

# 3D modelling and simulation of Calendria and pressure tube of PHWR

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## Abstract—

*The main objective of the project is 3D modelling of Calendria and pressure tube of PHWR” reactor components of PHWR using Autodesk 3dsmax. This model is similar to the CANDU Reactor which is a heavy fuel nuclear reactor which can refuel reactor channels. It consists of many mechanical components and drives (i.e. Calandria, Fuel pipes and RAMC head). 3D models of FM components are made using 3Ds max with the help of 2D AutoCAD drawings.*

*3Ds Max is a 3D modelling, animation and rendering program from the Media and Entertainment division of Autodesk. Widely used in the areas of interactive games, visual effects for movies and industrial design models. The application also includes an animation module.*

*For animating these components Unity 3D software which is a game designing software. By making use of Unity 3D we can import components from 3Ds max and simulate them.*

*The components are simulated by making use of C# programming language which is used in Unity for game programming*

*By using this software, we create 3D models of Calandria and pressure tube of PHWR” to study the design of CANDU and it will also help new trainees to understand the system well. It helps us understand the working of every pipe present in CALANDRIA separately.*

## Introduction

Fuelling machine is a very complex machine which is used to refuel the reactor whenever required. Simulation of Fuelling machine will help the operators to understand the working of the fuelling machine on the reactor. 3D models of fuelling machine component help operator to visualize objects and understand them in a better way. 3D models of FM components are made using 3Ds max with the help of 2D AutoCAD drawings

To model the components of Fuel Handling Machine using 3Ds max which will be used to develop the simulation of Fuel Handling Machine.

The main objective is to show mechanical internal details of Fuel Handling Machine for training purpose. It is a part of the simulation application which shows the activities taking place in the Fuelling Machine on the computer monitor so that the operator or controller can watch what is going on inside the Fuelling Machine

This project is a training tool which helps employees understand how will the system work in reality. The system is basically a replica of CANDU which is considered as Canada’s most successful nuclear reactor plant. CANDU consists of Calandria which consists of 300 fuel pipes.it also consists of RamC head which is used in order to view the functioning of all the pipes .in this project we made use of various software such as AutoCAD -Which was used to design the entire system, 3Ds Max which was used to convert all the images to 3D,Unity 3D is a gaming software which we used to simulate the entire system .For simulating the components we made use of c# programming language.CANDU is a heavy water reactor which contains uranium or heavy water as the main fuel used. Coolant used in this plant is water. The main purpose of initiating this project was to observe the exact working of the nuclear power plant by creating its equivalent software model.By doing so we can give real-life experience to employees by avoiding the possibility of various damages that may likely occur in the system.This is done by programming the system in such a way that we can view all the pipes that are present in the calandria Also we can observe the core of the given system.in order to understand the system well.

It is in the field of Computer Graphics object-oriented programming system. The main working of project is based on Fuelling Machine.

## Literature review

[1] By referring the book the second edition of unity projects using virtual reality written by Jonathan Lewis we learned how to use gaming options to simulate objects .3D modelling was done by referring the paper written by Surendra Pal Singhla, Kamal Jain1b, V. Ravibabu Mandla.

3D graphics are used for a very long time for understanding components well and their functioning. Also we can easily add details of all the components present in the observed system by using 3ds max.3ds Max is a software which helps the user view a 3D animation or component by considering all details present in it.Also we used programming language since it is the only scripting language that we can use in Unity 3D.

In Order to acquire the knowledge required to implement the project we made use of various software tools and referred various papers and articles to gain the knowledge which we needed for implementation.

### 1)AutoCAD:

AutoCAD is a commercial computer-aided software which is used by engineers and architects for preparing a general design of a certain machine component or a building plan.in this project AutoCAD was used to model the components present in the system and to understand how exactly the component will look like. AutoCAD is a software which is commercially sold by AUTODESK. In this project AutoCAD was used to design the components by taking the appropriate dimensions. Later these drawings were imported to 3DS MAX.

### 2)3DS Max

3DS Max is a high-level gaming tool which is mainly used to create different animations models and games. This software is mainly used by video game developers, TV commercial studios, Architecture component visualization studios .3ds Max helps us to create a realistic model of the components and also give the trainee a realistic knowledge of the various machines which is used in the system

### 3)Unity 3D

Unity 3D is a gaming software which is mainly used to create games in both 2D as well as 3D. The main scripting language which is used in this software is c#. C# programming language in Unity 3D can be used for both plugins of the editor as well as games and drag and drop functionality. For 3D games and simulations, Unity allows specification of texture compression, mipmaps, and resolution settings for

each platform that the game engine supports, and provides support for bump mapping, reflection mapping, parallax mapping, screen space ambient occlusion, dynamic shadows using shadow maps, render-to-texture and full-screen post-processing effects. Unity also offers cloud-based services to the developers. In this project unity 3D is mainly used for simulation of components present in the machine. It allows us to import 3D graphic images into unity and later carry out programming and animation

### Methodology:

Steps used for 3D modelling of Calandria and pressure tube of PHWR

Following were the steps that had to be followed for the completion of the project that we had undertaken. Each stage was significant and we came across different results. Each and every step is explained in detail along with results

#### 1)Study of components and their representation in AutoCAD

By making use of AutoCAD we could detect whether the component we are working on is hollow or not It is easy to model components using AutoCAD by considering the exact dimensions of the modelled components. Thickness was measured easily. Also, it is easier to import the components from AutoCAD to3ds Max.In AutoCAD we studied the components how they would look when we observe from the top, frontetc. These views helped us understand how exactly will the components look like before they were converted to 3D.for drawing the components we used AutoCAD because the proposed system is a basic training tool which will give realistic experience to the trainees. If we want to achieve this purpose it is necessary that we give them a clear idea of how big the system will be. This can be properly done only by making use of AutoCAD software. Also, it is possible to import the components from AutoCAD to 3ds Max.

#### 2)Study the system under observation

Calandria is a low-pressure horizontal vessel, consisting of circular channels arranged in a regular fashion and immersed in moderator (heavy water). The pressure tubes (containing fuel assemblies) are loaded in the channels of calandria with the coolant (heavy water) flowing around the zircaloy tubes inside the pressure tubes. This extracts the heat released during fission and transfers the same to the secondary coolant (light water) that boils to generate steam. Calandria in the reactor is placed horizontally. It consists of pressurized coolant pipes that are present in it. fuel which is present move through these coolant pipes. The calandria has provisions for

accommodating liquid poisons in tubes at specific locations in the calandria. The moderator also acts as neutron reflectors. Therefore, control of neutron flux and hence the reactor power can be achieved by controlling the level of moderator. In nutshell, calandria represents the most important assembly of PHWRs as fuel, coolant, moderator, control rods etc. are all present in it. One of the important aspects of CANDU reactors is the facility for online refuelling without shutting down the reactor. The spent-fuel bundles can be replaced by the bundles of fresh fuel during the normal operation of the reactor.

In software Calandria was developed by considering the proper dimensions as mentioned in the plan which was given to us. We made use of extruding command and a tube.

**Fuel pipe**

Coolant circulates through a nuclear reactor core to transfer the heat away from it and prevent a meltdown that would halt energy production. The CANDU reactor uses either light or heavy water coolant. The inner tube holds the fuel and pressurized heavy water coolant. During service, they are subjected to a high neutron flux and consequently undergo irradiation strengthening/hardening and some loss of ductility. Based on the published information, they will perform satisfactorily without need for replacement over the design life of the reactor.

Initially the pipe was designed in AutoCAD which was converted to 3D by importing the diagram to 3ds max and using the lathe command

#### **RAM-C Head**

RAM assembly is one of the important subassemblies of the fuelling Machine. It comprises of three telescopic rams namely B Ram, C Ram & Latch Ram. All these rams are operated through oil hydraulic motors. B Ram & C Ram are provided with water hydraulic backup. These rams are used for refuelling operations & various plug operations.

The system which is under observation is calandria and pressure tube in PHWR. The model of the system is similar to that of CANDU reactor which is considered as one of the most successful nuclear reactors of Canada which are used for the generation of electricity. The reason why we considered this system for observation is that it was something new which is developed and also the energy generated is a renewablesource. Hence while developing more and more machines we need to ensure that no damage occurs in the system. During training there

is a possibility that damages may occur since the person is not aware as to how the system can be operated efficiently. They can make mistakes which may cause a huge loss. To avoid such problems, we have made a software equivalent model of the system. Hence by doing so the trainee can get real-life experience of the system, can observe the system well and can do the needful. Also he can observe its working by looking into each and every pressure tube which is present in the system

#### **3)Import the AutoCAD drawings to 3ds Max**

For converting the drawings designed in AutoCAD to 3D graphics we made use of 3ds Max. To perform the same we imported the drawings to 3ds Max .3ds Max is a software which helps us create 3D models with all features and details .Even the slightest detail can be observed well by using 3ds Max.Also 3ds max is a software which can be used efficiently.Hence we used 3ds max to carry out the operations well with greater accuracy and simplicity. Also, we can view the 3D graphic images in 3ds Max in all views hence it helps us to design the 3D object without any problem. We can import components that are designed in 3ds Max more easily to Unity 3D than the other software.

#### **4)Convert the drawings to 3D graphics by using the appropriate modifier commands**

Lathe command was used to convert the pressure pipe while doing so.Lathe command helped us to maintain the thickness of the pipe.In doing so we understood that a pressure tube which is present in the nuclear reactor has a constant thickness and it also contains a holder where it can be connected to other places. It forms the core of the calandria.Also to construct any hollow component in 3ds Max we need to make use of lathe command.by doing so all we need to do is trace through the thickness of the tube .Lathe command directly converted it to a tube.Calandria consists of a tube along with two hexagonal shaped components both at its front end as well as in the back .for this extrude command was used.Calandria is the main component which is present in the reactor which mainly contains pipes that are fitted into it. Calandria is a vessel that contains cold heavy water moderator at atmospheric temperature. Calandria is not a hollow component. Hence, we can say that the tubes which are fitted into the calandria are pierced into it. For multiplying the tubes we created a matrix for them because on studying the structure of the calandria we understood that the tubes are placed symmetrically at equal distances. After merging the pipes along with the calandria we made use of Boolean operation to

pierce the pipes into the calandria thus creating a realistic effect. Later to view the contents and the working of each pipe present in calandria we made another component called the Ram-C head. All rams are operated through oil hydraulic motors. B Ram & C Ram are provided with water hydraulic backup. These rams are used for refuelling operations & various plug operations. RamC head was made by using lathe cutting by setting a proper plane and later by using mirroring effect to maintain symmetry

#### **5)import the components created to Unity 3D**

From 3ds Max components were imported to 3D. The components could be viewed from both gaming point of view as well as by camera view. Simulation could be done by considering each and every component that was present in the image separately

#### **6)Simulate the components using the scripting language**

Animation of the components had to be done through c# since it is the primary scripting language for Unity. By doing so we coded the pipes in such a way that we could explore through the pipe and also check the working of each and every pipe which was present in the system's we set up the system in such a way that we prevented the occurrence of collision that happens in the system. As soon as objects collide the ranc head will stop moving

#### **7)Set a camera to observe the pressure tube of Calandria by using programming language**

Camera was set up in the system in such a way that we could observe the system well and avoid collisions that mainly occur hence by doing so

#### **8)Create a report on the observations**

### Conclusions

The need for the project is to mainly minimize and issue that may arise for trainees due. To do this we have used three software Autoad,3ds Max and unity 3D. Here,while using these software we mainly concentrated on the accuracy ,simplicity and efficiency. Apart from monetary losses, this device will also help us to see how the system will work.

### References

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