

Virtual Reality Based on Training Environment in a Cement Plant

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1.1 Abstract

The industrial Process became more complicated, to the extent that it is not easy for the individual not only to understand quickly what is required from him, but also to deal with heavy industries such as steel, aluminum industry, mineral exploration and the work in the nuclear power stations. The same weakness in Cement Industry, which is the topic of this paper. Therefore finding the solution is the only way that enables the individual to reach fast understanding and to make experiments on an environment similar to the reality not only to prove concepts but avoid risks as well.

Here the Virtual Reality (VR) found its way to penetrate these fields in spite of the difficulties that VR confronted.

1.2 Introduction

The most common VR definition is a technology which allows a user to interact with a computer-simulated environment, be it a real or imagined one, either displayed on a computer screen or through special or stereoscopic displays. However, some simulations include additional sensory information, such as sound through speakers or headphones. Some others are advanced where users can interact with a virtual environment or a virtual artifact (VA) either through the use of standard input devices such as a keyboard and mouse, or through multimodal devices such as a wired glove. [1]

Virtual Reality environments (VRE) technique can be classified by a long a number of axioms. This classification based or ranked by the sense of immersion, or the degree of presence it provides. The common classification is:

- 1- Immersive VR
- 2- Non immersive VR or commonly known as desktop VE
- 3- Augmented reality systems

Immersive systems totally surround the user, This environment is done through special hardware such as caves, head-mounted and large wall-mounted displays.

Non-immersive systems typically use more generic hardware. The same software techniques are used but the system does not totally immerse the viewer.

Other view for non-immersive VR is augmented reality system; it generates a composite view for the user, it is a combination of the real scene viewed by the user and a virtual scene generated by the computer that augments the scene with additional information. [1]

1-3 Human factors via Immersion

In virtual environments, they are supposed to simulate the real world, but it is important to know briefly about the human senses to be able to fool the user's senses. This matter is

not an easy task as it is important to know which senses are most significant. The following are the five human senses with the percentage of immersion: [2]

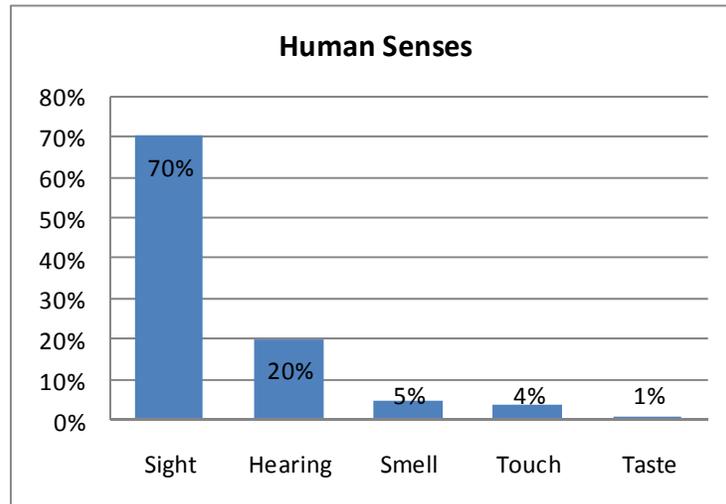


Figure- 1 Rank of Human Factors

1-4 VR Applications

VR applications can be categorized into four groups: virtual prototyping, visualization, training, and entertainment. Using VR in industry is a subgroup of virtual prototyping genre. Virtual Reality can be used to prototype any product ranged from small product tell the complex one, this products can be small machine, factory, place and building and that can be use for marketing, training and manufacture.

1-5 CAD and VR Integration

Most of these simulators done by combination between CAD package and VR Library then assembled in VR engine, which provides real-time user interaction in a simulated virtual environment. VR engine is a revolutionary new tool that may be used to create training applications quickly and simply on a PC. This powerful software has been developed by many software house developers. Also some sensors can be added to give the sense of interaction and reality. [4], [5]

1.6 Cement Industry Overview

Cement is manufactured by combining a homogenous blend of carefully proportioned raw materials (limestone or chalk and clay/ shale/ sand) at a very high temperature (1450C) in a rotary kiln; it is a heat conversion operation. The raw materials fuse together to form 'clinker', a hard granular material. The clinker is ground to a powder along with gypsum to make cement.

The cement plant divide into many departments, Crushing Area where rocks exploded from mountain and crushing into small rocks, Stacker and reclaimer area where material are stored, Raw mill department for grinding material, Preheater tower to preheat material before sending it to kiln to form clinker, material has to cooled in cooler department, clinker sent to cement mill department to turn it to powder, then the last department where packing plant. [6]

1.7 Traditional Training Methods

In the conventional training, the user gets his information from some documents that have been submitted to him. These documents may be mechanical to show how the equipments should be installed, Electrical drawings as low voltage drawings; Motor

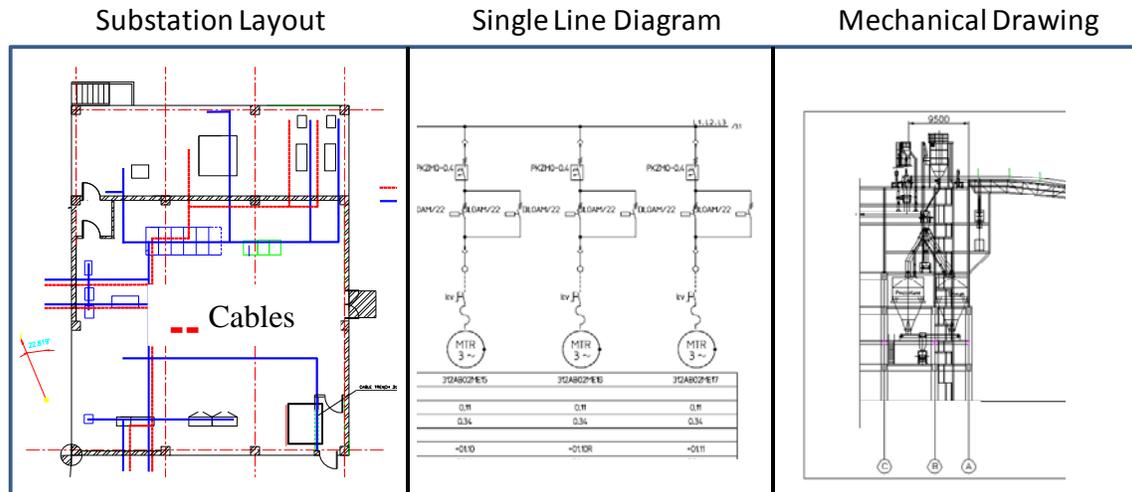


Figure- 2 Traditional training drawings (6)

Control Center Drawing (MCC) to supply motors and equipments all over the plant, Auxiliaries Control Center Drawing (ACC) to feed all the auxiliaries as lighting and fire alarm. Also, there are electrical drawings to manipulate the cables routing, to identify quantity and type of cables and how it will be supplied from the source to target.

Despite these huge documents, the user finds himself in front of abstract data. He should imagine everything about any equipment or processes. Many of the obstacles facing the user is that he is challenged to understand and imagine a lot of things alone.

1.8 Survey:

It was necessary to make survey to discover the reasons behind lack of knowledge acquisition gained from traditional training. A survey has been done among 20 engineers who have been sent to different sites all over the country or outside. They were working in an organization specializing in upgrading and constructing new cement factories. They spent a period from one to three years in this company. All of them were young engineers their ages were between 27 and 32 years. Lot of facts could be concluded from that survey. The survey consisted of structure and semi-structure questions, the following are the results of that survey:

- All the engineers have been sent to site without good training about the task they will do.
- Most of them have not seen the cement plant before.
- They know a lot of information by try and error, This technique is very dangerous in risky environment as Cement Plants.
- Seniors did not give them all the required information about the tasks they had to perform.

2.0 Virtual Cement Plant

Despite the reported successful VR applications in many fields, there have been a number of challenges or limitations when considering some industrial fields such as cement Industry. The risky and hazardous environment in cement plant requires provision of all working staff with more skills and knowledge for the enhancement of this industry. Such risks make it essential to utilize a sophisticated and still cost effective VR training environment.

2.1 History of Virtual Reality in Cement industry

Enhancing user quality and avoiding hazards in cement plant were the stimuli behind the thought of developing a VR solution to serve this area. Cement plant size is too big. Sometimes, it reached many kilometers. This is to realize how difficult it was to create a physical simulator to train the worker.

Some efforts were done to create a virtual cement environment based on non-immersive technique for its benefits. What was done by Portland Cement Association (PCA) in the United States and Canada was one of these few applications. A virtual cement plant was made by Serin Interactive Association (a general market web design and e-Learning company) in 2007. However, it was considered as a small application. If we apply the VR measurements, we will find that they take the desktop VR as a technique to perform the application. However, there is neither a user tracking nor an interaction technique. There is no navigation ability also.

Other application what is done by Virtual Reality Magazine (VRMAG) is an online magazine born in 2001 dedicated to the Virtual Reality community and industry. VRMAG Model made by using digital photos which were taken in definite angle (30°) then they started to use Quick Time VR to assemble the scenes. The user can navigate in this scene but he can't turn around the factory components as it is not 3d objects. These photos are stitched together to form wide scene which is saved in QTVR format. The VRMAG application is applied on desktop VR technique where there is no tracking or interaction. There is no collision or gravity to control the user navigation in the VR model.

3.0 Building a VCP (Virtual Cement Plant) system

Building this virtual cement plant required the following steps in an iterative way. Creating or adapting drawings 2D, transform this drawings to 3D then start the simulation process. in developing this model, it is mainly intended to use three software packages to create this VR Solution; two of them belong to CAD system. They are the most common used in modeling creation all over the world. These packages are AutoCAD, 3DMAX both of them belong to Autodesk Co. and third software called Quest3D which is one the most powerful game engines.

3.1 The First Iteration (Modeling 2D)

In the first iteration, a lot of drawings collected to make and adjust 2D drawings by AutoCAD software. Adjusting drawings by assign units type to be millimeter, collect match entity in definite layers, purge (remove) non used entity to facilitate transforming

to 3D. These drawings are factory layout, substations and Mechanical drawings. also a lot of photos are needed for all departments, packing, cement mill, cooler, kiln, preheater, stacker and reclaimer, this photo will be as a texture or help the user to choose a texture that looks like it in case of reaching the reality.

3.2 The Second Iteration (3D Modeling)

The second iteration in this model creation starts from importing the drawing file from AutoCAD to 3D MAX. Convert drawing to spline, detach elements by elements for extruding, loft. It is the most difficult iteration in developing this VR Application.

Some important modifiers used in developing this Cement Plant 3d Model such as Extruding, Lathing, Lofting and Sweeping. After that the object mapped with a real photo as texture to enhance rendering and emulate the reality. All the factory objects done with the same way.

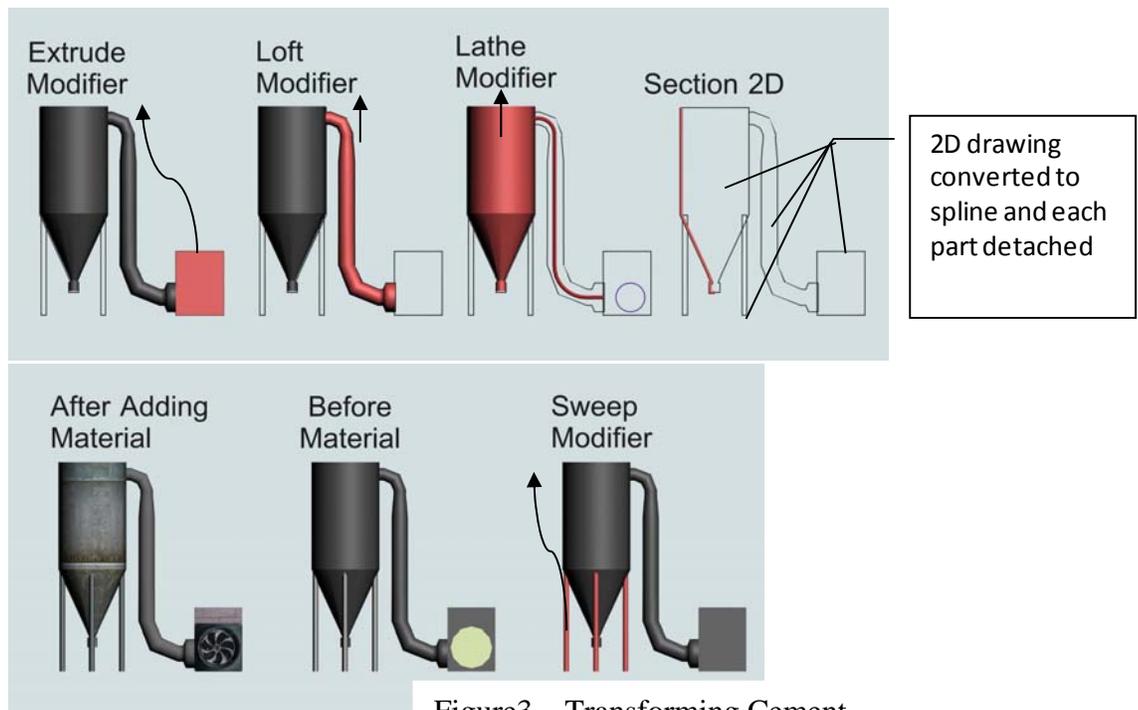


Figure3 – Transforming Cement 2D object to 3D

3.3 Third Iteration (Simulation)

Quest3D is a software package selected to develop this real-time 3D applications. It is used to create architecture visualizations, computer-based-training programs, digital entertainment and many other real-time 3D-based programs.

In Quest3D the user creates everything by dragging components from program templates tape or channel tape to the graph window. The component in Quest3D is called a channel. Channels are small programs that can be loaded in memory and called and used by other channels. Channels can communicate with each other by linking them together. Every channel has a type. a type can be anything from something simple as a "Value" to something complex as 3D Object.

First step in this iteration is to drag walkthrough camera to the graphic window only the important factors will be changed such as zoom factor value equal 0, far clipping distance

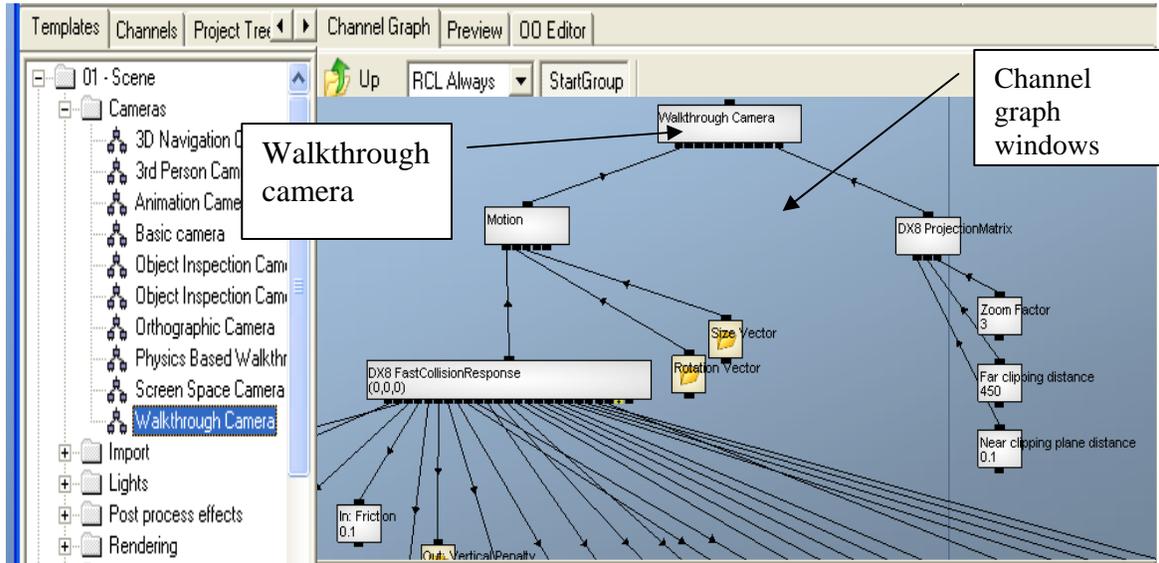


Figure4 – Install Walkthrough Camera

Equal 450 where the near clipping distance Value adjusted to 0.1 and Gravity Value adjusted to be -1, all the others values kept as it is,

3.4 Importing files into Quest3D Scene

The first module to be imported to Quest3D is Cement Factory Layout. From Import type compobox select Hiercrchy and animation to keep the 3D object with its animation, scal factor has to be 1 to keep the real scale of the model.

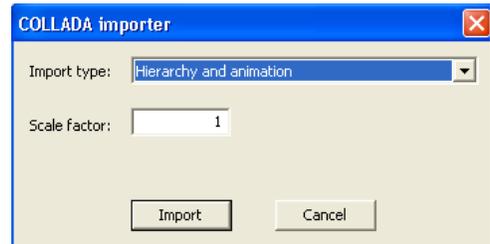


Figure5 – Import 3d object

After importing the layout to channel graph window, Layout should be connected to render channel, the benefits of render channel is to show the detail of the Object, if the object connected directly to the main start channel it will appear as dark solid area, also the light will not affect it. All The imported objects has to connected also to collasion detection channel to enable the user to sense this objects, he can move and touch it.

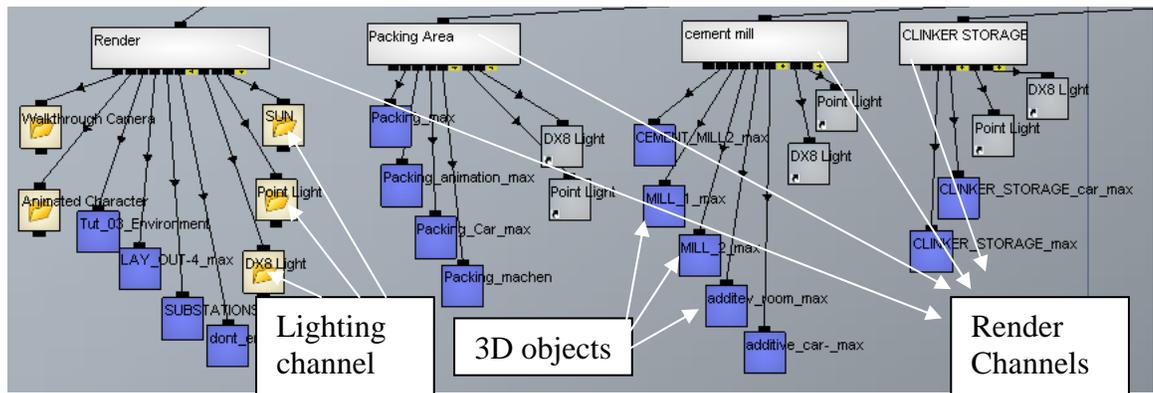


Figure6 – connect 3d objects to render channel with lighting

Dividing big 3D objects into small channels or small objects to facilitate control, animation and modification in material objects or adding special particles such as smoke, fire on specific area of the 3D object.

Each 3d object inserted to the graph window at the same time it should be connected to collision response channel to enable objects to link and interact together.

Adding two lighting channels to each render group is attempt to reach to the real lighting in cement factory in day hours. also shadow added to enhance the feeling of reality.

In figure below, the scene preview after adding 3D objects and connect them to collision response, adding lighting channels, special affects as smoke and fire particles.

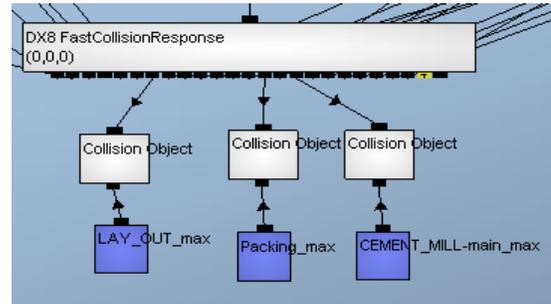


Figure7 – connect 3d objects to collision response channel



Figure8 – Scene Preview

3.5 Movements

After importing the layout and inserting walkthrough camera, it is time to control how the user will move or navigate in this virtual cement plant. It is easy to use the movements channel of the walkthrough camera. The user can use both of the keyboard and mouse in navigation. left cursor to turn to left right is the opposite, up cursor to go forward and down cursor to go back. Left mouse click used to go forward to increase the user control. Other choice add To facilitate user control, some characters selected such as “W” to go forward and “S” to go back, A to go left, D to go right.

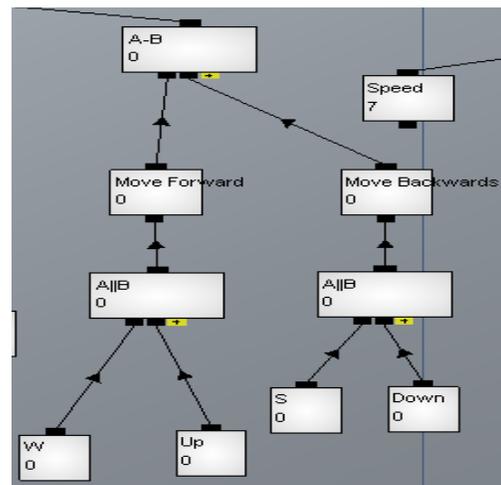


Figure9 – Movments channel

3.6 Safety Rules

One of the advantages of this VR model is the safety Rules reminder, which appears from time to time to remind the user that he must wear the suitable safety appliances in the appropriate area. Safety shoes and helmets have usually to be worn. Glasses and masks are necessary in the dusty areas as well as ear protection are beside the mill and crusher. Safety belt should be fixed when the user works in very high places as the Preheater Tower. All these cases are applied in

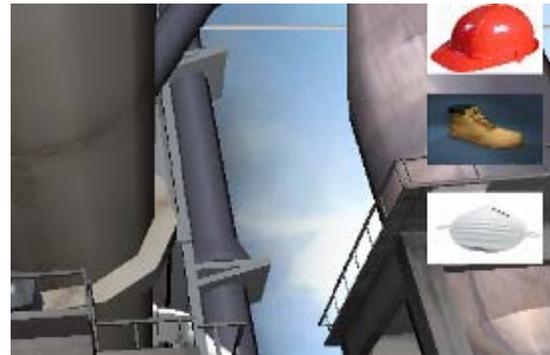


Figure10 – Safety Rules

this model. The figure below for the safety helmet, this channel are copied for all the other safety tools, only the photo of the tools will be reloaded and its position will be changed to be under the other.

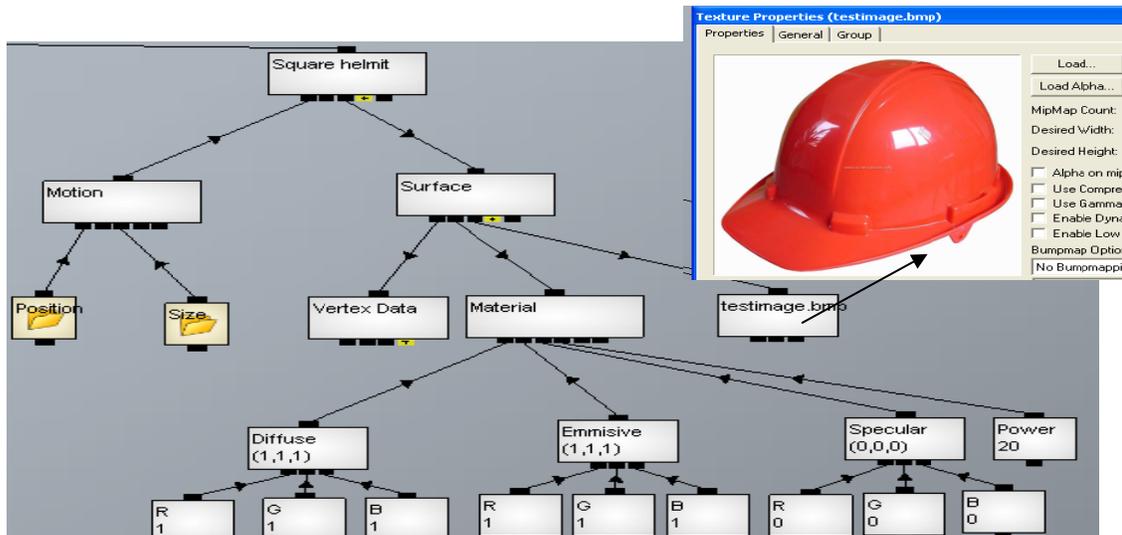


Figure11 – Safety channel group for helmit

3.7 Particles system

to emulate the reality in this virtual cement plant , particles system such as smoke, steam and fire inserted to the model, around the kiln tube it seam to emit a heat with smoke as the same in the real world. The position, rotation and size has to be adjusted to be as the same in figure #12

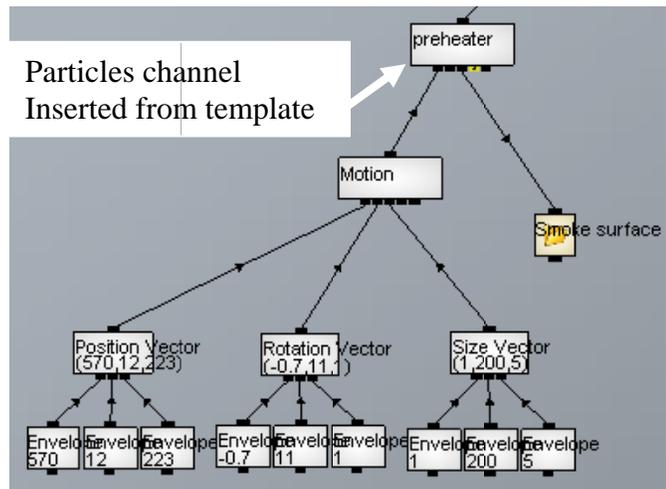


Figure12 – Particles Channel group around Kiln tube

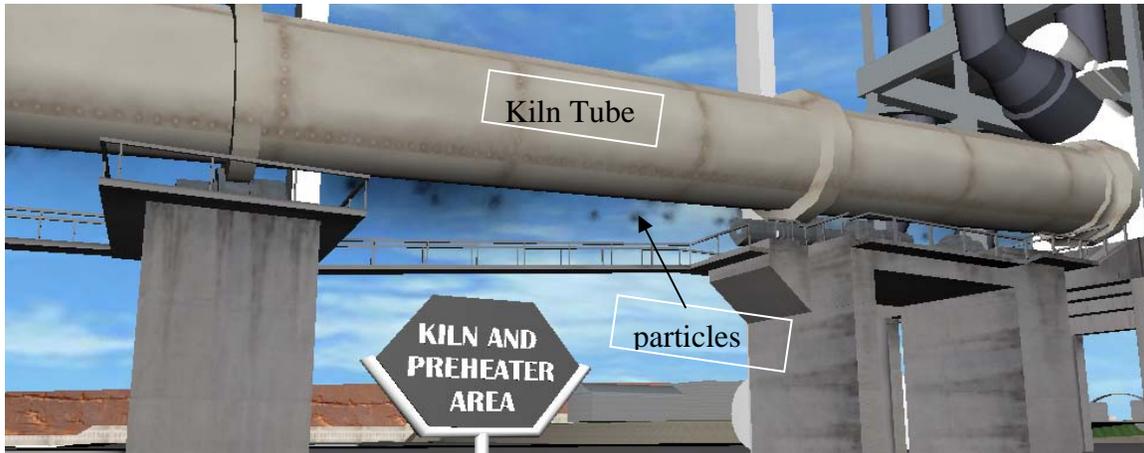


Figure13 – Particles system in Kiln

3.8 Adding Sound to the Scene

Because of it is important to immerse the user in this application not only to navigate and touch machines and buildings, but this application augmented with sound machines, motor to enhance feeling of reality. To connect sound on the main root of the application is easy but what is not easy is to make it real. It can be heard when the user is near to the machine. When he goes away, the sound faded, thus, the channels tree in figure #14 are belt to do that.

3.9 Interaction between the user and Machines in Cement Mill Room

Cement Mill substation are chosen as example to emulate the reality and apply interaction between user and this model. The door will open when the user reach to it, to start interaction with cement factory machine. The user will go inside to find three monitor, main one in the middle where the control buttons are located on the bottom, the left monitor connected to camera fixed on cement mill itself to show if it is running or not.

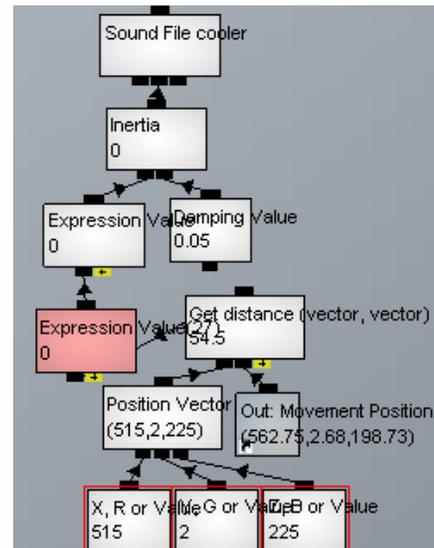


Figure14 – Sound Channel



Figure15 – Control screens

The right monitor is connected to camera to see the state of feeding conveyor of the cement mill which is located in the highest level of the cement mill.



Figure16 – Control screens

The cement department is divided into four parts:

- Feeding, where the material transferred from clinker silo by conveyor to cement mill.
- Main Drive, very big cylindrical mill has a lot of steel ball inside to fine grinding.
- Separator, important operation where the material checked if it is milled well or not.
- Outlet, the fine material by extraction transferred to packing.

Each part has two pushbuttons, Run to start the process and stop to block it. There is some precautions the user has take care such as the user can't stop the mail drive without stopping the feeding because the material will block the mill, also he cannot stop the separator with stopping both of Feeding and Main Drive. If there is problem in the last

process outlet, all the other process has to be blocked, the program will enable the user from doing that automatically where the user will start manually each one step by step. Yellow button will run all the four processes, on pushbutton will on/off the monitor itself

4.0 Conclusion

Both of the two examples of virtual cement plant mentioned in this Paper are so poor if we compare them with this our Virtual Cement application. In both of them, there is no interaction between user and the VR application, no 3D modeling, no collision, no gravity, no true navigation. The user cannot touch the object or turn around it. Also, the user cannot change the view angle.

It was a big challenge to create this 3D Model as it collect between 3D modeling and user ability to navigate between the components of this VR model, not only that but to interact with this model in real time.

Photo mapping technique used to support rendering to avoid traditional rendering problems and enhancing object reality rendering. Both of 3D modeling and photo mapping are used to maximize the user manipulation and sense of immersion.

It is not a claim, but it is true that this VR model is one of the fastest Methodology to implement the a virtual Reality system.

Many incidents and sometimes even the serious that occur in the cement plant resulting from either lack of knowledge or carelessness, for that this model is a wealth for any organization concerning creating and revamping or even maintenance the cement plant. This model is ready to implement any scenario they want and export it in form of VR application. The importance of that come from, the analysis taking place in major cement companies showed common reasons for incidents and breakdowns occur in the cement factory so it is possible to apply any of these cases on this VR model to avoid the occurrence of such faults or accidents in the future.

The reason behind using CAD in VR modeling that Most of the new cement plant engineering is carried out in CAD format, these drawings is considered as the base for VR modeling. CAD format can be converted to many other formats that can serve the VR engine.

Hence we can say The VCP model used the advantages in graphic software, CAD, VR engine software to produce a VR methodology that can be used as guidelines to facilitate creating VR applications to serve the cement industry field.

PC-based VR is of relatively low-cost and hence provides a low-risk environment in which initial prototyping of innovative Problem solving can be tried.

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