JOINT INSTITUTE FOR NUCLEAR RESEARCH

Veksler and Baldin Laboratory of High Energy Physics

FINAL REPORT ON THE INETREST PROGRAMME

Topic- Simulation of Solar-heating of the MPD-Pit and MPD-Hall

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Abstract

The main goal of this project is to conduct the simulation study of external solar heating of MPD-Pit and MPD-Hall, where MPD (Multi Purpose Detector) is one of the two detectors of NICA-Megaproject (Nuclotron- based Ion Collider fAcility) at JINR (Joint Institute for Nuclear Research) in Dubna (Russia). During the work CFD (Computational Fluid Dynamics) analysis was done to determine the overall temperature of the Hall.

The project also includes making a simplified 3D CAD model of the original design of MPD Hall in Autodesk Inventor Pro alongwith the analysis of the simulation results in Autodesk CFD software is presented.

Introduction

NICA (Nuclotron-based Ion Collider fAcility), is being implemented to create an ionic collider based on the Nuclotron as part of a program to study nuclear matter in a hot and dense state.The main objectives of the program is the creation of an accelerator complex of ions with high luminosity in the energy range of up to 11 GeV/nucleon and a modern multi-functional detector for the study of heavy ion collisions.

The collider has two meeting points for the beams, which makes it possible to install two detectors and simultaneously carry out two experiments.

One of the detectors, the MPD (Multi-Purpose Detector), is planned to study the properties of hot and dense nuclear matter formed during collisions of high-energy heavy ions.The MPD is an advanced technical device with many parameters and features that require constant monitoring and control in on-line mode. Therefore, the MPD construction requires designing and execution of dedicated technical installations using advanced technologies that will meet the task. Service requirements for MPD, made it an integrated structure placed on the wagon, allowing the entire module to be moved within 11 meters for service purposes. Therefore, the MPD control room will be placed on a special mechanical structure in four floors. This mechanical block is referred to as the Mechanical Platform. In this design, we will install the MPD infrastructure at 32 RACKs.

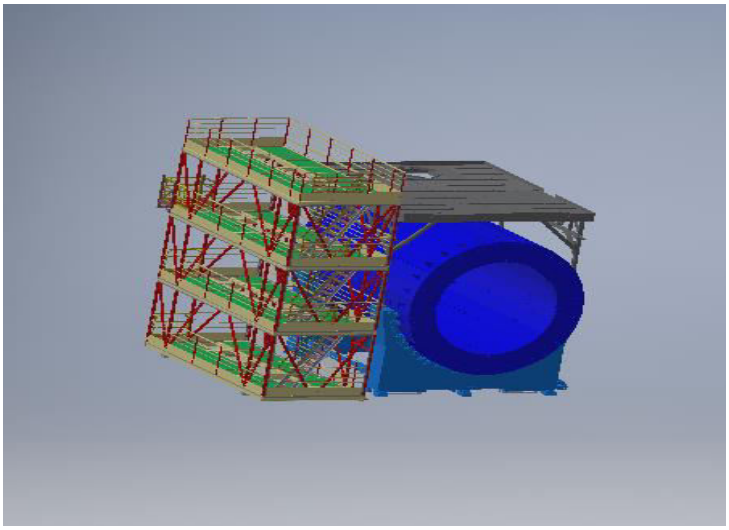
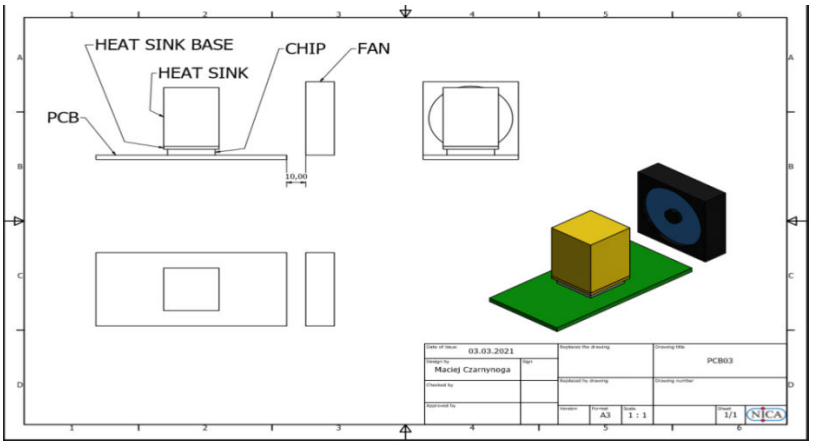


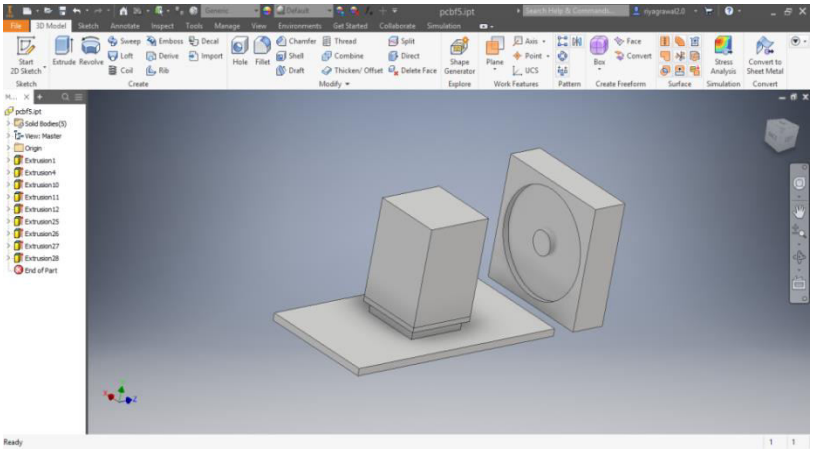
Fig: RACK and MPD

Electronics Cooling

The electronic chassis is interpreted and the geometry model is prepared based on technical drawings to determine the component temperatures and the flow distribution. The enclosure consists of a PCB, chips, heat sink and a fan. A commercially-available fan moves cooling air through the enclosure.

Materials and Boundary Conditions that are considered for the same are:
Chip heat generation: 15W
PCB material: Default PCB
Chip material: Silicon
Heat sink base material: Copper
Heat sink material: MC20
Fan case material: ABS (default)
Fan material: ComairRotron FlightII 120 2000RPM (default)
Temperature of the environment: 20C
Dimension of the external volume: x length: 30cm, y length: 40cm, z length: 40cm





Results Visualization

Visualization of Flow-

To visualize the flow, some of the visualization tools like result planes and iso surfaces are used. Outer area appears blue because the current result is in velocity magnitude, and the velocity outside is 0 cm/s and the maximum velocity is found to be 501.14 cm/s.

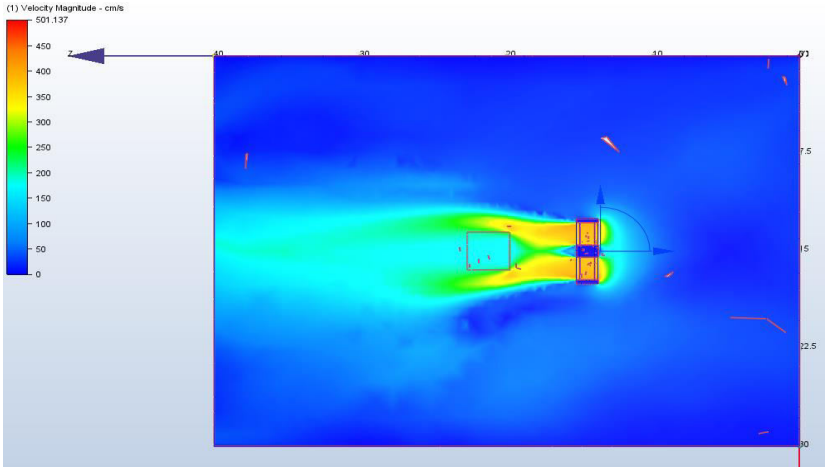


Fig: Cross-section plane for velocity

Visualization of Temperature-

The minimum temperature recorded is 20 C and the maximum temperature for the same is 30.27 C.

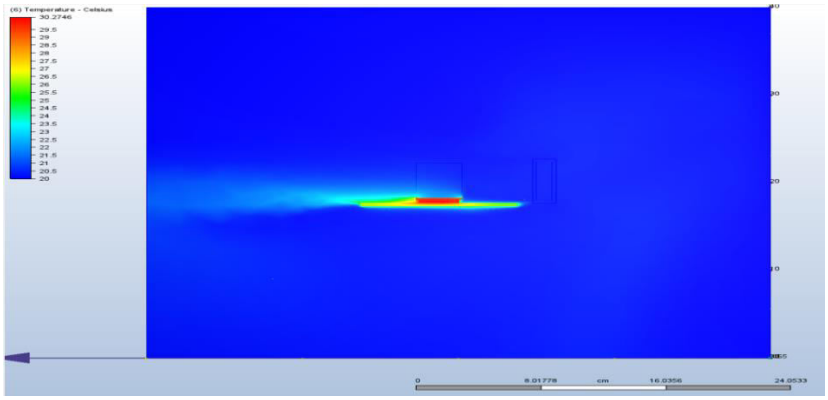


Fig: Cross-section plane for temperature

Air which is pushed by the fan-

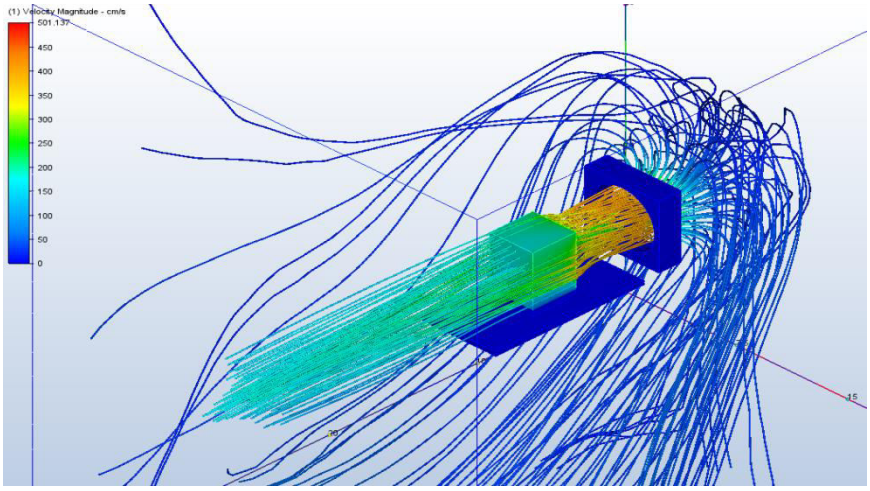


Fig: Particle tracking

Solar Heating

As a part of the design process, a simplified model of MPD-Pit and MPD-Hall needs to be created for easy obtaining of simulation and without much variation in the results.

The conservative approach of neglecting the flow calculation is considered. The predicted temperatures will be higher than actual because the convection is omitted which would have a significant cooling effect, and since the project aims to conduct external solar heating and not considering any solar heating of the interior of hall henceforth all windows and doors are removed.

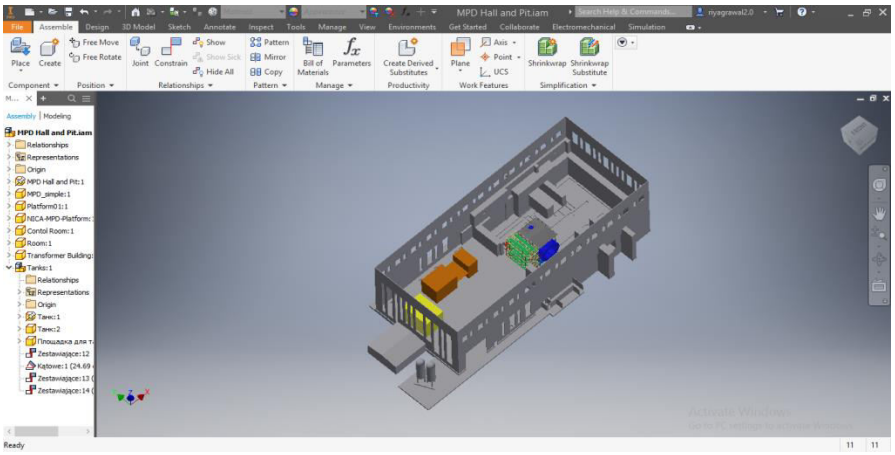


Fig: MPD-Pit and MPD-Hall assembly

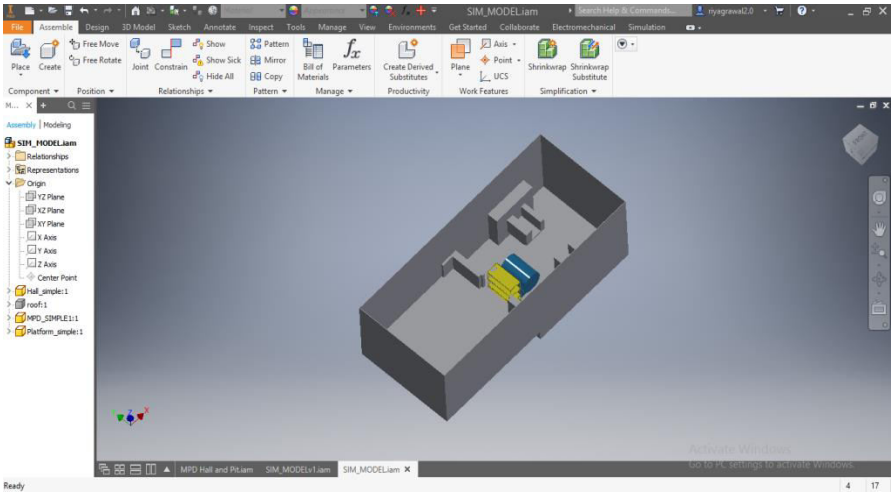


Fig: Simplified 3D CAD Model of MPD-Pit and MD-Hall

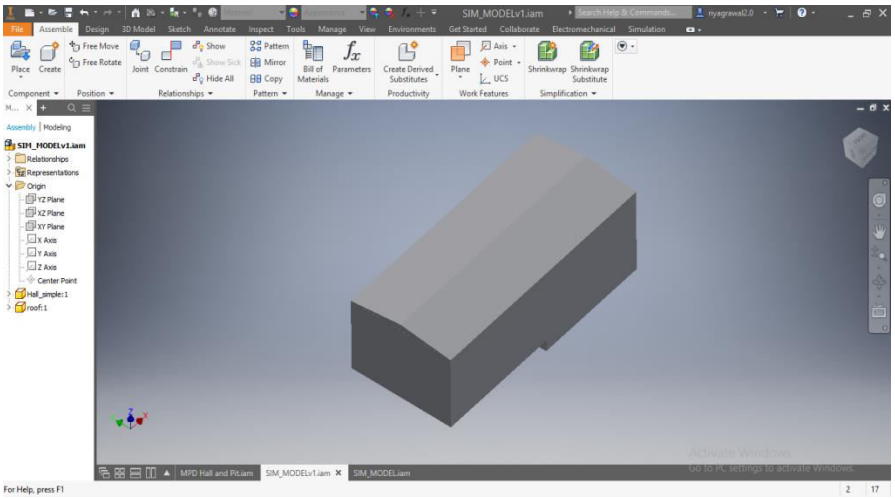


Fig: Simplified 3D CAD Model of MPD-Pit and MD-Hall with rooftop

Solar heating plays an important role in the design of buildings as it significantly affects occupant's comfort and accounts for the overall energy efficiency of the structure or space.

Autodesk CFD computes solar heating by using the radiation model to compute view factors and visual projections. For external simulations, Autodesk CFD requires a volume of air to be constructed around the scene to contain the working fluid (typically air), the purpose of environment is to properly simulate the effects of reflected and emiited radiative heat transfer between the object and its surroundingswhich allow for proper simulation of the indirect solar flux and the radiative energy loss or gain to the sky.

The shape of the environment volume is not critical, and a cube is the convienient choice. The environment volume should extend atleast 10 times the height of the objects in the analysis model. A smaller environment can be used but if natural convection is analyzed, a small volume will influence and potentially complicate the buoyancy-induced flow.

Applying the sky radiation temperature to the external surface which is nearly the ambient temperature during the day, which typically falls within a narrow range roughly between 0 C and 30 C.

Material Selection-

For the External Volume-

Type: Fluid

Materal DB Name: My Materials

Name: Air_Emmsivity

Value: 0.3 (for Emissivity)

For the Building walls-

Type: Solid

Name: Concrete

For the Rooftop-

Type: Solid

Name: Steel

Temperature Boundary Condition to Environment-

For the Walls and Rooftop-

Type: Temperature

Time: Steady State

Temperature: 25 C

For the bottom surface-

Temperature: 20 C

In the solar heating Dialog Box-

Country: Russia

City: Moscow

Results

Number of Iterations= 100

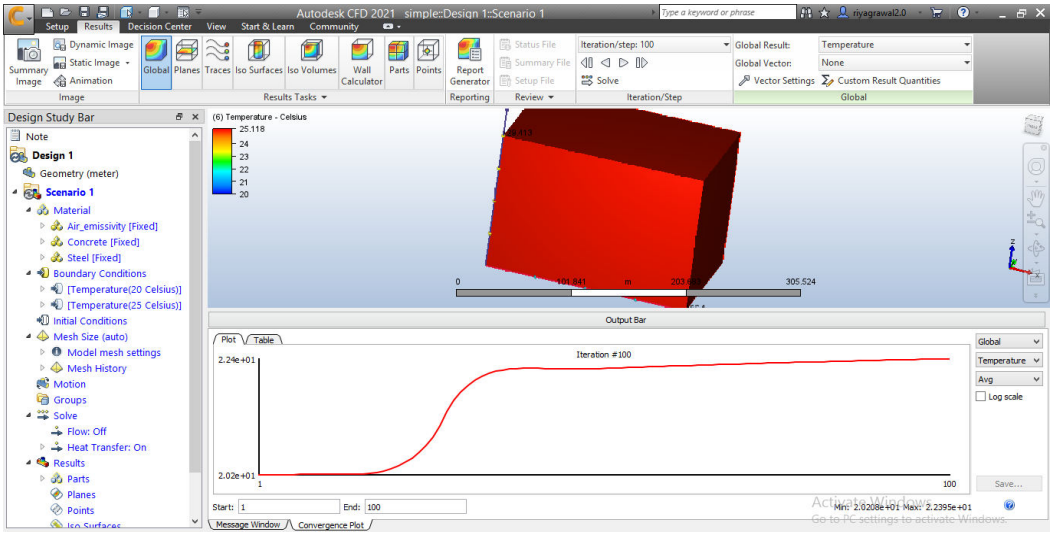


Fig: Plot for Temperature

The Minimum temperature is found to be 20 C and the Maximum Temperature recorded is 25.12 C.

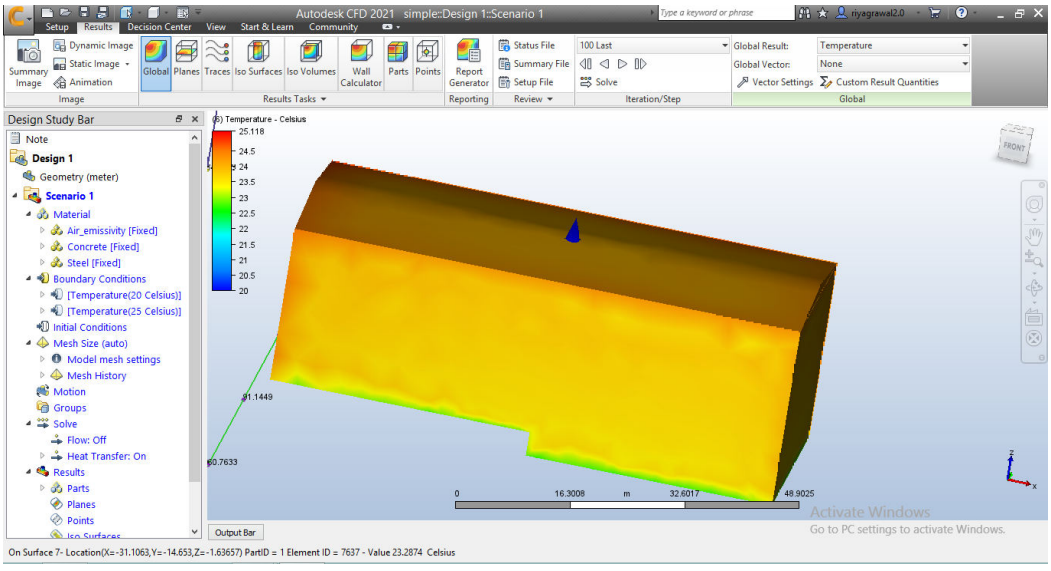


Fig: Front Contour Plot

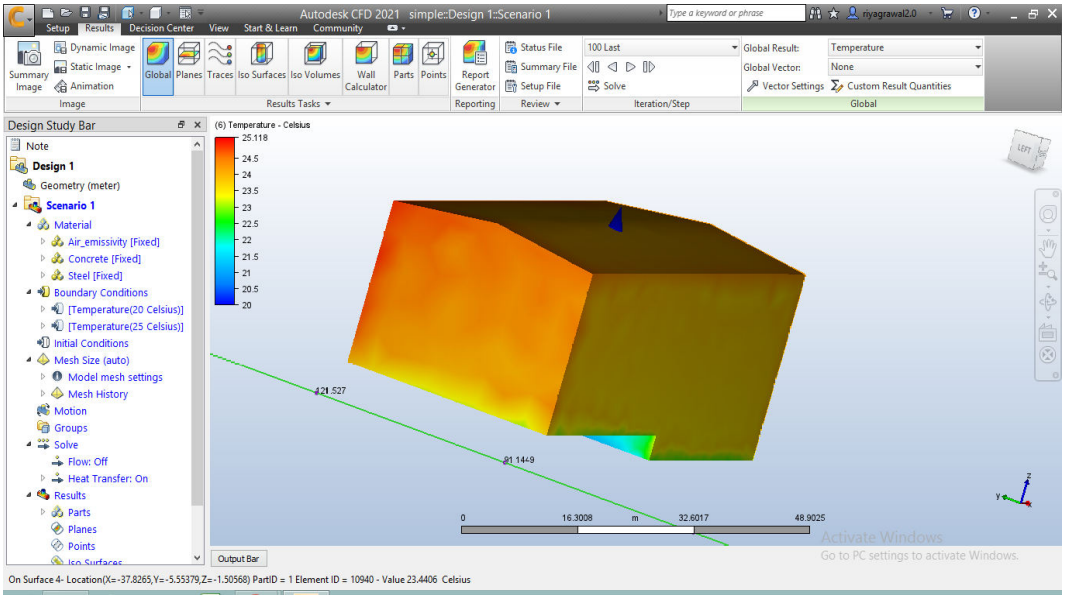


Fig: Side Contour plot

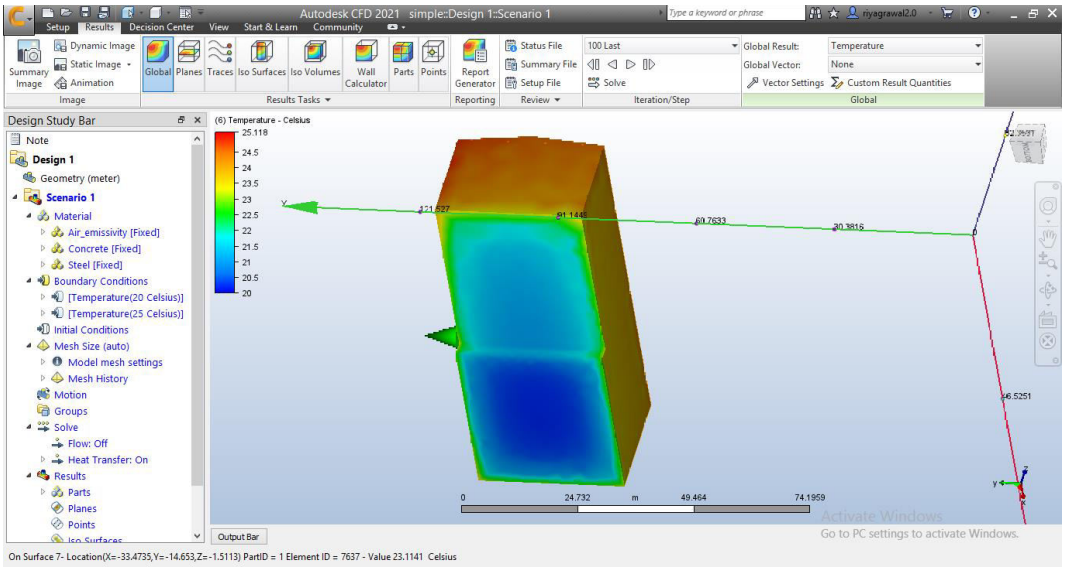


Fig: Bottom Contour Plot

Scope of Work

Furthermore, to get more realistic results, the 3D CAD model of MPD-Hall should be accompained with Glass curtain walls alongwith the beams on rooftop structures which is further simulated to get more accurate results of the solar heating on the Hall. The model shoud also be simulated for the Internal and AEC solar heating to determine the temperature variation, of the place inside which the MPD is kept ,which is due to the energy passing through the windows and other translucent fixtures as the solar heating supports radiative heat transfter through transparent media and so the different results will be obtained.

References

1. https://knowledge.autodesk.com/support/cfd/getting-started/caas/CloudHelp/cloudhelp/2019/ENU/SimCFD-QuickStart/files/GUID-F9435F15-8684-4FD5-A329-E6EC8B45B640-htm.html

2. https://knowledge.autodesk.com/support/cfd/learn-explore/caas/CloudHelp/cloudhelp/2019/ENU/SimCFD-UsersGuide/files/GUID-EBC7C1DC-11F8-4BC2-8D0D-D49AB3106848-htm.html

3. http://help.autodesk.com/view/SCDSE/2019/ENU/?guid=GUID-058152FD-D5CD-4F9A-8002-7877029825EC