JOINT INSTITUTE FOR NUCLEAR RESEARCH

Veksler and Baldin Laboratory of High Energy Physics

FINAL REPORT ON THE INETREST PROGRAMME

Simulation solar heating of NICA-MPD-Hall

Supervisor:
Mr. Maciej Czarnynoga

Student:
Riya Agrawal

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Abstract

The main goal of this project is to conduct a solar heating simulation study of MPD building and figuring out the minimum and maximum temperature values, where MPD (**M**ulti **P**urpose **D**etector) is one of the two detectors of NICA-Megaproject (**N**uclotron- based **I**on **C**ollider f**A**cility) at JINR (Joint Institute for Nuclear Research) in Dubna (Russia). During the work CFD (Computational Fluid Dynamics) analysis was done which includes the influence of solar heating temperature stability of MPD Equipment.

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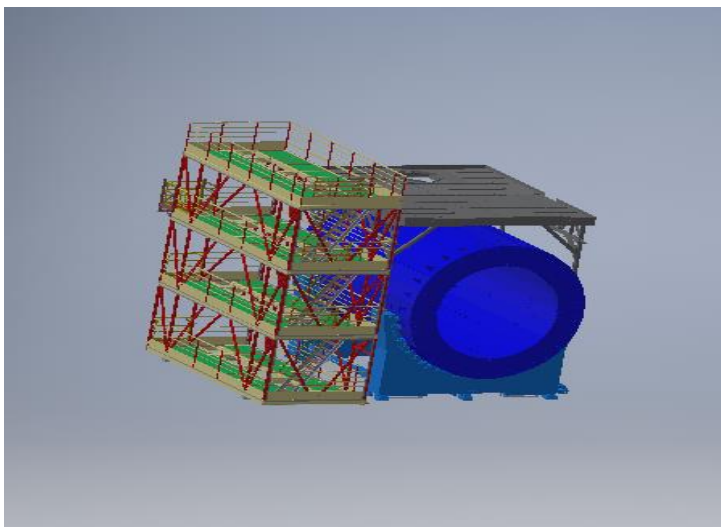

Fig: RACK and MPD

Revised Scope of Work

To get more realistic results, the simplified 3D CAD model of MPD-Hall is accompanied with Glass curtain walls and control rooms along with the beams on rooftop structure, which is then simulated to get more accurate results of the solar heating on the Hall.

Solar Heating

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. Passive Solar heating relies on architectural design (site, structure, material) and are utilized to maximize heating effect of sunlight. Well insulated buildings with large glass windows will effectively trap heat and reduce reliance on electricity. Mechanical means are used to store, collect, distribute solar energy in buildings. Also, entering sunlight warms the air and surfaces in room and this warmth is carried to other rooms in building by means of natural convection.

As a part of the design process, a simplified model of NICA-MPD-Hall is 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 and steady state condition was maintained.
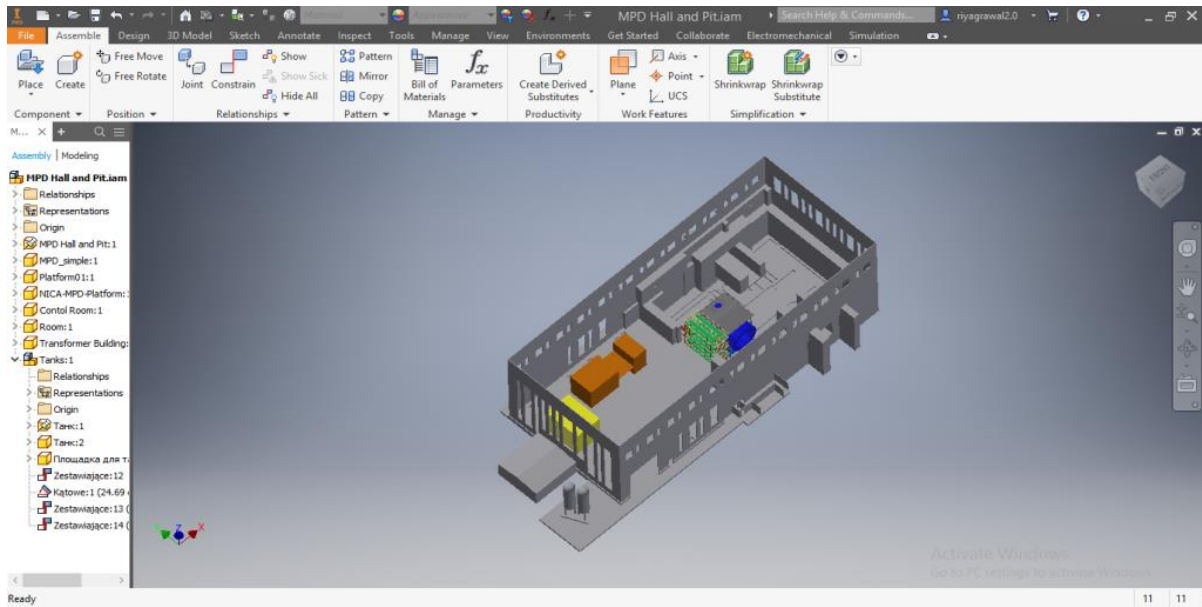
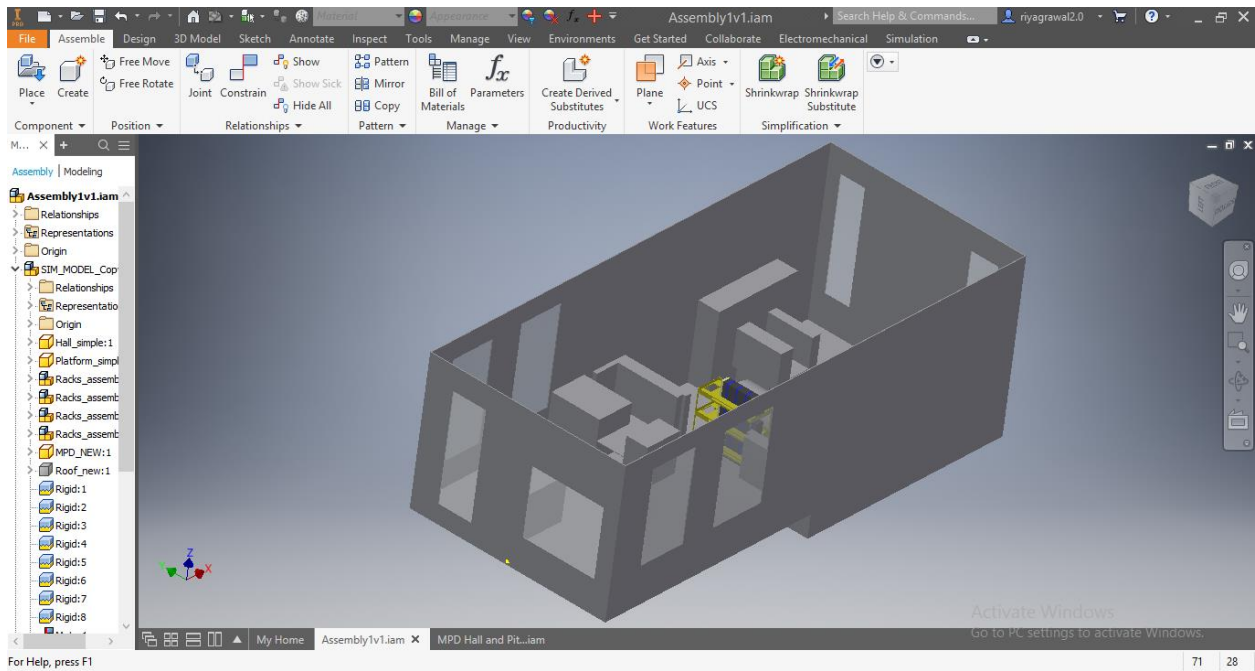Fig: Original MPD-Pit and MPD-Hall assembly

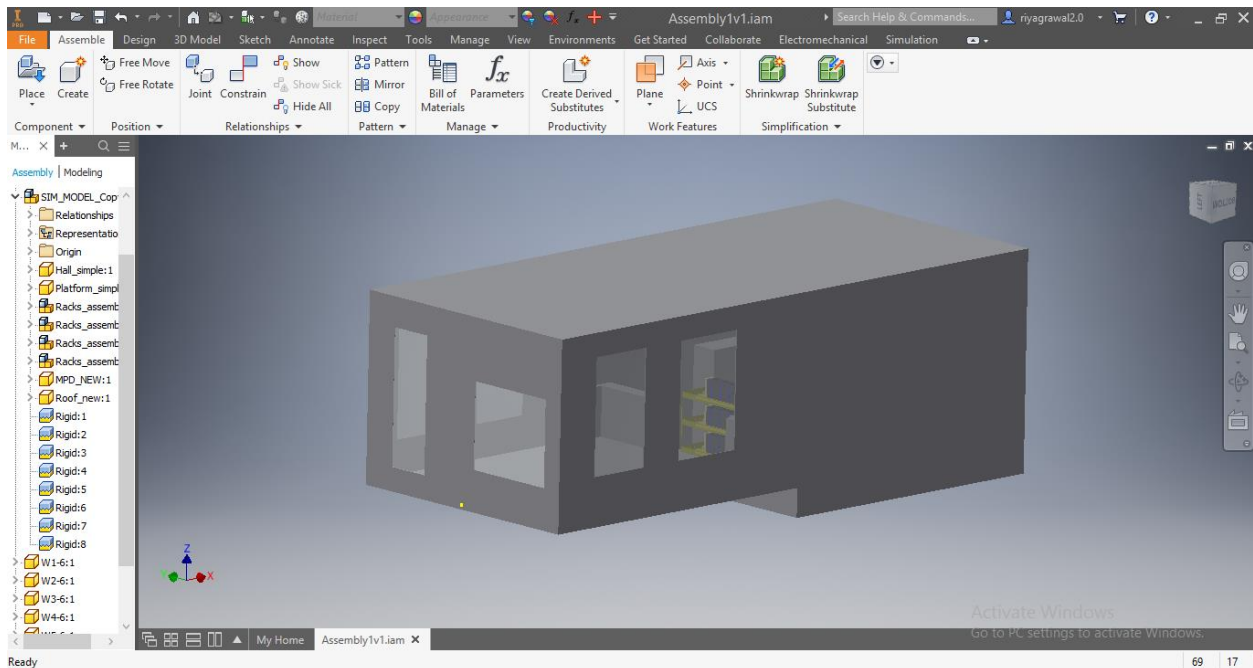Fig: Simplified 3D CAD Model of MPD-Hall with control rooms and windows

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

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 emitted radiative heat transfer between the object and its surroundings which 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 convenient choice. The environment volume should extend at least 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.

Revised Material Selection-

For the External Volume-

Type: Fluid

Material DB Name: My Materials

Name: Air_Emmisivity

Value: 0.3 (for Emissivity)

For the Building walls and rooftop-

Type: Solid

Material: Aluminium

For Windows-

Type: Solid

Material: Glass

For the MPD and Rack-

Type: Solid

Material: Steel

For supporting structures and floor-

Type: Solid

Material: Concrete

Temperature Boundary Condition to Environment-

<u>For the Walls and Rooftop-</u>

Type: Temperature

Time: Steady State

Temperature: 30° C

<u>For the bottom surface-</u>

Temperature: 25° C

In the solar heating Dialog Box-

Country: Russia

City: Moscow

Number of Iterations performed= 200
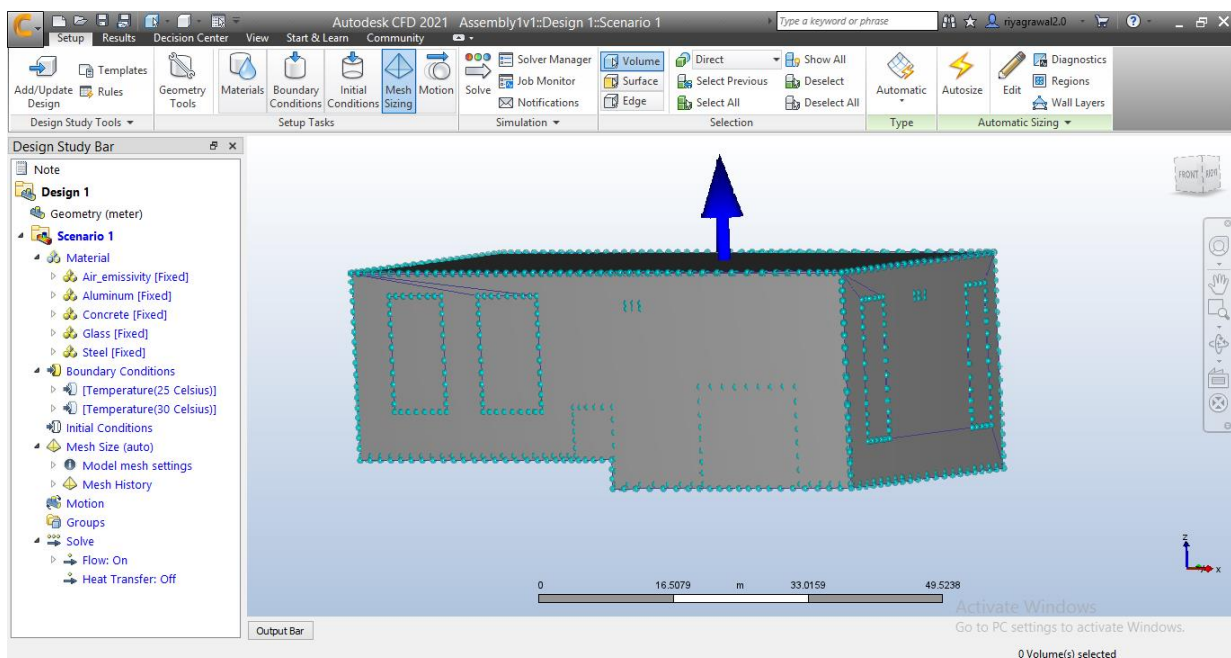
Results

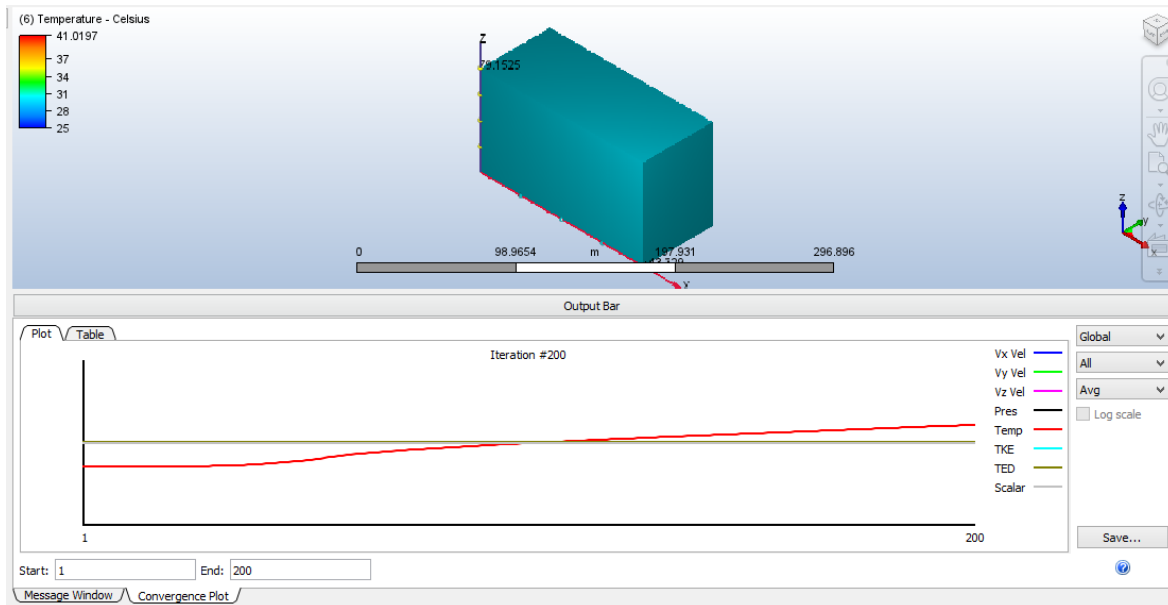The Minimum temperature is found to be 25° C and the Maximum Temperature recorded is 41.02° C.
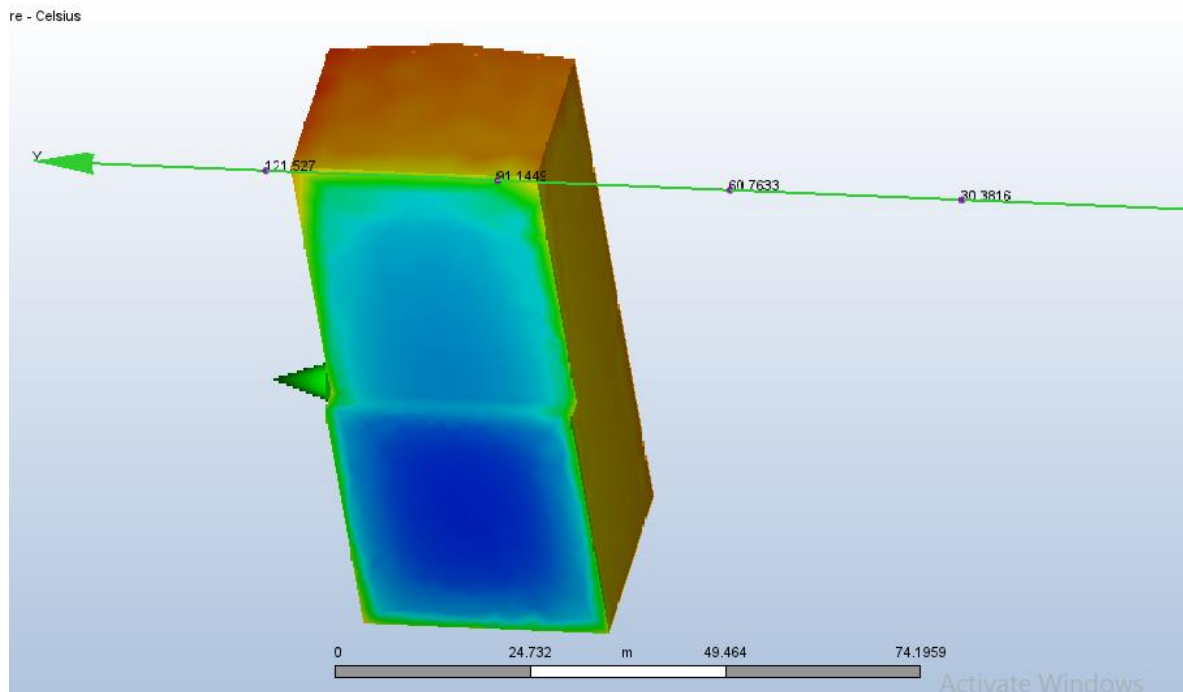

Fig: Plot for Temperature

Fig: Bottom Contour Plot

Revised Future Scope of Project

1. The model should 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 transfer through transparent media and so the different results will be obtained.
2. Heat generated through MPD and the variation in results due to installation of various air conditioning systems also needs to be studied.

Acknowledgement

References

1. https:/nica.jinr.ru/

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

3. https://nica.jinr.ru/ru/projects/mpd.php

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

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