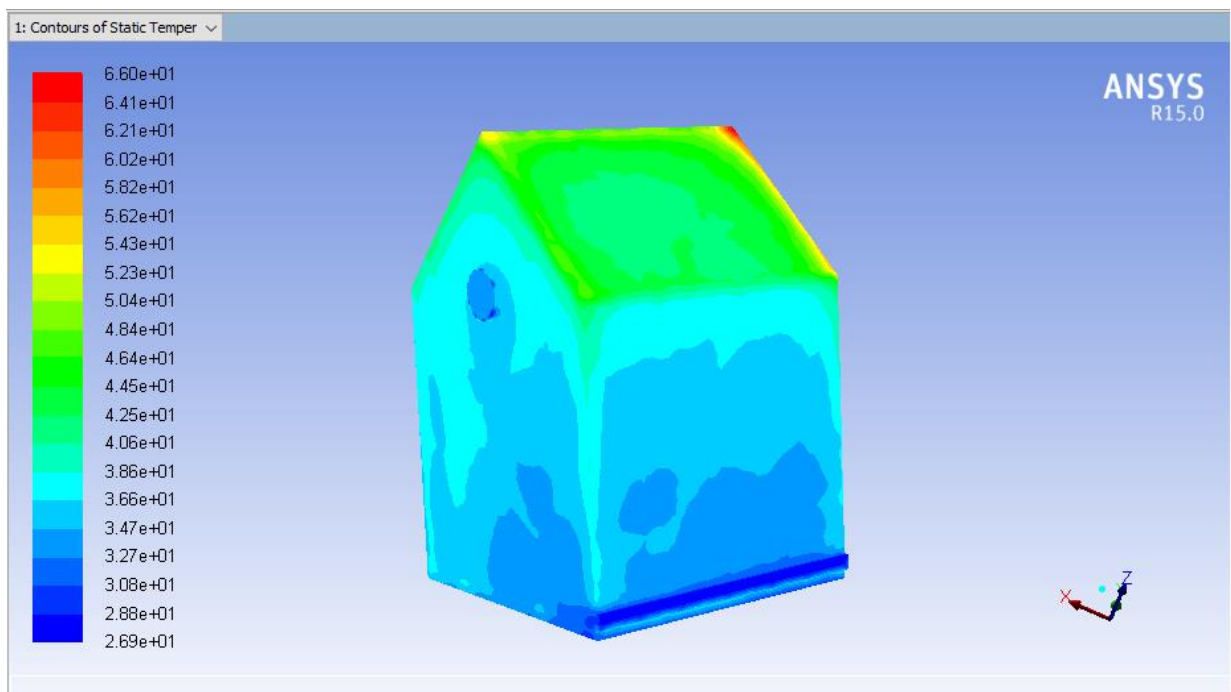


Fig 5.6 Temperature contour for triangular roof at 9am

The dryer is designed and analyzed with same volume with triangle roof. The dimensions of Triangle are 300x300 as shown in Fig 5.6 The system was analyzed with the north wall insulate at 9AM. The hole of diameter 15mm is placed for forced convection with an exhaust outlet. The outlet exhaust is at the top and the inlet is at the bottom openings with an inlet velocity of 2 m/s. It is noticed that maximum temperature achieved is 66.0°C due to the linear contact area with highest solar radiation on roof is larger. The inside temperature of the dryer is more than outside temperature as the heat is collected inside the dryer due to greenhouse effect. There is a gradual rise in the temperature from top to bottom of the plane. This is due to the solar radiation passes through the glass which acts like a transparent, allowing the radiation from sun into dryer. As a result, heat is collected in dryer by convection and exhaust fan is used to removes the air from the dryer slowly thereby increase the temperature of the dryer.

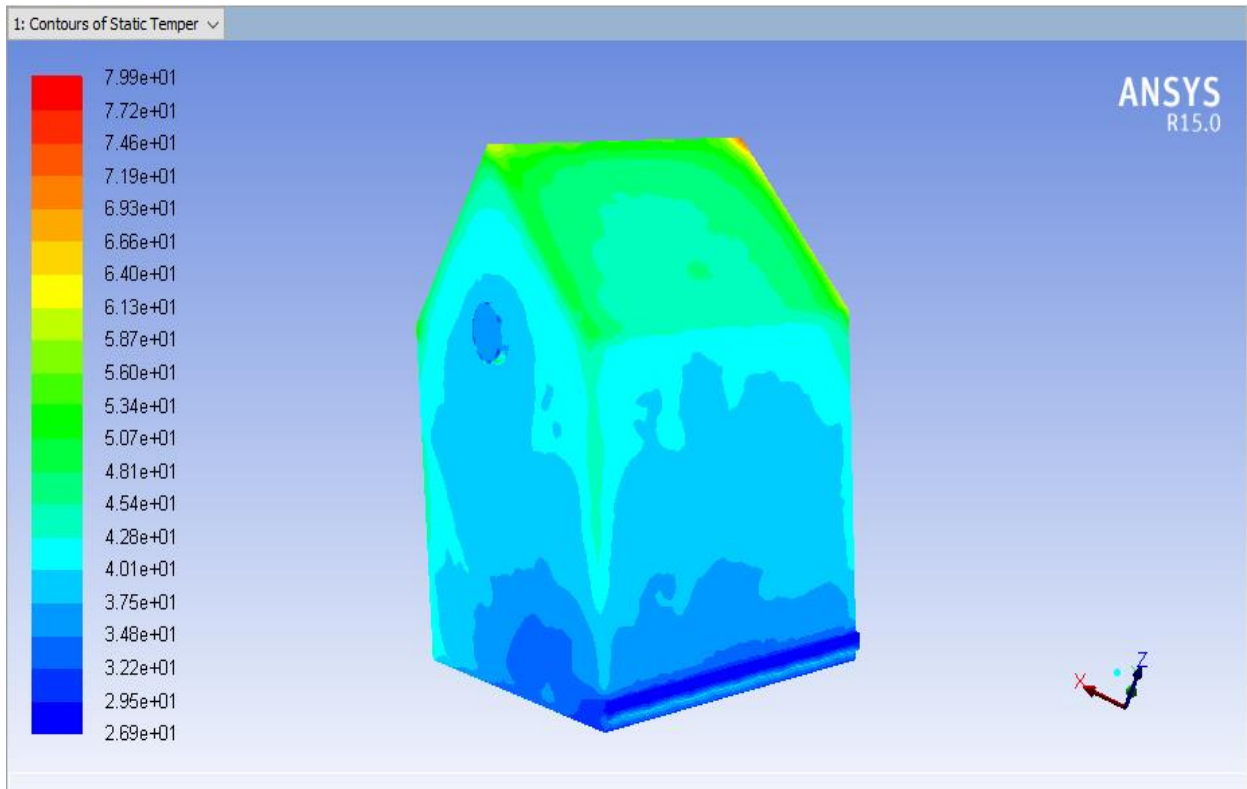


Fig. 5.7 Temperature contour for triangular roof at 11am

The dryer is planned and investigated with same volume with triangle rooftop. The elements of Triangle are 300x300 as demonstrated in Fig 5.7. the system was analyzed with the north wall insulate at 11AM. The opening of measurement 15mm is put for constrained convection with an exhaust outlet. The power source exhaust is at the top and the gulf is at the base openings with a channel speed of 2 m/s. It is seen that most extreme temperature accomplished is 79.9°C because of the direct contact territory with most noteworthy sun-oriented radiation on rooftop is bigger. Within temperature of the dryer is more than outside temperature as the warmth is gathered inside the dryer because of greenhouse impact. There is a continuous ascent in the temperature start to finish of the plane. This is because of the sun-based radiation goes through the glass which acts like a straightforward, permitting the radiation from sun into dryer. Subsequently, heat is gathered in dryer by convection and exhaust fan is utilized to eliminates the air from the dryer gradually in this manner increment the temperature of the dryer.

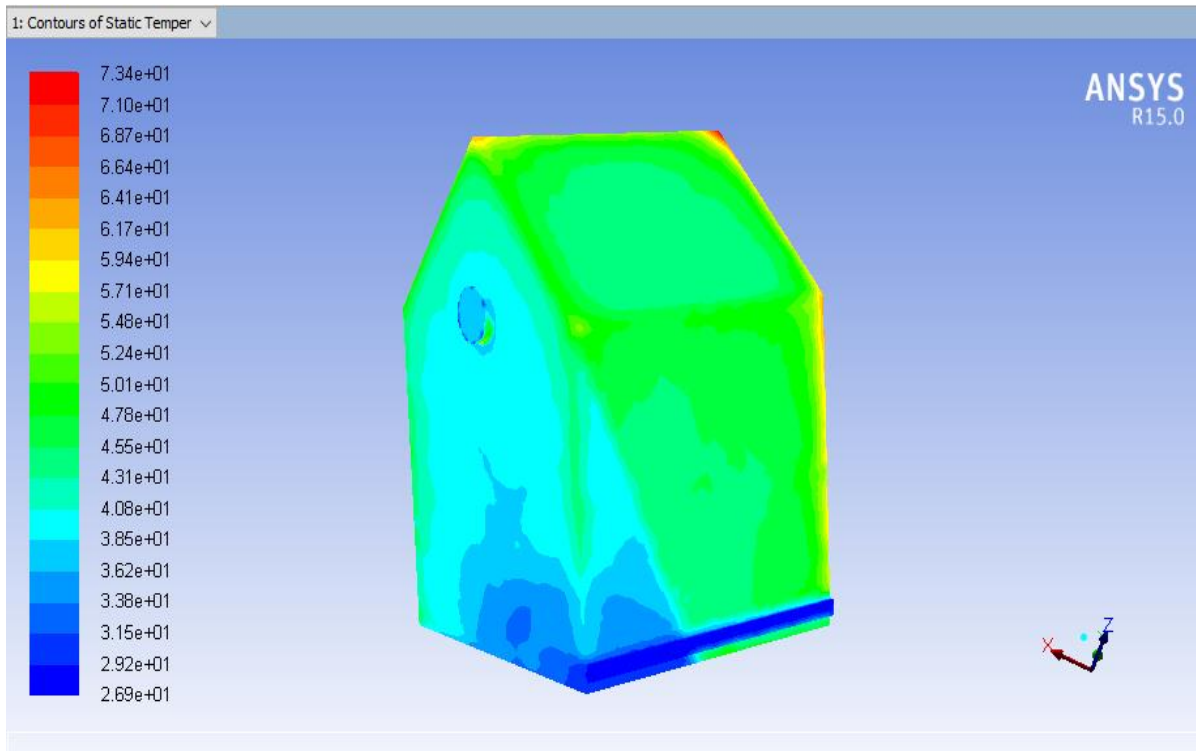


Fig. 5.8 Temperature contour for triangular roof at 1pm

The dryer is planned and investigated with same volume with triangle rooftop. The elements of Triangle are 300x300 as demonstrated in Fig 5.8. the system was analyzed with the north wall insulate at 1PM. The opening of measurement 15mm is put for constrained convection with an exhaust outlet. The power source exhaust is at the top and the gulf is at the base openings with a channel speed of 2 m/s. It is seen that most extreme temperature accomplished is 73.4°C because of the direct contact territory with most noteworthy sun-oriented radiation on rooftop is bigger. Within temperature of the dryer is more than outside temperature as the warmth is gathered inside the dryer because of greenhouse impact. There is a continuous ascent in the temperature start to finish of the plane. This is because of the sun-based radiation goes through the glass which acts like a straightforward, permitting the radiation from sun into dryer. Subsequently, heat is gathered in dryer by convection and exhaust fan is utilized to eliminates the air from the dryer gradually in this manner increment the temperature of the dryer.

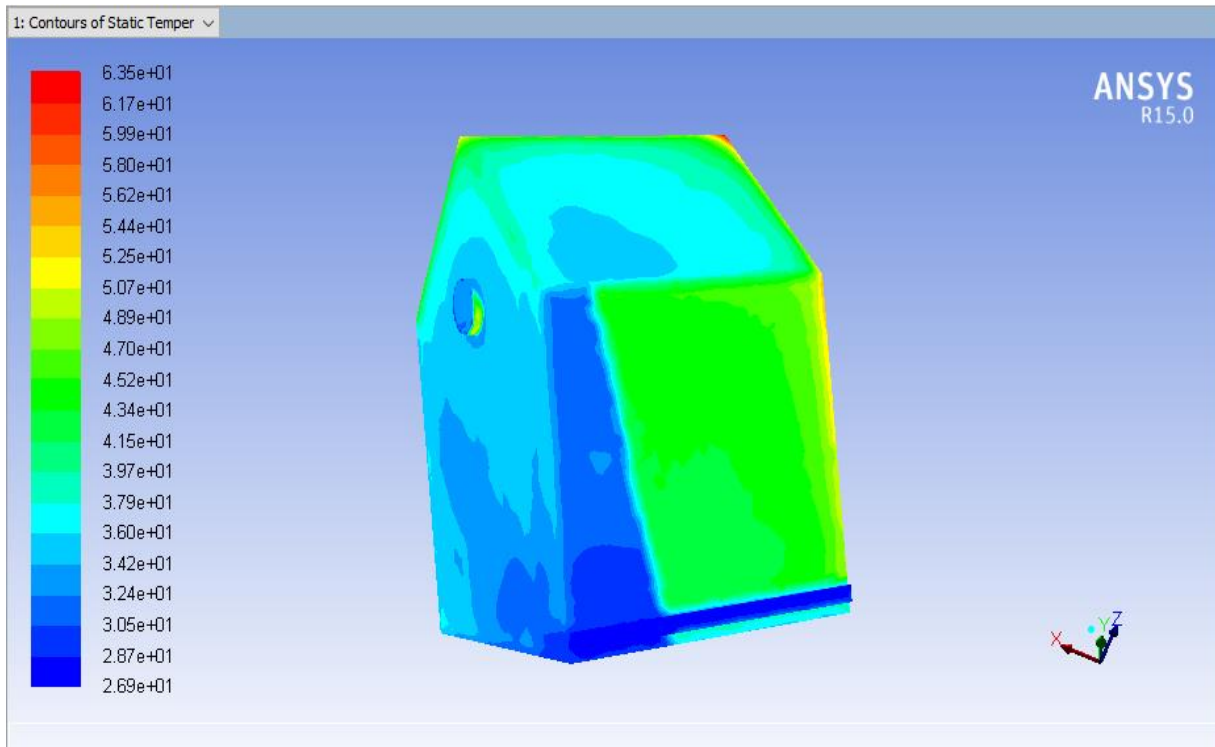


Fig. 5.9 Temperature contour for triangular roof at 3 pm

The dryer is planned and investigated with same volume with triangle rooftop. The elements of Triangle are 300x300 as demonstrated in Fig 5.9. the system was analyzed with the north wall insulate at 3PM. The opening of measurement 15mm is put for constrained convection with an exhaust outlet. The power source exhaust is at the top and the gulf is at the base openings with a channel speed of 2 m/s. It is seen that most extreme temperature accomplished is 63.5°C because of the direct contact territory with most noteworthy sun-oriented radiation on rooftop is bigger. Within temperature of the dryer is more than outside temperature as the warmth is gathered inside the dryer because of greenhouse impact. There is a continuous ascent in the temperature start to finish of the plane. This is because of the sun-based radiation goes through the glass which acts like a straightforward, permitting the radiation from sun into dryer. Subsequently, heat is gathered in dryer by convection and exhaust fan is utilized to eliminates the air from the dryer gradually in this manner increment the temperature of the dryer.

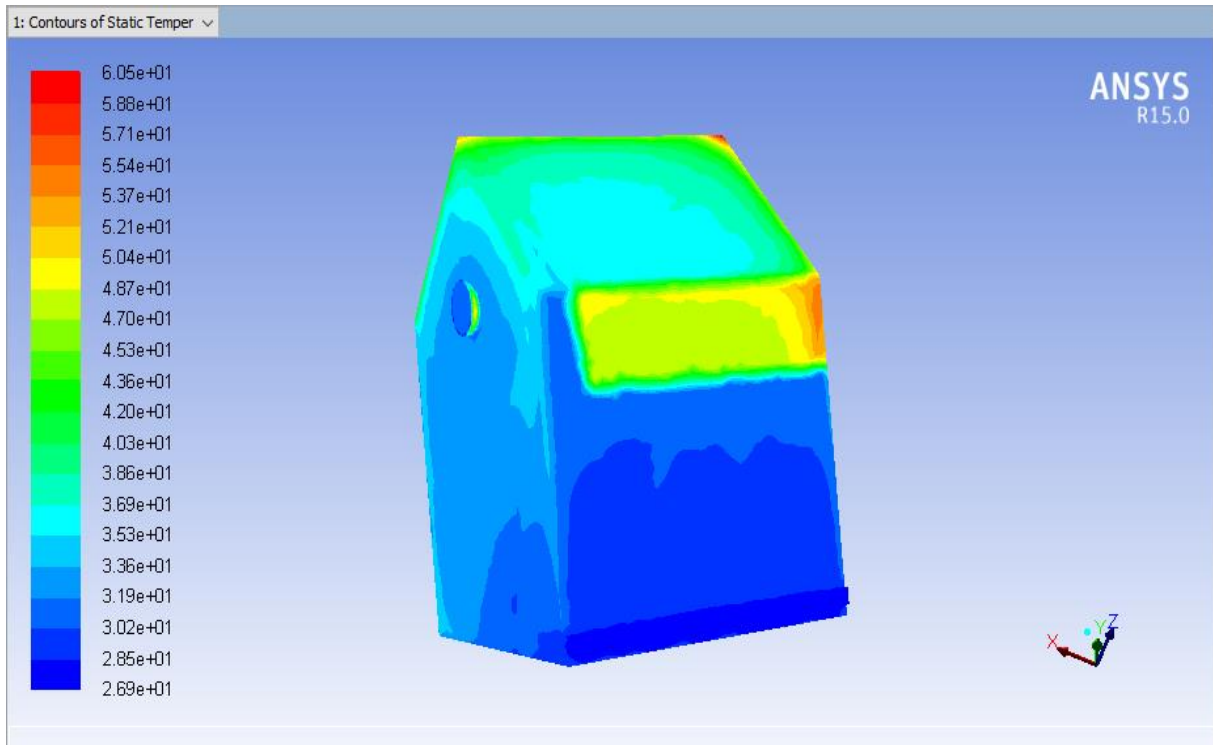


Fig. 5.10 Temperature contour for triangular roof at 5 pm

The dryer is planned and investigated with same volume with triangle rooftop. The elements of Triangle are 300x300 as demonstrated in Fig 5.10. The system was analyzed with the north wall insulated at 5 PM. The opening of measurement 15mm is put for constrained convection with an exhaust outlet. The power source exhaust is at the top and the gulf is at the base openings with a channel speed of 2 m/s. It is seen that most extreme temperature accomplished is 60.5°C because of the direct contact territory with most noteworthy sun-oriented radiation on rooftop is bigger. Within temperature of the dryer is more than outside temperature as the warmth is gathered inside the dryer because of greenhouse impact. There is a continuous ascent in the temperature start to finish of the plane. This is because of the sun-based radiation goes through the glass which acts like a straightforward, permitting the radiation from sun into dryer. Subsequently, heat is gathered in dryer by convection and exhaust fan is utilized to eliminate the air from the dryer gradually in this manner increment the temperature of the dryer.

5.1.3 Simulation results of parabolic roof without north wall insulation

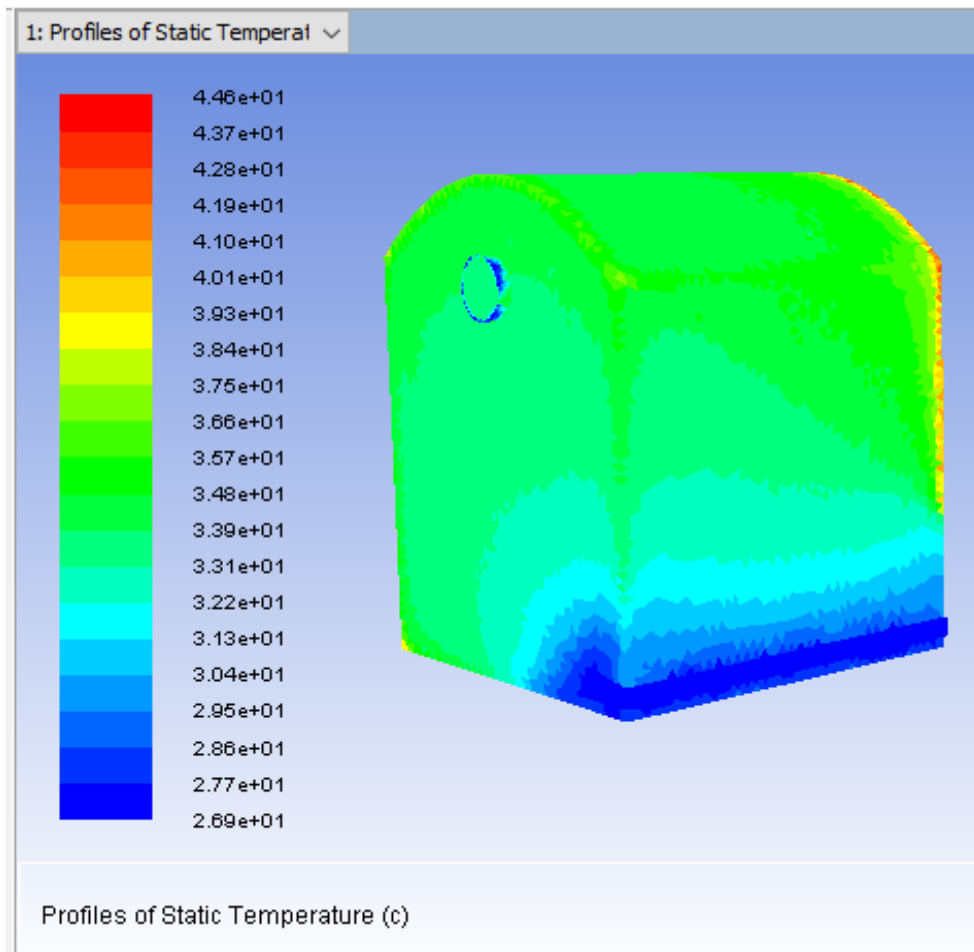


Fig. 5.11 Temperature contour for parabolic roof at 9am

The dryer is designed and analyzed with same volume with parabolic roof. The dimensions of hemispherical are 300x300 as shown in Fig 5.11. The system was analyzed without north wall insulated at 9AM. The hole of diameter 15mm is placed for forced convection with an exhaust outlet. The outlet exhaust is at the top and the inlet is at the bottom openings with an inlet velocity of 2 m/s. It is noticed that maximum temperature achieved is 44.6°C due to the linear contact area with highest solar radiation on roof is larger. The inside temperature of the dryer is more than outside temperature as the heat is collected inside the dryer due to greenhouse effect. There is a gradual rise in the temperature from top to bottom of the plane. This is due to the solar radiation passes through the glass which acts like a transparent, allowing the radiation from sun into dryer. As a result, heat is collected in dryer by convection and exhaust fan is used to remove the air from the dryer slowly thereby increase the temperature of the dryer.

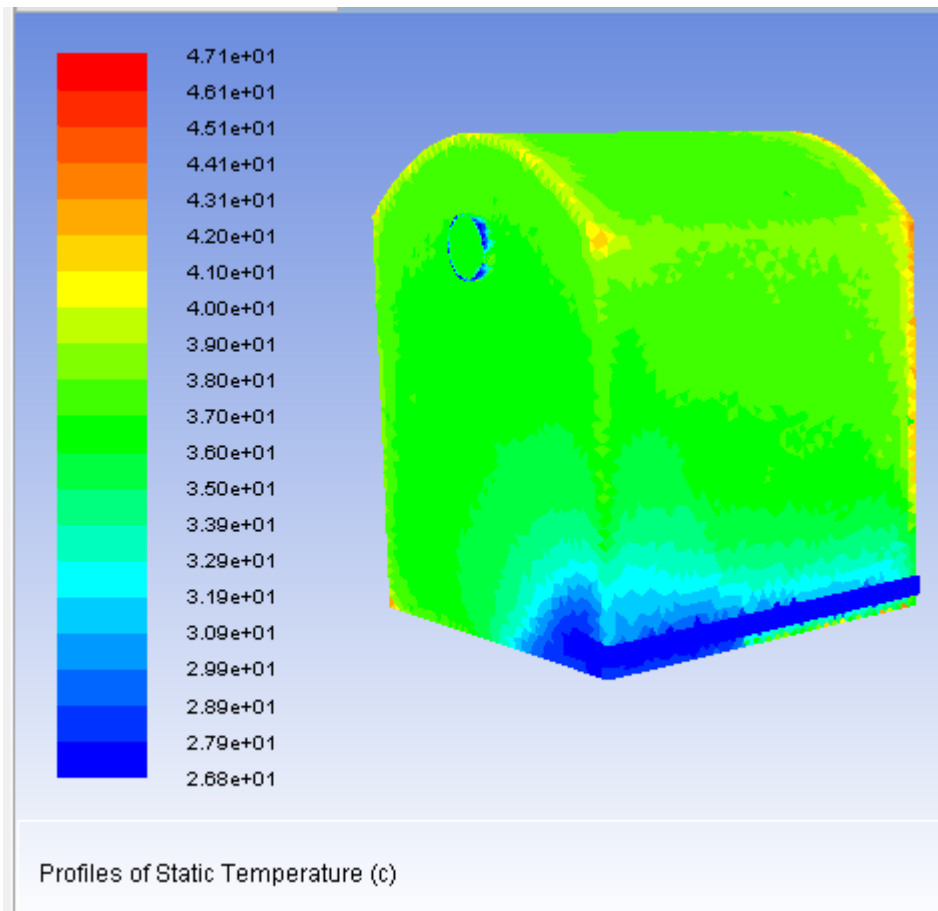


Fig. 5.12 Temperature contour for parabolic roof at 11 am

The dryer is planned and broke down with same volume with parabolic rooftop. The elements of hemispherical are 300x300 as demonstrated in Fig 5.12. the system was analyzed without north wall insulated at 11AM. The hole of diameter 15mm is placed for forced convection with an exhaust outlet. The power source exhaust is at the top and the bay is at the base openings with an inlet velocity of 2 m/s. It is seen that most extreme temperature accomplished is 47.1°C because of the straight contact territory with most noteworthy sunlight-based radiation on rooftop is bigger. Within temperature of the dryer is more than outside temperature as the warmth is gathered inside the dryer because of greenhouse impact. There is a steady ascent in the temperature start to finish of the plane. This is because of the sun powered radiation goes through the glass which acts like a straightforward, permitting the radiation from sun into dryer. Therefore, heat is gathered in dryer by convection and exhaust fan is utilized to eliminates the air from the dryer gradually subsequently increment the temperature of the dryer

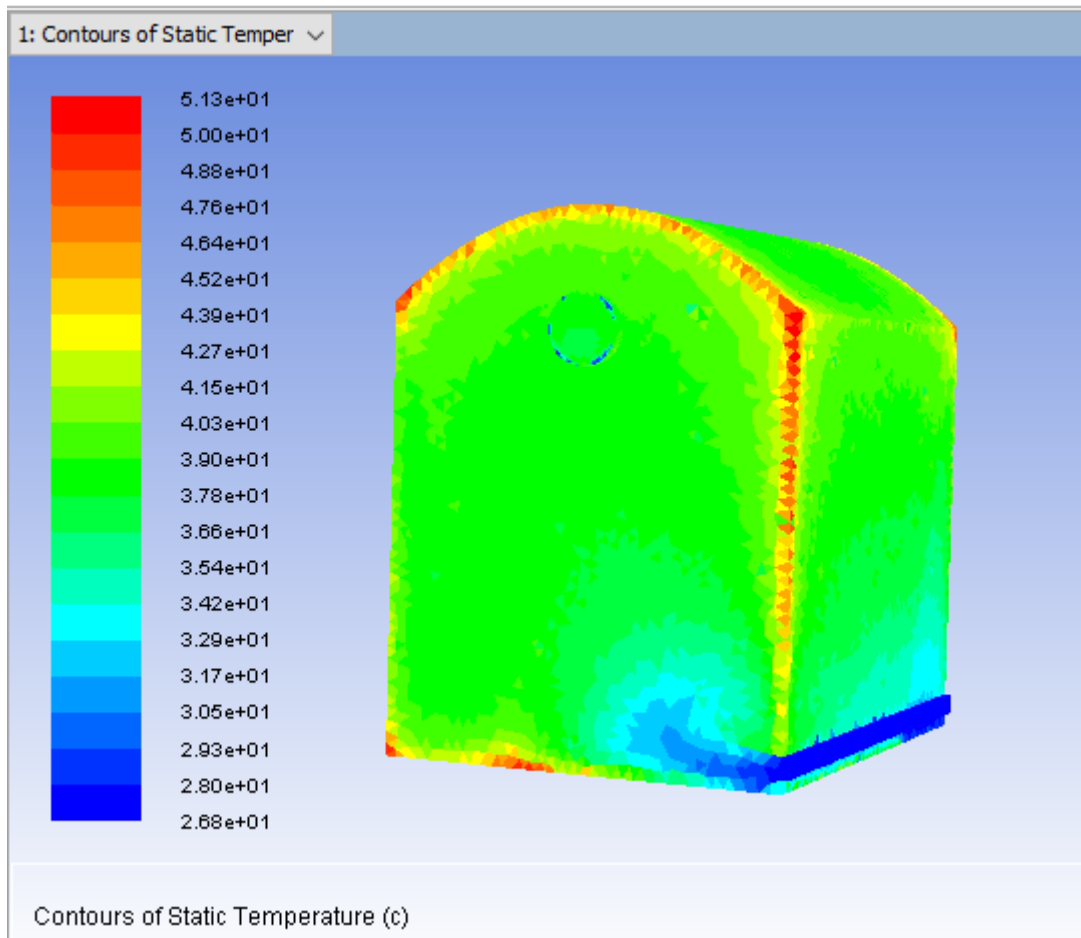


Fig. 5.13 Temperature contour for parabolic roof at 1pm

The dryer is planned and broke down with same volume with parabolic rooftop. The elements of hemispherical are 300x300 as demonstrated in Fig 5.13. the system was analyzed without north wall insulated at 1PM. The hole of diameter 15mm is placed for forced convection with an exhaust outlet. The power source exhaust is at the top and the bay is at the base openings with an inlet velocity of 2 m/s. It is seen that most extreme temperature accomplished is 51.3°C because of the straight contact territory with most noteworthy sunlight-based radiation on rooftop is bigger. Within temperature of the dryer is more than outside temperature as the warmth is gathered inside the dryer because of greenhouse impact. There is a steady ascent in the temperature start to finish of the plane. This is because of the sun powered radiation goes through the glass which acts like a straightforward, permitting the radiation from sun into dryer. Therefore, heat is gathered in dryer by convection and exhaust fan is utilized to eliminates the air from the dryer gradually subsequently increment the temperature of the dryer.

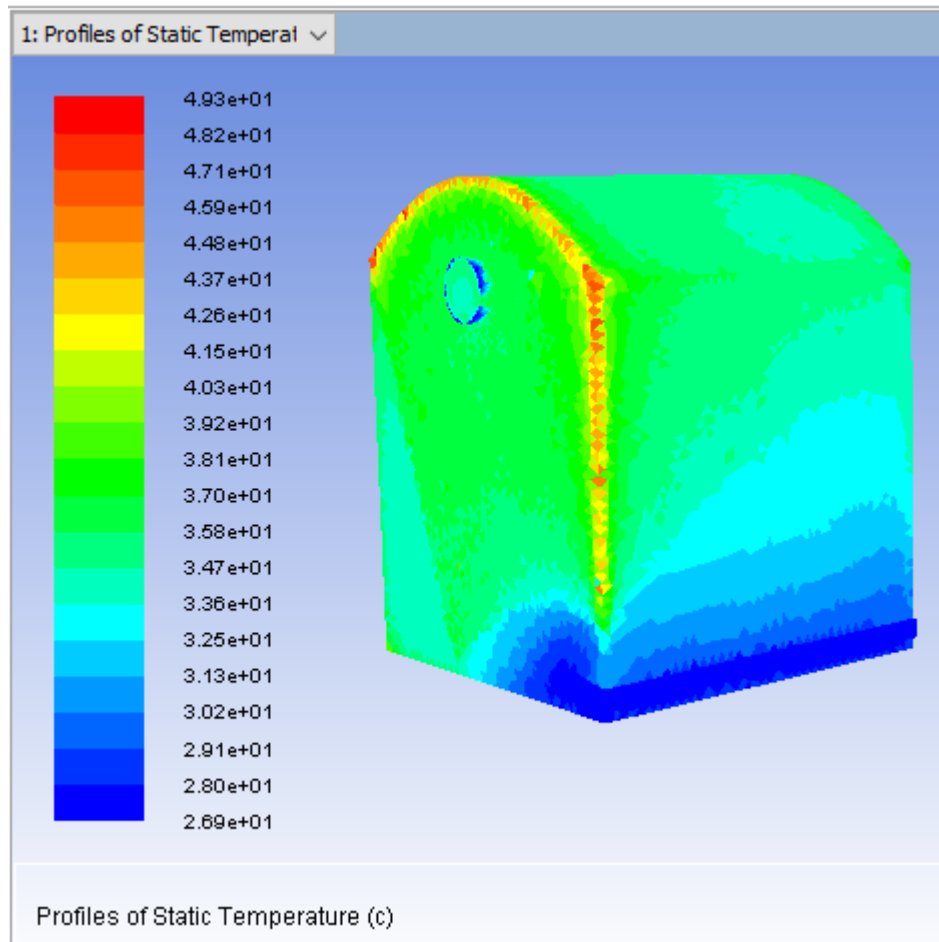


Fig. 5.14 Temperature contour for parabolic roof at 3 pm

The dryer is planned and broke down with same volume with parabolic rooftop. The elements of hemispherical are 300x300 as demonstrated in Fig 5.14. the system was analyzed without north wall insulated at 3PM. The hole of diameter 15mm is placed for forced convection with an exhaust outlet. The power source exhaust is at the top and the bay is at the base openings with an inlet velocity of 2 m/s. It is seen that most extreme temperature accomplished is 49.3°C because of the straight contact territory with most noteworthy sunlight-based radiation on rooftop is bigger. Within temperature of the dryer is more than outside temperature as the warmth is gathered inside the dryer because of greenhouse impact. There is a steady ascent in the temperature start to finish of the plane. This is because of the sun powered radiation goes through the glass which acts like a straightforward, permitting the radiation from sun into dryer. Therefore, heat is gathered in dryer by convection and exhaust fan is utilized to eliminates the air from the dryer gradually subsequently increment the temperature of the dryer.

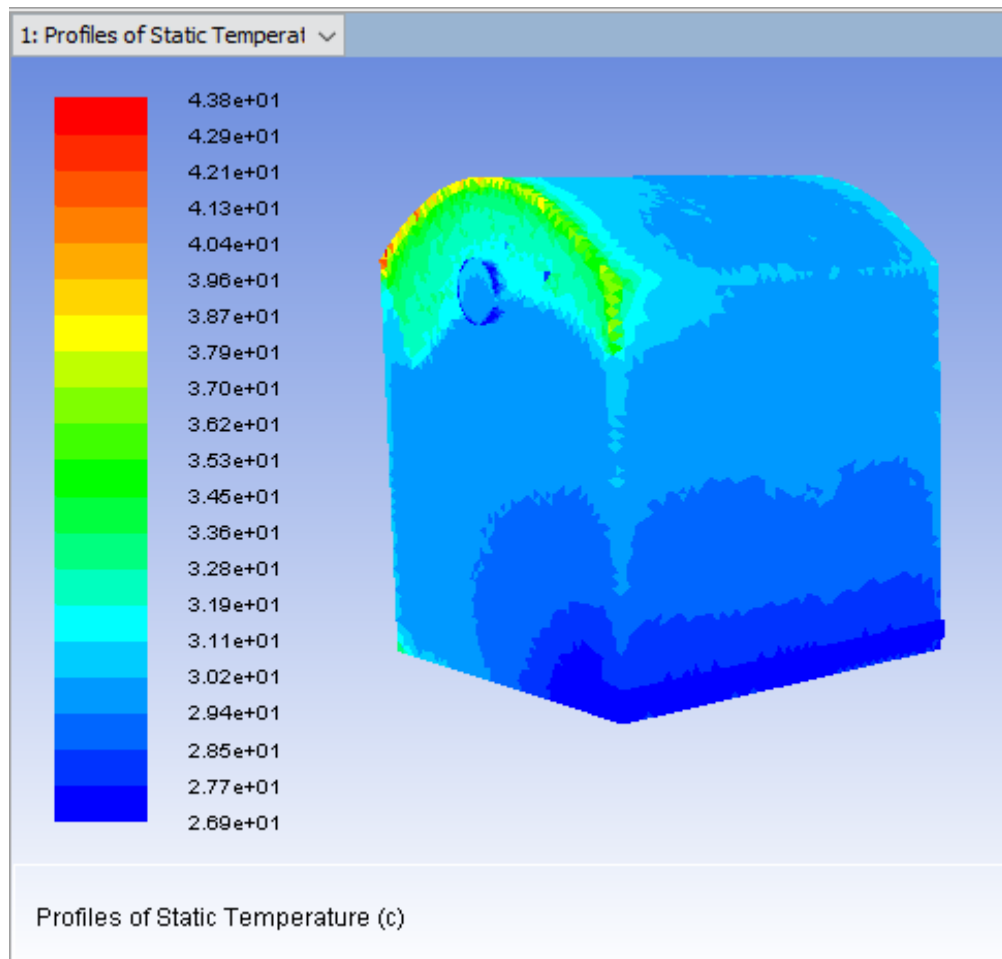


Fig. 5.15 Temperature contour for parabolic roof at 5 pm

The dryer is planned and broke down with same volume with parabolic rooftop. The elements of hemispherical are 300x300 as demonstrated in Fig 5.15.the system was analyzed without north wall insulated at 5PM.The hole of diameter 15mm is placed for forced convection with an exhaust outlet. The power source exhaust is at the top and the bay is at the base openings with an inlet velocity of 2 m/s. It is seen that most extreme temperature accomplished is 43.8°C because of the straight contact territory with most noteworthy sunlight-based radiation on rooftop is bigger. Within temperature of the dryer is more than outside temperature as the warmth is gathered inside the dryer because of greenhouse impact. There is a steady ascent in the temperature start to finish of the plane. This is because of the sun powered radiation goes through the glass which acts like a straightforward, permitting the radiation from sun into dryer. Therefore, heat is gathered in dryer by convection and exhaust fan is utilized to eliminates the air from the dryer gradually subsequently increment the temperature of the dryer

5.1.4 Simulation results of parabolic roof with north wall insulation

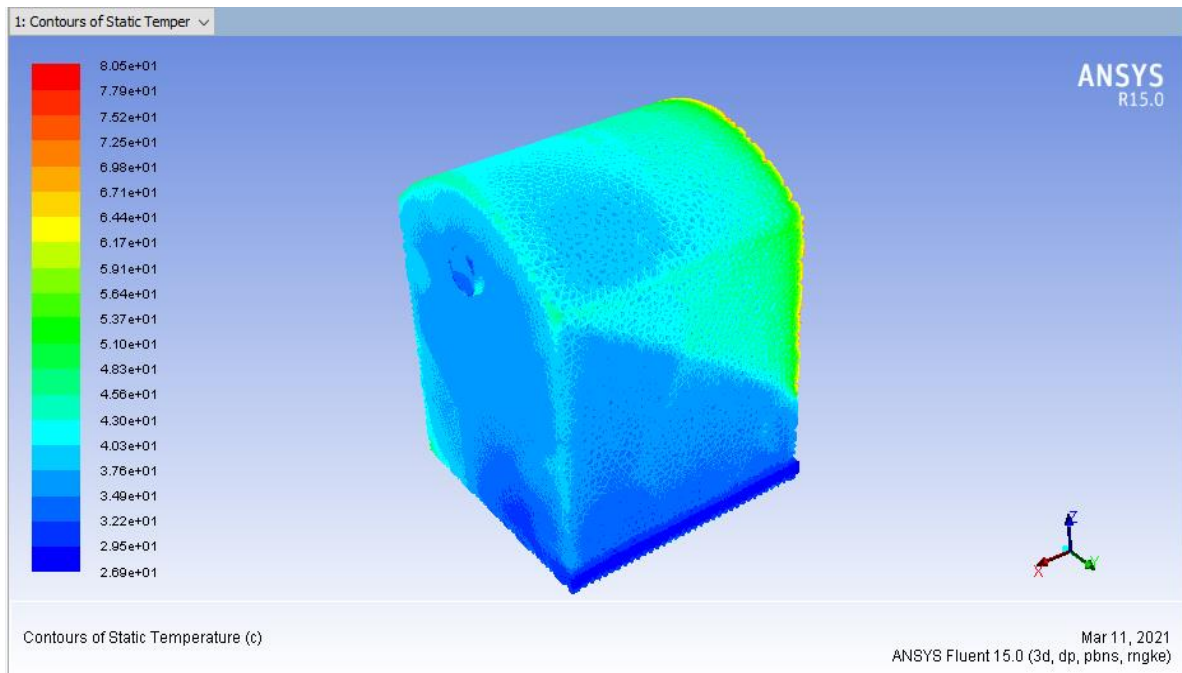


Fig. 5.16 Temperature contour for parabolic roof at 9am

The dryer is designed and analyzed with same volume with parabolic roof. The dimensions of hemispherical are 300x300 as shown in Fig 5.16 The system was analyzed with the north wall insulate at 9 AM. The hole of diameter 15mm is placed for forced convection with an exhaust outlet. The outlet exhaust is at the top and the inlet is at the bottom openings with an inlet velocity of 2 m/s. It is noticed that maximum temperature achieved is 80.5°C due to the linear contact area with highest solar radiation on roof is larger. The inside temperature of the dryer is more than outside temperature as the heat is collected inside the dryer due to greenhouse effect. There is a gradual rise in the temperature from top to bottom of the plane. This is due to the solar radiation passes through the glass which acts like a transparent, allowing the radiation from sun into dryer. As a result, heat is collected in dryer by convection and exhaust fan is used to removes the air from the dryer slowly thereby increase the temperature of the dryer.

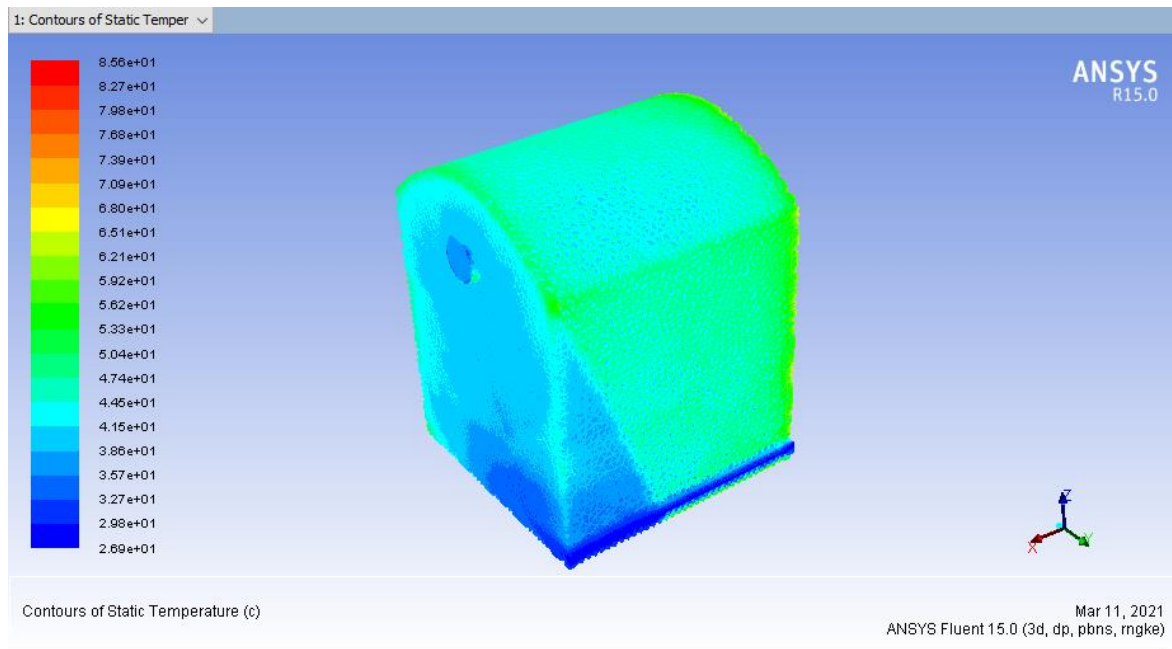


Fig. 5.17 Temperature contour for parabolic roof at 11 am

The dryer is planned and examined with same volume with parabolic rooftop. The elements of hemispherical are 300x300 as demonstrated in Fig 5.17. The system was analyzed with the north wall insulate at 11AM. The hole of diameter 15mm is placed for forced convection with an exhaust outlet. The power source exhaust is at the top and the delta is at the base openings with an inlet velocity of 2 m/s. It is seen that greatest temperature accomplished is 85.6°C because of the direct contact territory with most noteworthy sunlight-based radiation on rooftop is bigger. Within temperature of the dryer is more than outside temperature as the warmth is gathered inside the dryer because of greenhouse impact. There is a steady ascent in the temperature start to finish of the plane. This is because of the sunlight-based radiation goes through the glass which acts like a straightforward, permitting the radiation from sun into dryer. Thus, heat is gathered in dryer by convection and exhaust fan is utilized to eliminates the air from the dryer gradually in this manner increment the temperature of the dryer

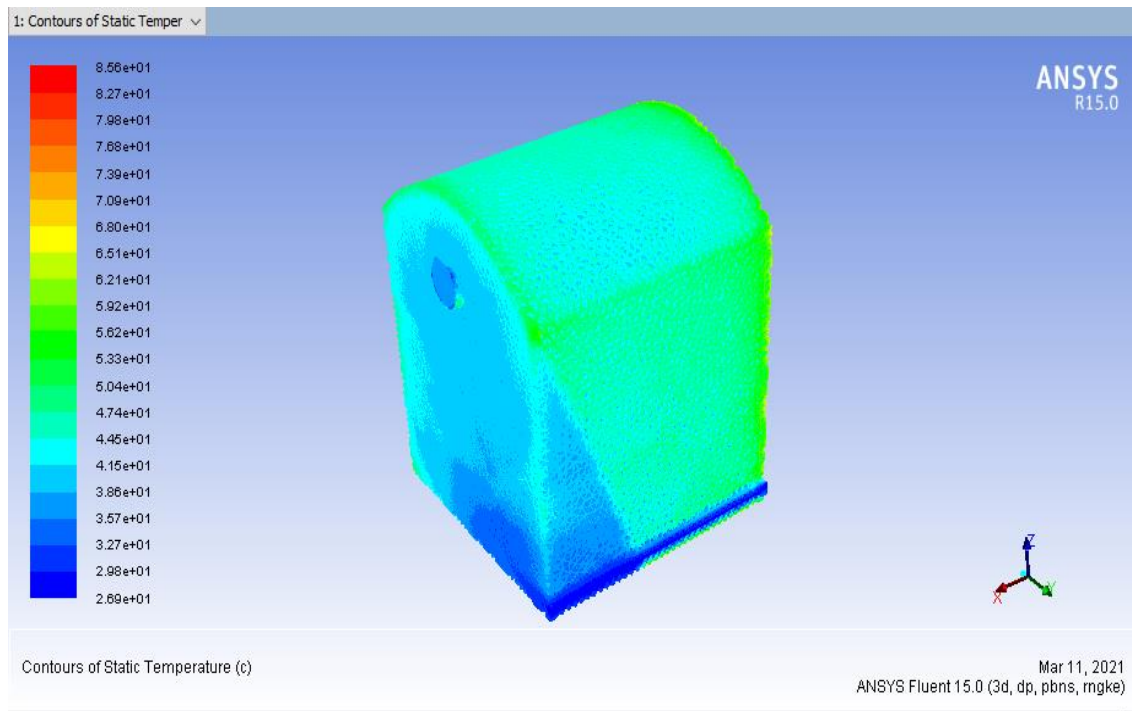


Fig. 5.18 Temperature contour for parabolic roof at 1pm

The dryer is planned and examined with same volume with parabolic rooftop. The elements of hemispherical are 300x300 as demonstrated in Fig 5.18. The system was analyzed with the north wall insulate at 1PM. The hole of diameter 15mm is placed for forced convection with an exhaust outlet. The power source exhaust is at the top and the delta is at the base openings with an inlet velocity of 2 m/s. It is seen that greatest temperature accomplished is 85.6°C because of the direct contact territory with most noteworthy sunlight-based radiation on rooftop is bigger. Within temperature of the dryer is more than outside temperature as the warmth is gathered inside the dryer because of greenhouse impact. There is a steady ascent in the temperature start to finish of the plane. This is because of the sunlight-based radiation goes through the glass which acts like a straightforward, permitting the radiation from sun into dryer. Thus, heat is gathered in dryer by convection and exhaust fan is utilized to eliminates the air from the dryer gradually in this manner increment the temperature of the dryer

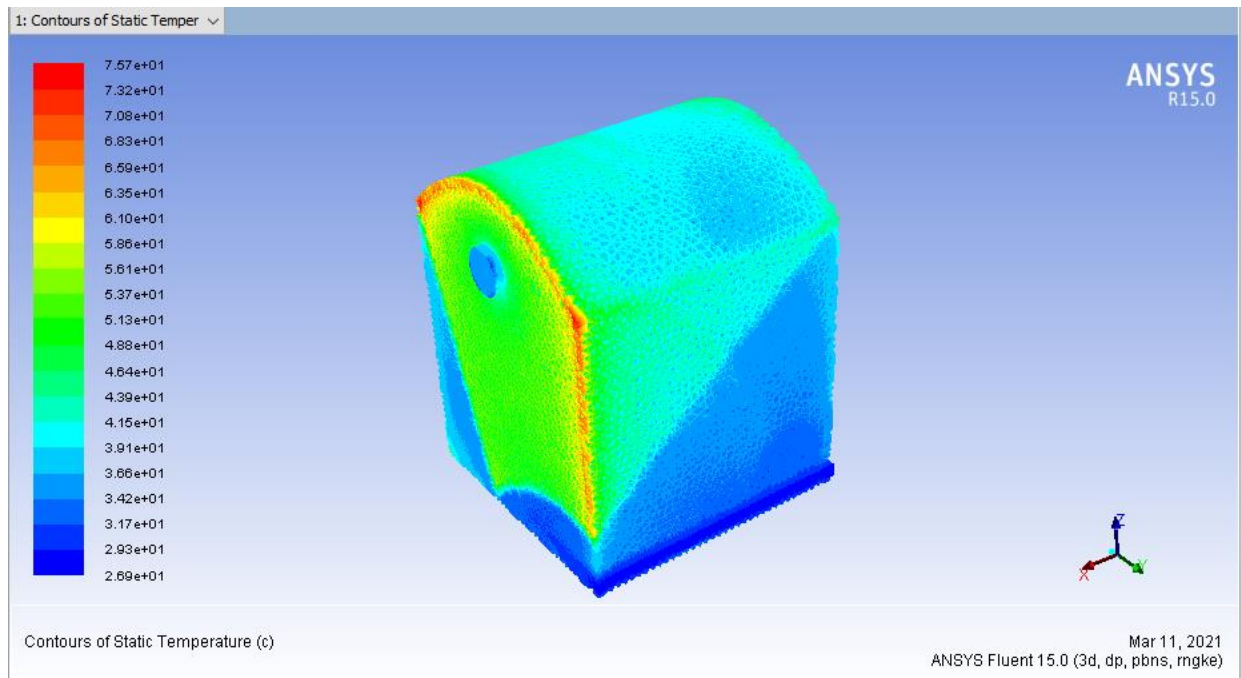


Fig. 5.19 Temperature contour for parabolic roof at 3pm

The dryer is planned and examined with same volume with parabolic rooftop. The elements of hemispherical are 300x300 as demonstrated in Fig 5.19. The system was analyzed with the north wall insulate at 3PM. The hole of diameter 15mm is placed for forced convection with an exhaust outlet. The power source exhaust is at the top and the delta is at the base openings with an inlet velocity of 2 m/s. It is seen that greatest temperature accomplished is 75.7°C because of the direct contact territory with most noteworthy sunlight-based radiation on rooftop is bigger. Within temperature of the dryer is more than outside temperature as the warmth is gathered inside the dryer because of greenhouse impact. There is a steady ascent in the temperature start to finish of the plane. This is because of the sunlight-based radiation goes through the glass which acts like a straightforward, permitting the radiation from sun into dryer. Thus, heat is gathered in dryer by convection and exhaust fan is utilized to eliminates the air from the dryer gradually in this manner increment the temperature of the dryer.

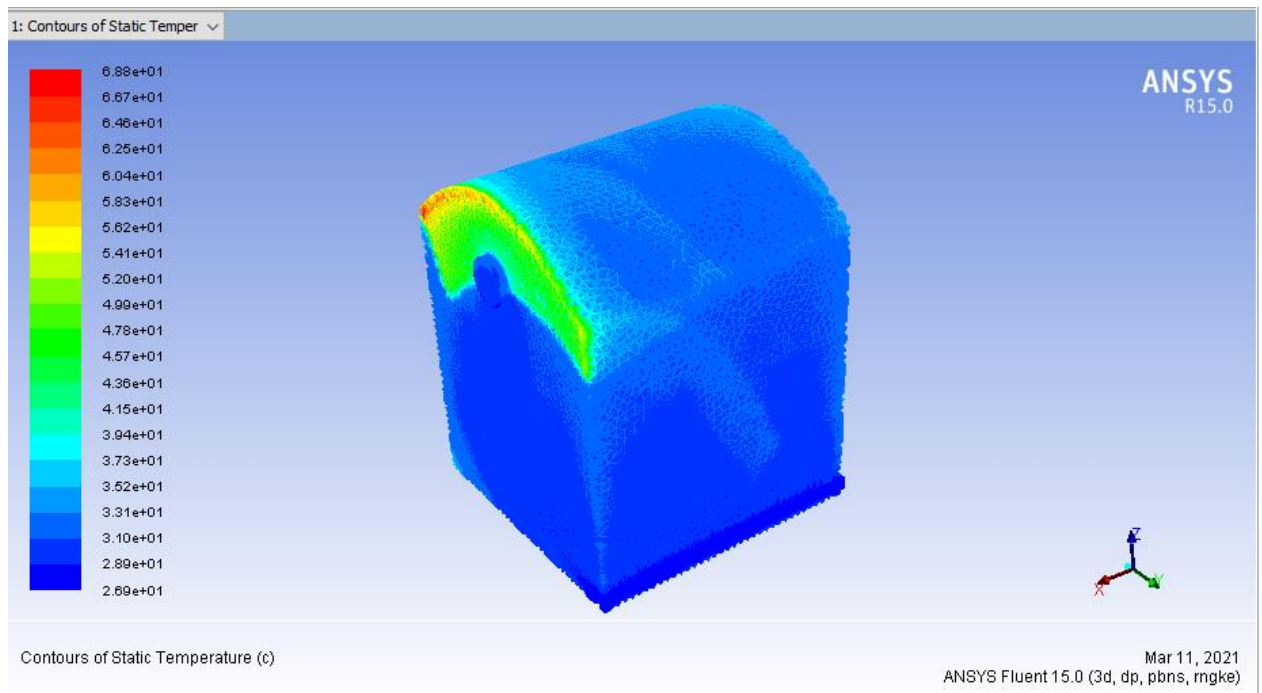


Fig. 5.20 Temperature contour for parabolic roof at 5 pm

The dryer is planned and examined with same volume with parabolic rooftop. The elements of hemispherical are 300x300 as demonstrated in Fig 5.20. The system was analyzed with the north wall insulate at 5PM. The hole of diameter 15mm is placed for forced convection with an exhaust outlet. The power source exhaust is at the top and the delta is at the base openings with an inlet velocity of 2 m/s. It is seen that greatest temperature accomplished is 68.8°C because of the direct contact territory with most noteworthy sunlight-based radiation on rooftop is bigger. Within temperature of the dryer is more than outside temperature as the warmth is gathered inside the dryer because of greenhouse impact. There is a steady ascent in the temperature start to finish of the plane. This is because of the sunlight-based radiation goes through the glass which acts like a straightforward, permitting the radiation from sun into dryer. Thus, heat is gathered in dryer by convection and exhaust fan is utilized to eliminates the air from the dryer gradually in this manner increment the temperature of the dryer

5.2 ANALYSIS

5.2.1 Triangular Roof shape comparison for with and without north wall

insulation

Table 5.1 Comparison of Triangular roof shape for 9 AM

	Tri Roof without Insulation	Tri Roof with Insulation
9:00 AM	32.7°C	66.0°C

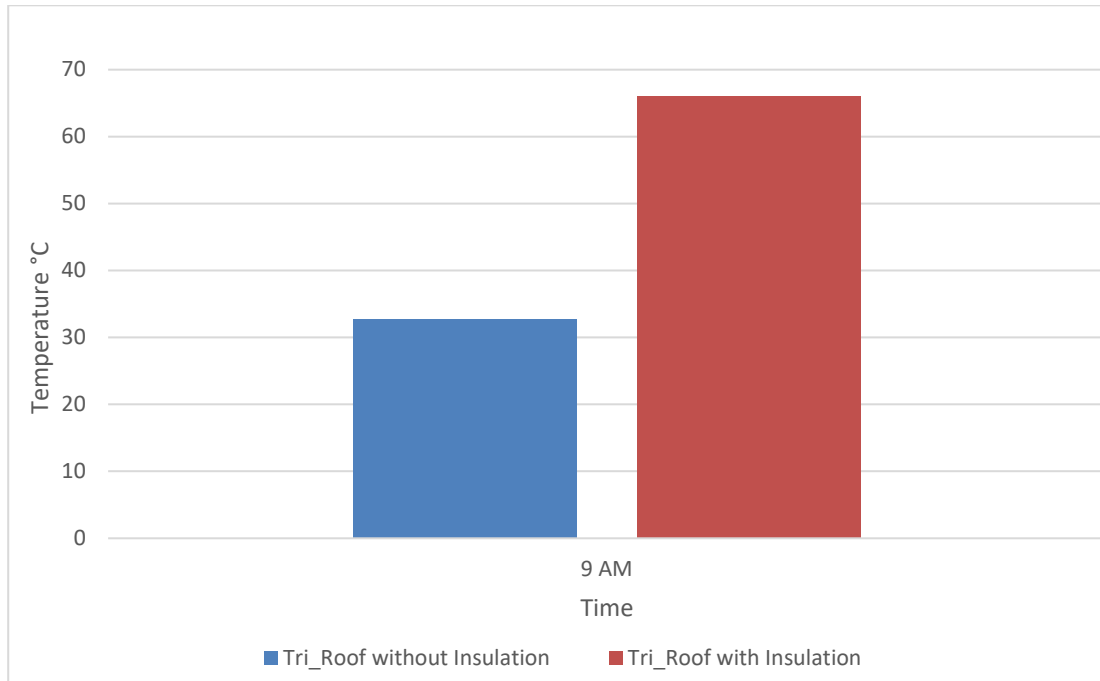


Fig. 5.21 Comparison of Triangular roof shape for 9 AM

From the results of triangular roof shapes at 9:00 AM with north wall insulated (66.0°C) has better performance than the triangular roof shape without north insulated (32.7°C)

Table 5.2 Comparison of Triangular roof shape for 11 AM

	Tri Roof without Insulation	Tri Roof with Insulation
11:00 AM	33.5°C	79.9°C

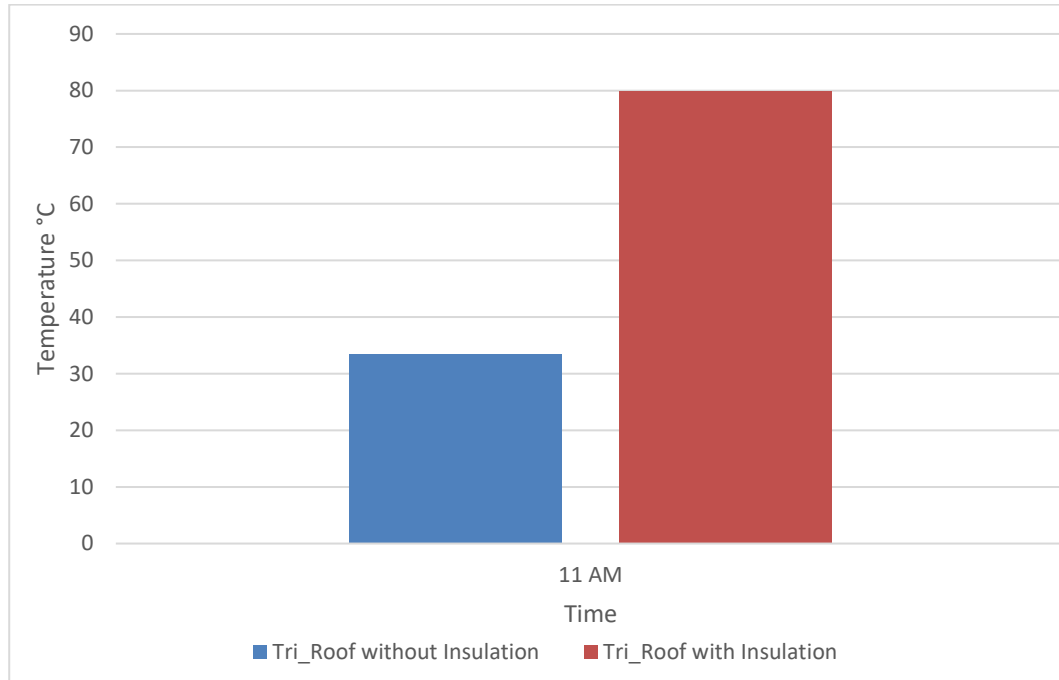


Fig. 5.22 Comparison of Triangular roof shape for 11 AM

According to the findings, triangular roof shapes with insulated north walls (79.9°C) perform better than triangular roof shapes without insulated north walls (33.5°C).

Table 5.3 Comparison of Triangular roof shape for 1 PM

	Tri Roof without Insulation	Tri Roof with Insulation
1:00 PM	40.6°C	73.4°C

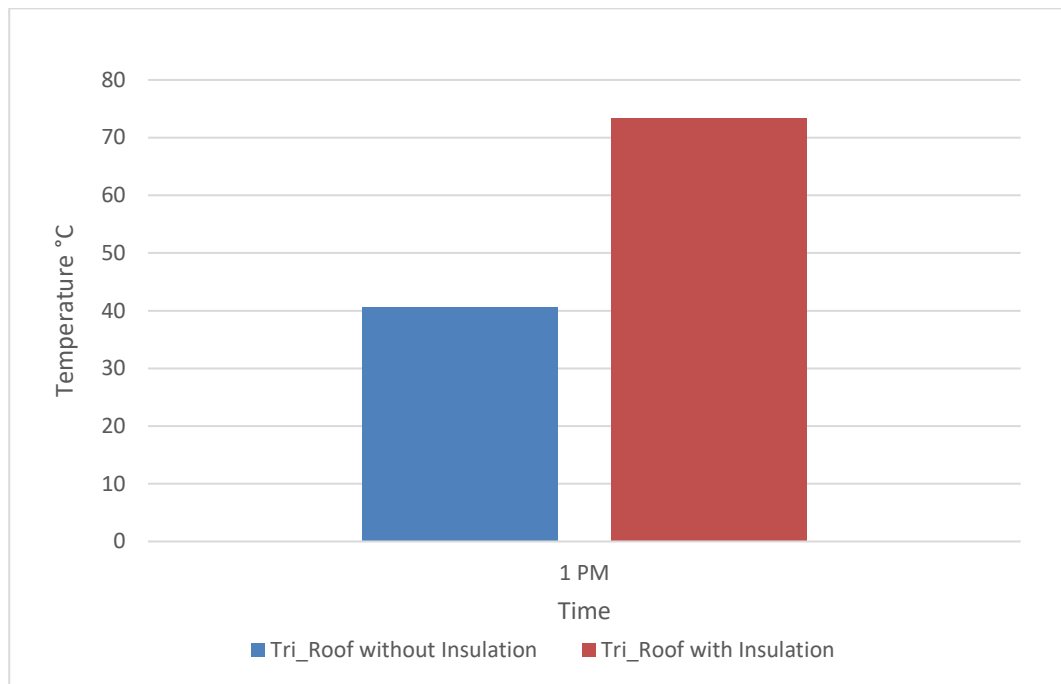


Fig. 5.23 Comparison of Triangular roof shape for 1 PM

Triangular roof shapes with insulated north walls (73.4°C) perform better than triangular roof shapes without insulated north walls (40.6°C), according to the results.

Table 5.4 Comparison of Triangular roof shape for 3 PM

	Tri Roof without Insulation	Tri Roof with Insulation
3:00 PM	39°C	63.5°C

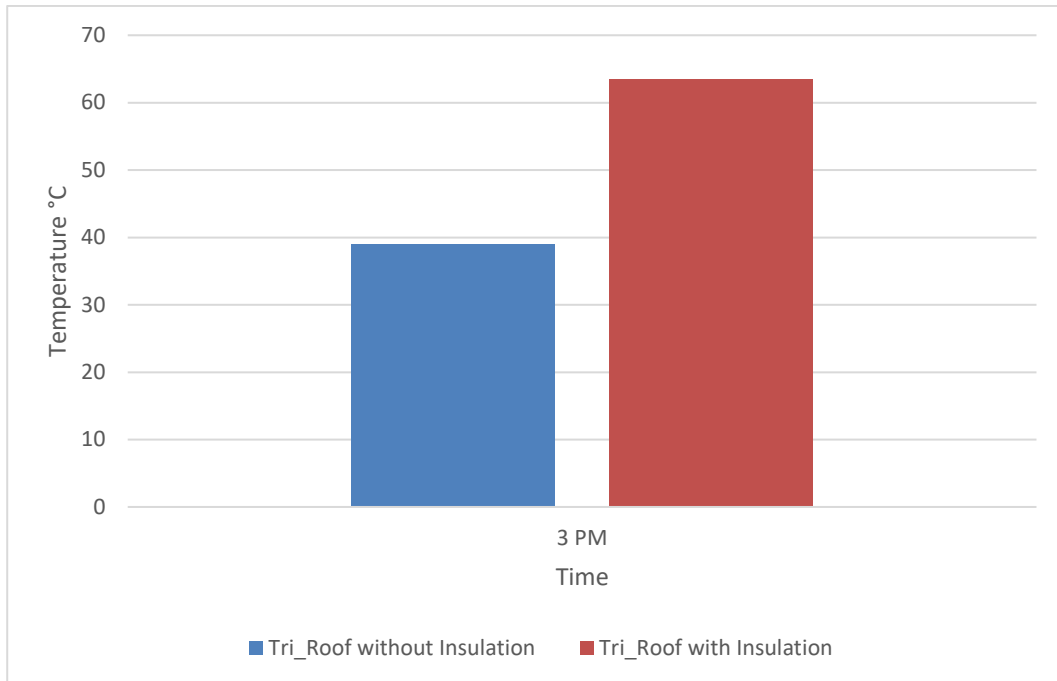


Fig. 5.24 Comparison of Triangular roof shape for 3 PM

According to the findings, triangular roof shapes with insulated north walls (63.5°C) perform better than triangular roof shapes without insulated north walls (39°C).

Table 5.5 Comparison of Triangular roof shape for 5 PM

	Tri Roof without Insulation	Tri Roof with Insulation

5:00 PM	35.4°C	60.5°C
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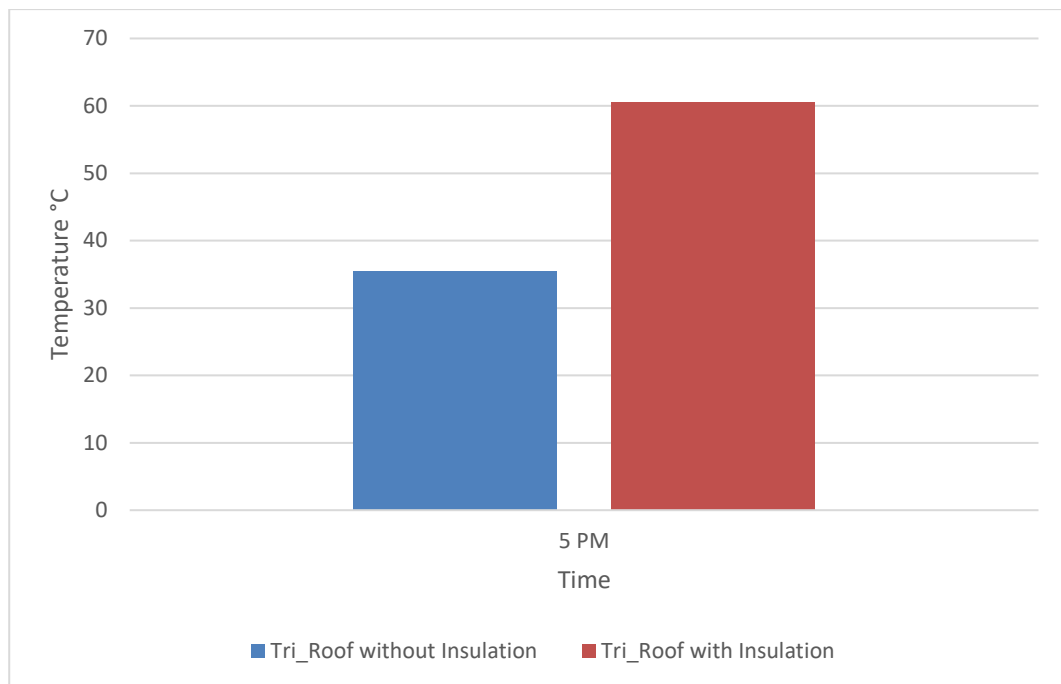


Fig. 5.25 Comparison of Triangular roof shape for 5 PM

The performance of triangular roof shapes at 5:00 PM with north wall insulation (60.5°C) is better than the performance of triangular roof shapes without north wall insulation (35.4°C).

5.2.2 Parabolic roof shape comparison for with and without north wall insulation

Table 5.6 Comparison of Parabolic roof shape for 9 AM

	Para Roof without Insulation	Para Roof with Insulation
9:00 AM	44.6°C	80.5°C

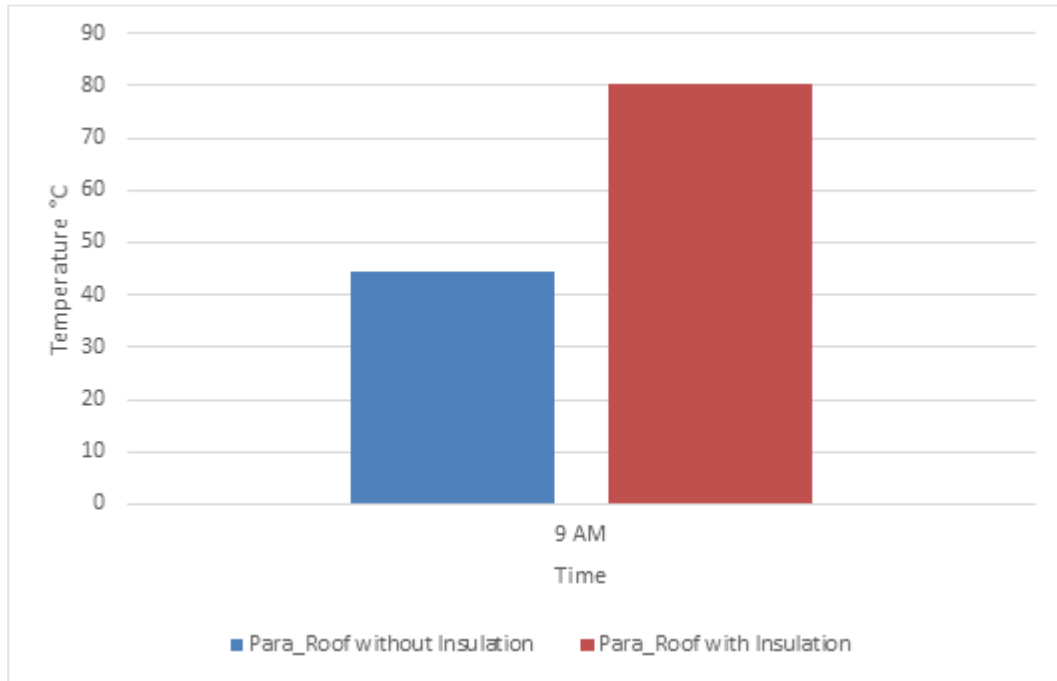


Fig. 5.26 Comparison of Parabolic roof shape for 9 AM

According to the results, parabolic roof shapes at 9:00 AM with north wall insulation (80.5°C) perform better than parabolic roof shapes without north wall insulation (44.6°C).

Table 5.7 Comparison of Parabolic roof shape for 11 AM

	Para Roof without	Para Roof with
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	Insulation	Insulation
11:00 AM	47.1°C	85.6°C

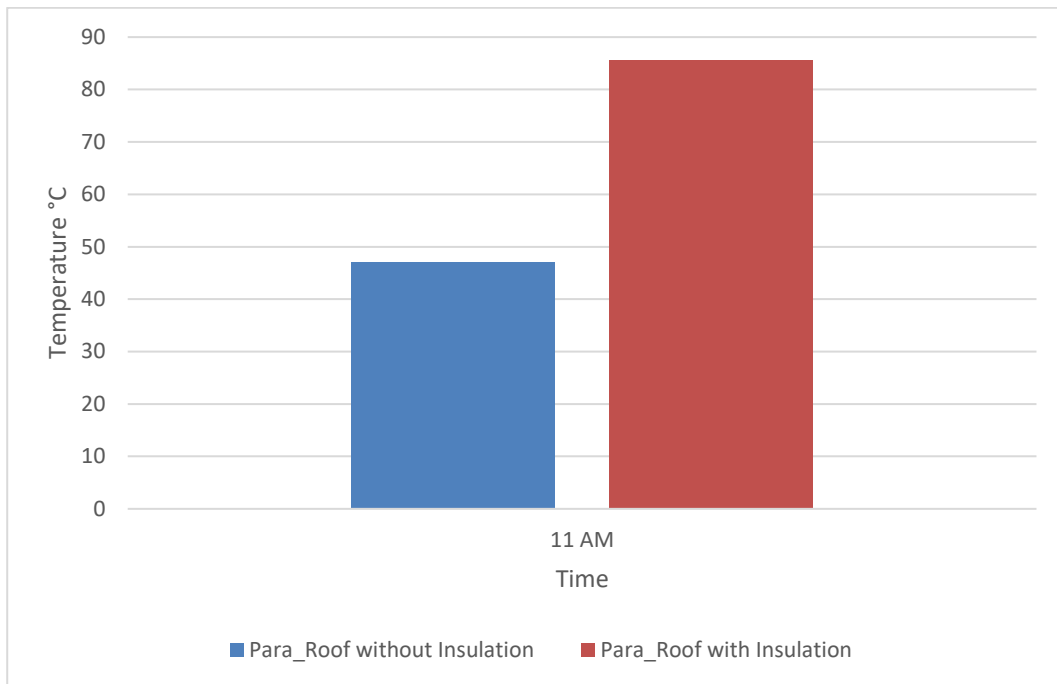


Fig. 5.27 Comparison of Parabolic roof shape for 11 AM

According to the results, parabolic roof shapes with north wall insulation (85.6°C) perform better than parabolic roof shapes without north wall insulation (47.1°C) at 11:00 AM.

Table 5.8 Comparison of Parabolic roof shape for 1 PM

	Para Roof without	Para Roof with Insulation
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	Insulation	
1:00 PM	51.3°C	85.6°C

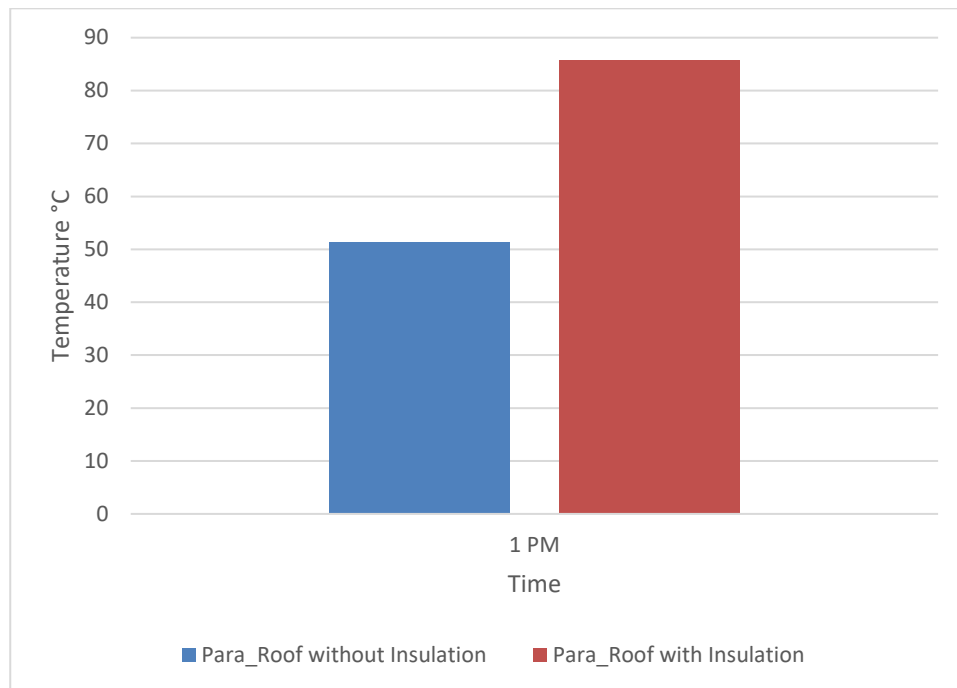


Fig. 5.28 Comparison of Parabolic roof shape for 1 PM

According to the results, parabolic roof shapes with north wall insulation (85.6°C) perform better than parabolic roof shapes without north wall insulation (51.3°C) at 1:00 PM

Table 5.9 Comparison of Parabolic roof shape for 3 PM

	Para Roof without Insulation	Para Roof with Insulation
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3:00 PM	49.3°C	75.7°C
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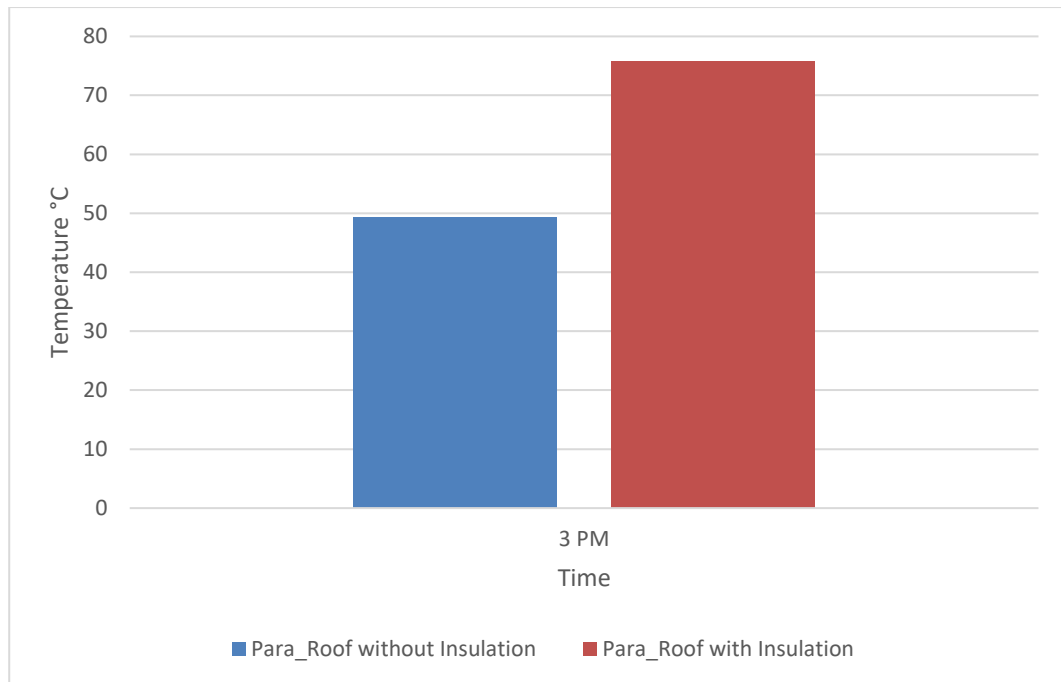


Fig. 5.29 Comparison of Parabolic roof shape for 3 PM

According to the results, parabolic roof shapes with north wall insulation (75.7°C) perform better than parabolic roof shapes without north wall insulation (49.3°C) at 3:00 PM

Table 5.10 Comparison of Parabolic roof shape for 5 PM

	Para Roof without Insulation	Para Roof with Insulation
5:00 PM	43.8°C	68.8°C

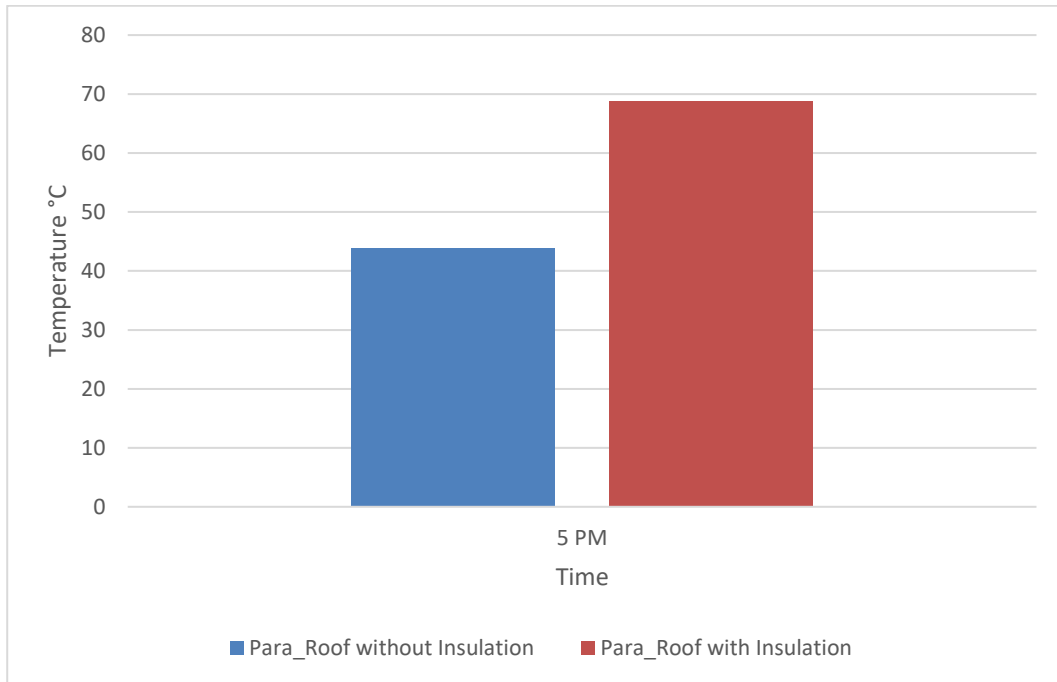


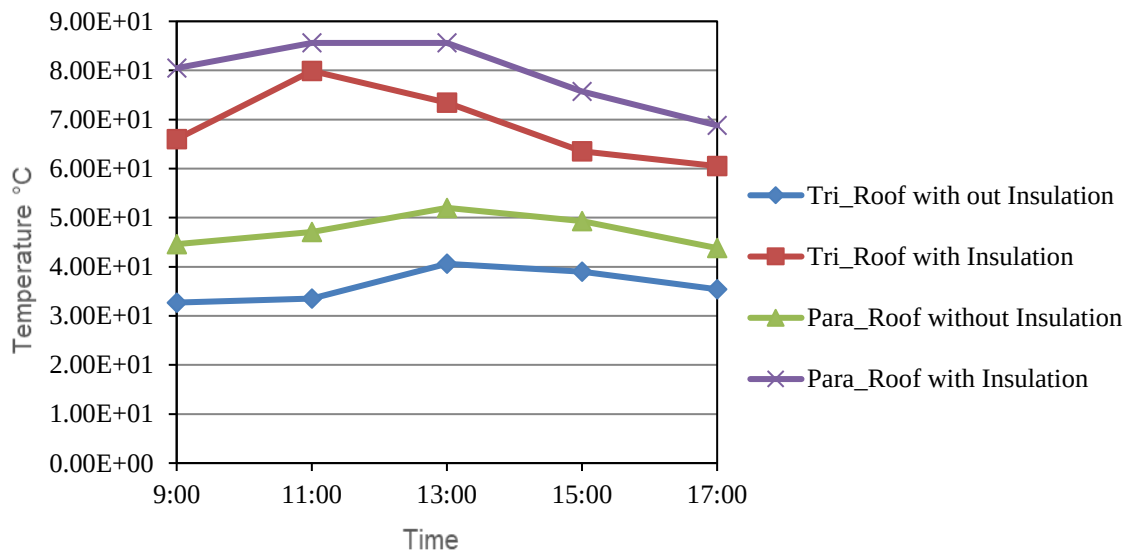
Fig. 5.30 Comparison of Parabolic roof shape for 5 PM

According to the results, parabolic roof shapes with north wall insulation (68.8°C) perform better than parabolic roof shapes without north wall insulation (43.8°C) at 5:00 PM

5.3 Performance Analysis

Table 5.11: Maximum temperature generated from the dryers

	Tri Roof without Insulation	Tri Roof with Insulation	Para Roof without Insulation	Para Roof with Insulation
9.00 AM	32.7°C	66.0°C	44.6°C	80.5°C
11.00 AM	33.5°C	79.9°C	47.1°C	85.6°C
1.00 PM	40.6°C	73.4°C	51.3°C	85.6°C
3.00 PM	39.0°C	63.5°C	49.3°C	75.7°C
5.00 PM	35.4°C	60.5°C	43.8°C	68.8°C

**Fig. 5.31 Temperature variation with time and cases considered**

The simulation has been made to study the temperature variation inside the dryer for two different convection processes. By the performance analysis of the different shapes, we got four cases of greenhouse solar dryer which is triangular roof with and without north wall insulation, parabolic roof with and without north wall insulation. The temperature profiles for all Cases are also plotted for the better

understanding of the temperature variation inside the dryer. According to the analysis we go the different temperatures to each case. The temperature has been taken in different timing from morning 9 AM to evening 5 PM through the Ansys fluent. Comparing to the triangular roof the parabolic roof got the highest temperature in both with north wall insulation and without north wall insulation the graph shows the temperature and timing for the results of the respective. The maximum temperature generated by the greenhouse solar dryer is the parabolic roof with north wall insulation, the linear contact area with highest solar radiation on roof is larger. As a result, heat is collected in dryer by convection and exhaust fan is used to removes the air from the dryer slowly thereby increase the temperature of the dryer. The 1st comparison is done between Triangular roof with north wall insulation and triangular roof without north wall insulation, the 2nd comparison is done between parabolic roof with north wall insulation and parabolic roof without north wall insulation

CHAPTER 6

6.1 SUMMARY AND CONCLUSION

The results suggest that the best performing solar dryer is the dryer with parabolic roof with insulation. The addition of insulation has better effect on the performance of the dryer. The performance of the parabolic dryer was better than the triangular

type. The simulation has been made to study the temperature variation inside the dryer for two different convection processes. By the performance analysis of the different shapes, we got four cases of greenhouse solar dryer which is triangular roof with and without north wall insulation, parabolic roof with and without north wall insulation. The temperature profiles for all cases are also plotted for the better understanding of the temperature variation inside the dryer. According to the analysis we go the different temperatures to each case. The temperature has been taken in different timing from morning 9 AM to evening 5 PM through the Ansys fluent. Comparing to the triangular roof the parabolic roof got the highest temperature in both with north wall insulation and without north wall insulation the graph shows the temperature and timing for the results of the respective. The maximum temperature generated by the greenhouse solar dryer is the parabolic roof with north wall insulation, the linear contact area with highest solar radiation on roof is larger. As a result, heat is collected in dryer by convection and exhaust fan is used to removes the air from the dryer slowly thereby increase the temperature of the dryer. The 1st comparison is done between Triangular roof with north wall insulation and triangular roof without north wall insulation, the 2nd comparison is done between parabolic roof with north wall insulation and parabolic roof without north wall insulation

The simulations for greenhouse solar dryer are carried out for two different roof shapes triangular and parabolic. Based on the analysis the following conclusions have been obtained:

- From the results it is observed that the solar radiation increases sharply from 10am to noon, reaches its peaks at 1pm and decreases after 1pm considerably. The maximum temperature will be attained only at 1pm.
- The mass flow rate of the air was maintained constant at 2 m/s with an exhaust outlet below roof

- The temperature attained by parabolic roof has more than the triangular roof.
- Therefore, from the analysis, it is concluded that triangular roof with forced convection process with 2m/s mass flow rate gives better results.

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