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Analysis of Latent Heat Thermal Energy Storage System Using Phase Change Material

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Abstract *-— Energy storage is that the capture of energy produced on just one occasion to be used at a later time. A device that stores energy is usually called an accumulator or battery. Energy comes in multiple forms, including radiation, chemical, gravitational potential, electrical potential, electricity, elevated temperature, the heat of transformation, and kinetic. Energy storage involves converting energy from forms that are difficult to store to more conveniently or economically storable forms. Bulk energy storage is currently dominated by hydroelectric dams, both conventional also as pumped.*

Keywords: *Phase Change Material(PCM), Thermal energy storage(TES), Latent Heat, CAD, CFD*

I. INTRODUCTION

Thermal energy storage (TES) is achieved with widely differing technologies. Counting on the precise technology, it allows excess thermal energy to be stored and used hours, days, or months later, at scales starting from the individual process, building, multiuser-building, district, town, or region. Other sources of thermal energy for storage include heat or cold produced with heat pumps from off-peak, lower-cost electrical power, and a practice called peak shaving; heat from combined heat and power (CHP) power plants; the heat produced by renewable electricity that exceeds grid demand and waste heat from industrial processes. Thermal energy storage through PCM is capable of storing and releasing large amounts of energy. The system depends on the shift in phase of the fabric for holding and releasing the energy. As an example, processes like melting, solidifying, or evaporation require energy. Heat is absorbed or released when the fabric changes from solid to liquid and the other way around. Therefore, PCMs readily and predictably change their phase with a particular input of energy and release this energy at a later time.

A) LATENT HEAT

Latent Heat Storage (LHS) is predicated on the warmth absorption or release when a storage material undergoes a phase transition from solid to liquid or liquid to gas or vice–versa. The heat of transformation is the energy released or absorbed, by a body or a thermodynamic system, during a constant-temperature process. Two common sorts of heat of transformation are the heat of transformation of fusion (melting) and heat of transformation of vaporization (boiling). These names describe the direction of energy flow when changing from one phase to the next: from solid to liquid and liquid to gas. The storage capacity of the LHS system with a PCM medium is given by Q = m [Csp (Tm – Ti) + am. hm + Ctp (Tf - Tm)]

B) Solid-solid PCM materials:

A specialized group of PCMs that undergo a solid/solid phase transition with the associated absorption and release of large amounts of heat. These materials change their crystalline structure from one lattice configuration to a different one at a hard and fast and well-defined temperature, and therefore the transformation can involve latent heats like the foremost effective solid/liquid PCMs. Such materials are useful because, unlike solid/liquid PCMs, they are doing not require nucleation to stop supercooling. Additionally, because it's a solid/solid phase transition, there's no visible change within the appearance of the PCM, and there are not any problems related to handling liquids, e.g., containment, potential leakage, etc.

C) PARAFFINS:

Paraffinsare the foremost common PCM for electronics thermal management because they need a high heat of fusion per unit weight, have an outsized freezing point selection, provide dependable cycling, are non-corrosive, and are chemically inert. When designing with paraffin PCM, void management is vital thanks to the quantity change from solid to liquid. Paraffin PCM does even have a coffee thermal conductivity, so designing sufficient conduction paths is another key design consideration.

II. CAD AND CFD MODELLING

CAD stands for Computer-Aided Design. CAD is employed to style, develop and optimize products.

While it's very versatile, CAD is extensively utilized in the planning of tools and equipment required within the manufacturing process also within the construction domain. CAD enables design engineers to layout and develop their work on a display screen, print and preserve it for future editing. When it had been introduced first, CAD wasn't exactly an economic proposition because the machines at those times were very costly. The increasing computer power within the later part of the 20 th century, with the arrival of the minicomputer and subsequently the microprocessor, has allowed engineers to use CAD files that are an accurate representation of the size properties of the thing.

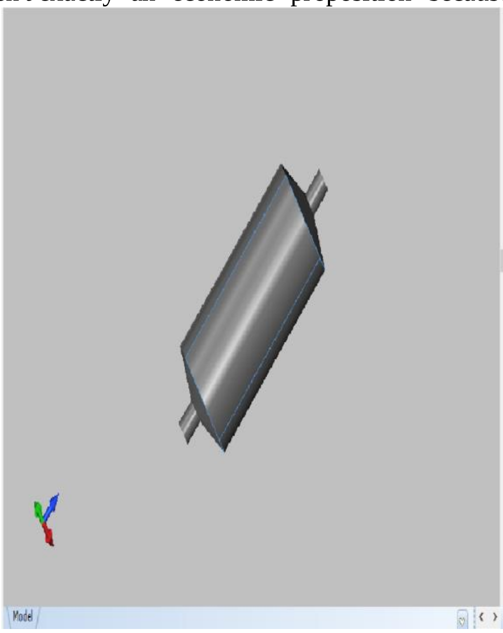

FIGURE 1:FULL GEOMETRY CAD MODEL FIGURE 2: CROSS – SECTION OF THE MODEL

CAD software enables

I. Efficiency in the quality of design.
II. Increase in the Engineer's productivity.
III. Improve record-keeping through better documentation and communication.

CAD facilitates the manufacturing process by transferring detailed information on a few products in an automatic form which will be universally interpreted by trained personnel. It is often wont to produce either two-dimensional or three-dimensional diagrams. The use of CAD software tools allows the thing to be viewed from any angle, even from the within searching. One of the most advantages of a CAD drawing is that the editing may be a fast process as compared to the manual method.

i)COMPUTATIONAL FLUID DYNAMICS

Computational fluid dynamics (CFD) may be a branch of hydraulics that uses numerical analysis and data structures to unravel and analyze problems that involve fluid flows. Computers are wont to perform the calculations required to simulate the interaction of liquids and gases with surfaces defined by boundary conditions. With high-speed supercomputers, better solutions can be achieved. Ongoing research yields software that improves the accuracy and speed of complex simulation scenarios such as transonic or turbulent flows. Computational fluid dynamics (CFD) is used to assess the hydrodynamic performance of a positive displacement left ventricular assist device. The computational model used implicit large eddy simulation direct resolution of the chamber compression and modeled valve closure to breed the in vitro results.

ii)**ANSA - CAE PREPROCESSOR**

ANSA may be a computer-aided engineering tool for Finite Element Analysis and CFD Analysis widely utilized in the automotive industry. It is developed by BETA CAE Systems. The software is distributed worldwide by a variety of BETA CAE Systems subsidiaries and business agents. In us, it's distributed by Beta CAE Systems, USA, based in Farmington Hills, Michigan. ANSA maintains the association between CAD geometry and, therefore, the FE mesh. This means that the FE meshes are better representations of their geometric parents. It is an advanced CAE pre-processing tool for Finite Element Analysis that provides all the necessary functionality for full-model build-up, from CAD data to ready-to-run solver input files, in a single integrated environment. ANSA software is the users' favorite due to its wide range of features and tools that meet their needs. The list of productive and versatile ANSA features is long, and therefore the alternative tasks and processes to be completed using them are countless. Also it's easy to take care of and update any changes within the geometry by simply reworking the updated area rather than recreating the FE from scratch.

It carries several proprietary algorithms for meshing suitable for both CFD and structural models. ANSA was initially standing for 'Automatic net generation for structural analysis, but the software has gone beyond that very quickly. ANSA has broadly six menus which are wont to do various activities those are: TOPO MESH VMESH DECK-SOLVER MORPH HBLOCK.

New technology CATIA V4, CATIA V5, NX, PTC Creo Parametric, Solid Works, Inventor, and JT to ANSA CAD data translators provide unique data access solutions. Numerous translation options, controlled through the translator's GUI or through the instruction, allow the complete control of the resulting data.

III. RESULTS AND DISCUSSION

a)WITHOUT PCM:

Result analysis of the model without containing phase change material.

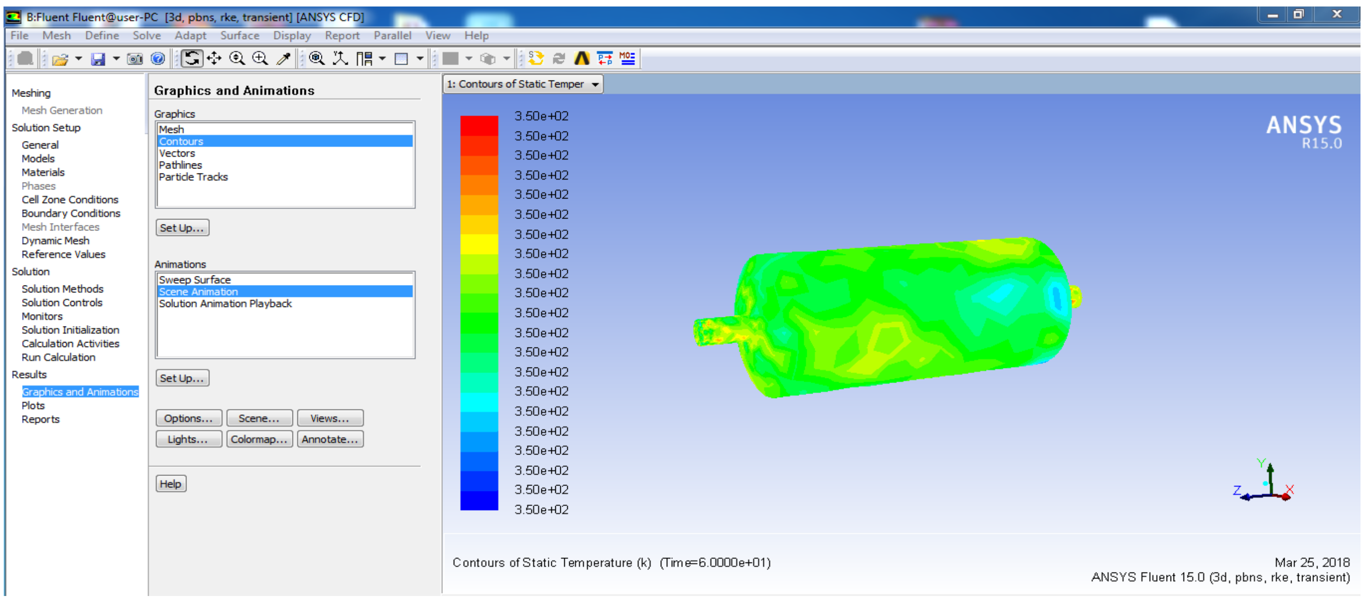

FIGURE3: STATIC TEMPERATURE CONTOUR WITHOUT PCM

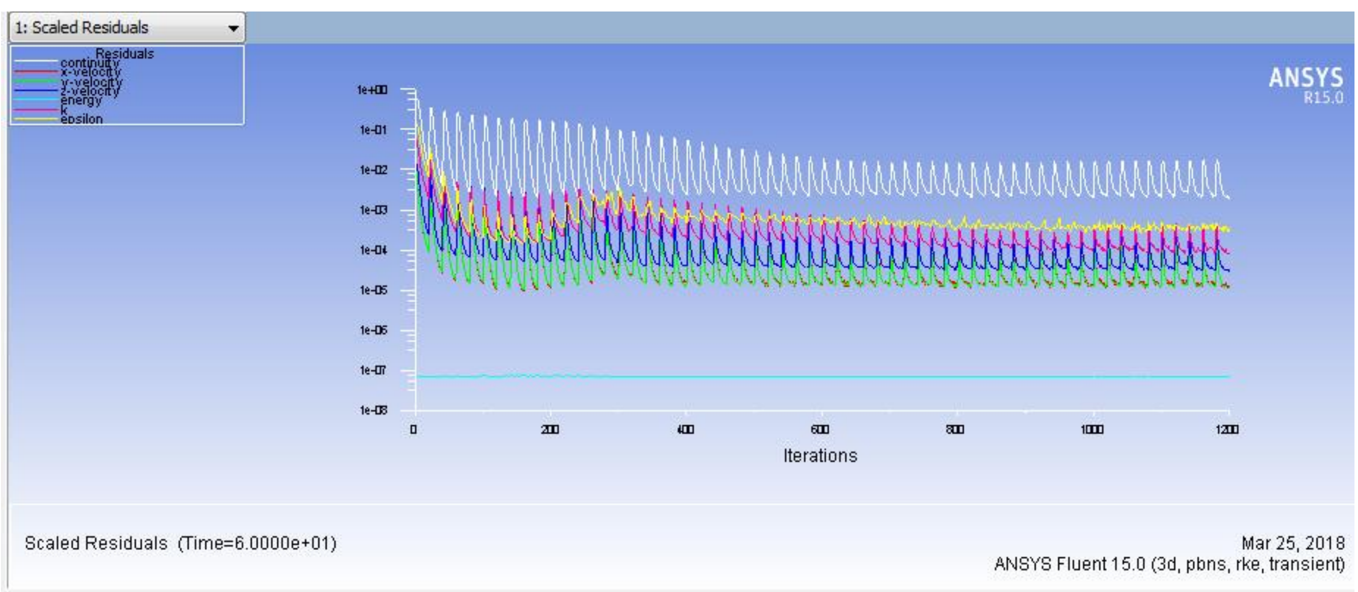

FIGURE4: SCALED RESIDUAL CURVE WITHOUT PCM

b)WITH PCM:

Result analysis of the model containing phase change material.

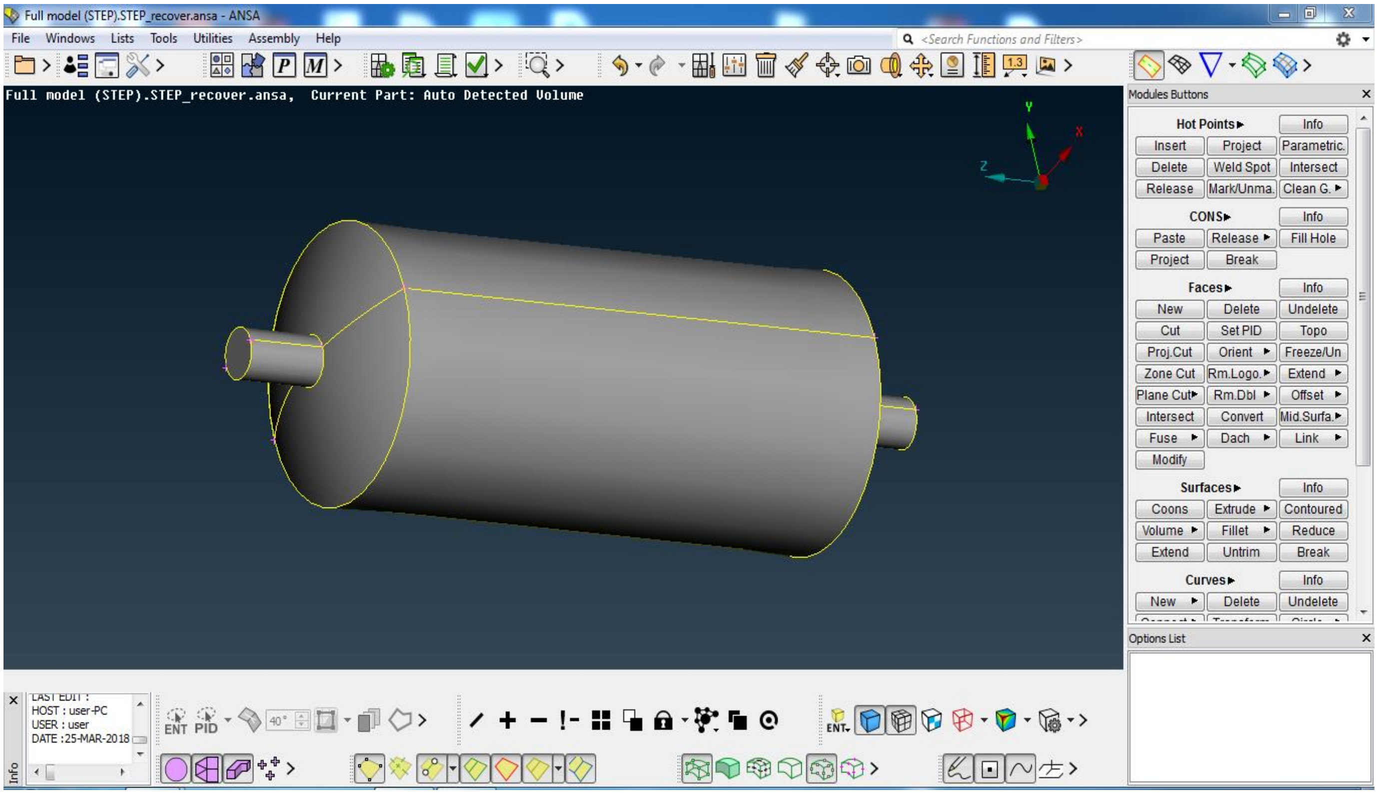

FIGURE5: FULL GEOMETRY WITH PCM

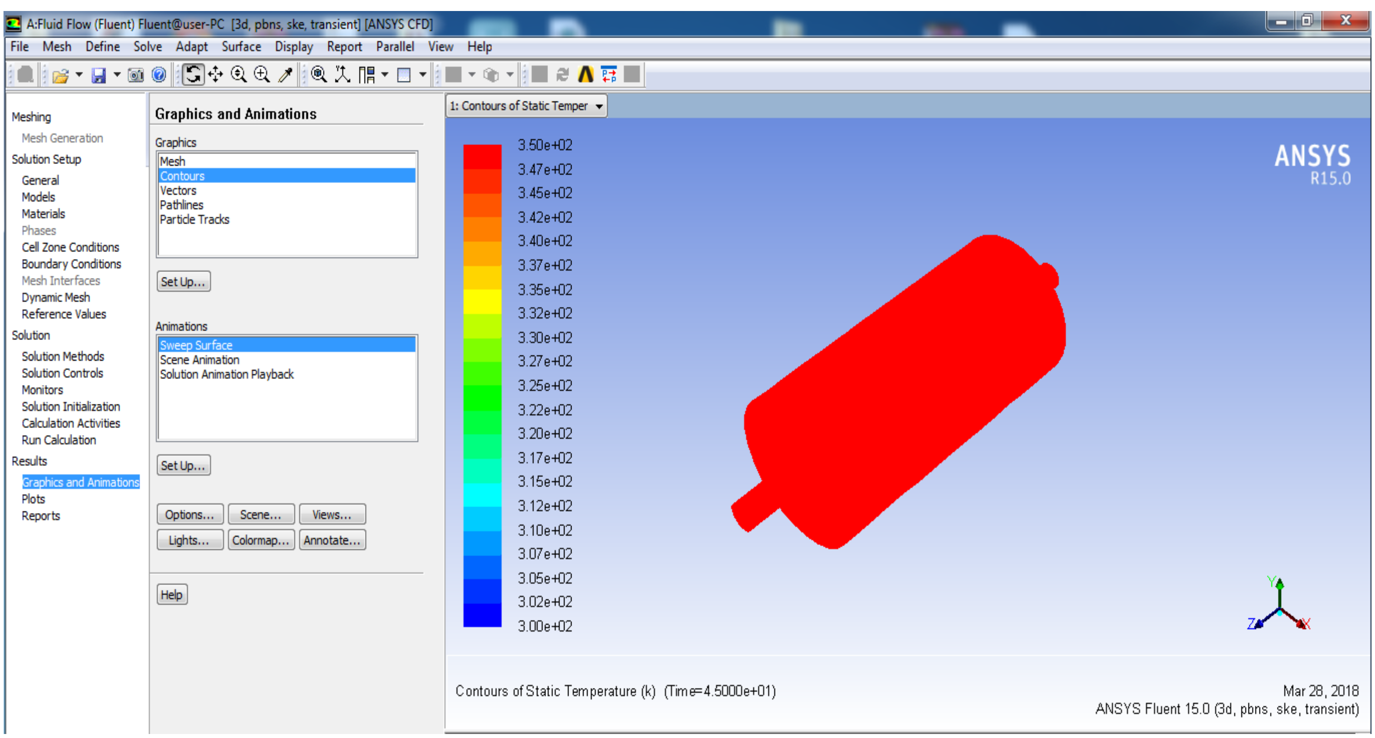

FIGURE6: STATIC TEMPERATURE CONTOUR WITH PCM

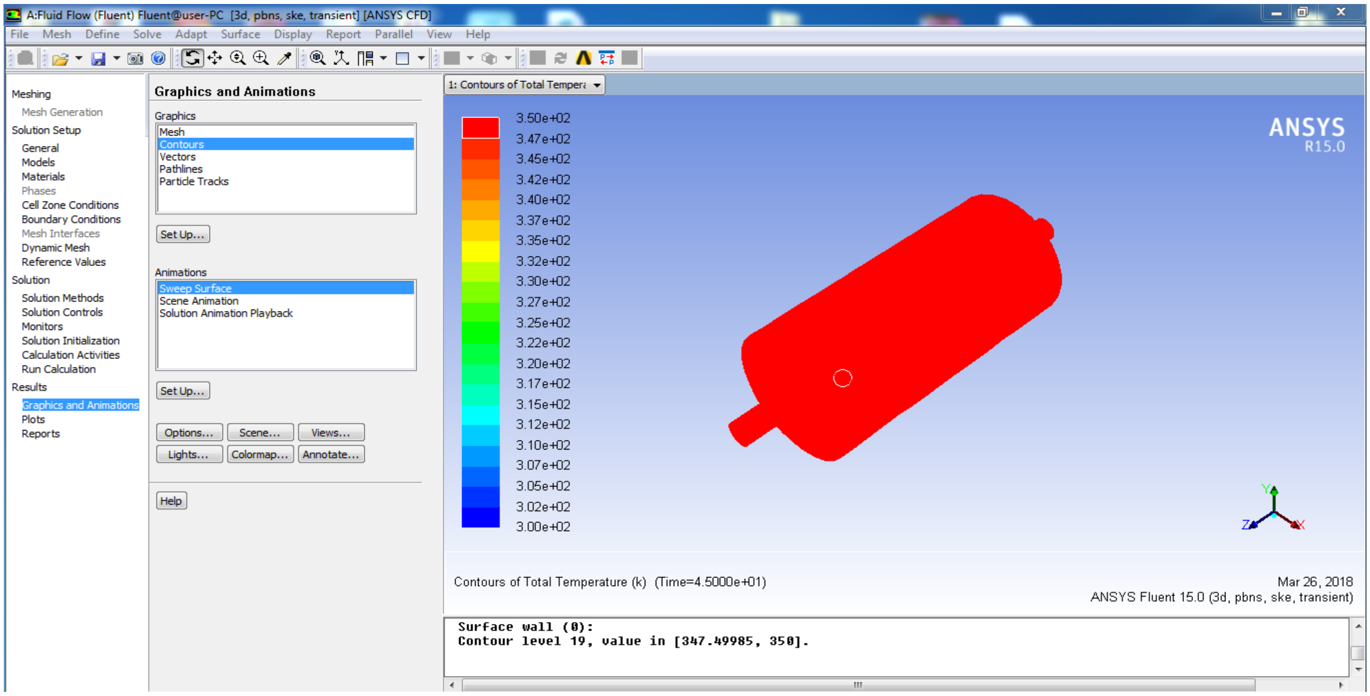

FIGURE 7: TOTAL TEMPERATURE CONTOUR WITH PCM

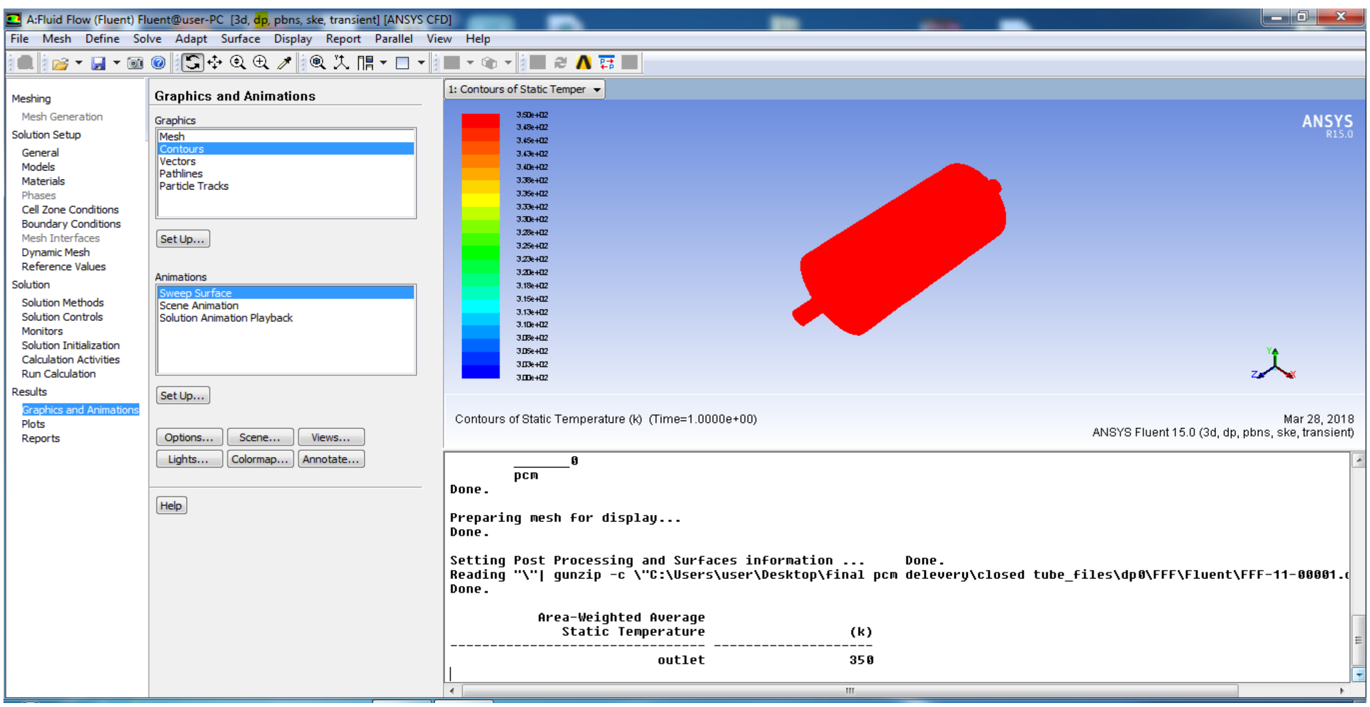

FIGURE 8: STATIC TEMPERATURE CONTOUR UNDER DOUBLE PRECESSION WITH PCM

Thus these analyses show that the thermal efficiency of the model is increased under the utilization of phase change paraffin wax. This improves the heat storage under the latent heat storage method, and the efficiency of the utilized model can be improved.

IV. CONCLUSION

The storage of thermal energy within the sort of sensible and heat of transformation has become a crucial aspect of energy management with the stress on efficient use and conservation of the waste heat and solar energy in industry and buildings. Latent heat storage is one of the most efficient ways of storing thermal energy. Solar energy may be a renewable energy source that will generate electricity, provide predicament, heat and funky a house, and supply lighting for buildings. Paraffin waxes are cheap and have moderate thermal energy storage density but low thermal conductivity and, hence, require a large surface area. Hydrated salts have a bigger energy storage density and a better thermal conductivity. In response to increasing electricity costs and therefore the desire for better lad management, thermal storage technology has recently been developed. The storage of thermal energy in the form of sensible and latent heat has become an important aspect of energy management with an emphasis on the efficient use and conservation of waste heat and solar energy. The heat distribution in HTF and PCM was analyzed by CFD analysis. Thus this emphasizes that the phase change material can improvise the thermal storage capacity of any working component of a system by improving its thermal storage efficiency.

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