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Monitoring and Controlling of Material Handling Equipment

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Abstract: To understand the process and working of different kinds of material handling equipment in real-time from the industry. To monitor and control the working of material handling equipment. And to design material handling equipment whose overall operating efficiency of a facility. Simulate the working of the Tower crane which consists of a trolley, hoist, and a jib. Also, coordinate all the parts of the tower crane for safe and efficient material handling. In doing so, we can plot the operating torques of the trolley, hoist, and jib for a time along with the load applied on each of them while moving the container. The hoist can raise andlower a load, and therefore the trolley moves the load towards and far from the tower. Blocks from the belts and cables library are accustomed to model the pulleys that control lifting the load and moving the trolley. A plot of load vs time and torque vs time is obtained for the tower crane. The working animation is also obtained from the simulation using simscape tools. The model uses a signal builder to coordinate the commands for the jib, trolley, and hoist which acts as input to the tower crane. For the future expansion of the project, it is recommended to implement a variable voltage variable frequency drive in place of the signal builder.

Keywords— Tower Crane, Simulink Model animation demo, Hoists.

1. INTRODUCTION

Material handling and transfer are defined as the movement of physical objects like raw materials, parts, sub-assemblies, assemblies, and finished goods within the manufacturing environment from receiving through shipping. The purpose of moving the material is to get the product which isn't available to us and that too for the least possible price. However, material handling involves transporting, housing, and controlling materials and goods add nothing but cost to the system. The material handling and transfer are thus regarded as a burden and therefore, often carried out as an ultimate step after product, process, and layout design have been completed.

Material handling activities may cost as much as 55% of the total production cost in an average industry. An efficient Materials Handling System (MHS) greatly improves the competitiveness of a product through a reduction of handling costs. The fundamental principles of material handling include the use of the 'system s approach' where the material handling requirements of the entire factory are considered and simplification of moves through the reduction or elimination of unnecessary and combination of several moves. Traditionally, some experts analyze a few alternatives from which a selection is made based on their experience in the application environment have determined MHS. The choice of appropriate MHE requires a complete analysis of the material handling problem.

The design of MHS includes the selection of material handling devices to transport material between facilities, which also impact lead time, safety, work in process, queue length, inventory levels, and overall operating efficiency of a facility. Thus, the proper design of MHS is precisely important for both conventional and advanced manufacturing systems.This paper involves a study of different kinds of material handling equipment and their respective monitoring and controlling methods and equipment involving them. In addition to that, we simulate a tower crane with a trolley and hoist in a MATLAB environment by building a Simulink model using simscape tools. This paper is an attempt to know more details about Material Handling Equipment by visiting Adani Krishnapatnam Port Corp. Ltd. Which is a real-time hub of material handling. Despite playing a significant role in our daily lives, very little is known about material handling both generally as well as academically. This paper serves the purpose of bridging the gap in the academics about material handling equipment and their application in the industry.

2. LITERATURE SURVEY

In this chapter, the discussions are more about the previous researched that have been done. In the never-ending effort of the humanity to simplify their work.

Design and Implementation of Conveyor Line Speed Synchronizer for Industrial Control Applications: A Case Study O F Champion' S Breweries Plc, Uyo

The work in this paper is focusing on

mathematical modelling of a belt conveyor system and controlling its applications taking Champion's Breweries Plc., as a case study. The paper comes up with a solution to the problem of detection of liquor levels in the bottle. The problem is raised due to lack of synchronism of the conveyor line speed and the speed of bottles, be it empty or fully filled. To eliminate this, it employs a PID controller to act as a speed synchronizer.

It takes account of the mechanical and electrical aspects of the conveyors system design for tuning and designing the PID controller. To figure the conveyor line speed problem it is required to model the model the conveyor line without the synchronization. A PID controller with N-order filter is designed with auto tuning to achieve balance between performance and parameter variations. The designed is the implemented using a simulation to test it before implementation and results show case the desired outcome out of it. The controller's design specifications were chosen to accommodate uncertainties in the system, was able to synchronize the speed of the conveyor lines with the speed of the empty bottle and full bottle inspection units.[1]

Automation of Material Handling with Bucket Elevator and Belt Conveyor

Belt Conveyor & Bucket elevators are the media of transportation of material from one location to a different in a very commercial space. Belt conveyor features a huge load carrying capacity, large covering area simplified design, easy maintenance, and high reliability of operation. The Belt Conveyor system is additionally used in material transport in foundry shops such as supply and distribution of molding sand, molds, and removal of waste. On the opposite hand, a Bucket elevator may be of great use during bulk material handling.

This paper is particularly focuses on the combination of Belt and Bucket Conveyors to perform the complex task within a brief time and successfully in an exceedingly cost-effective way.[2]

Design and Development of Automated Conveyor System for Material Handling

In the process or manufacturing industry, raw materials and products must be transported from one manufacturing stage to a different. Material handling equipment is designed in such a way that they facilitate easy, cheap, fast, and safe loading and unloading with the least amount of possible human interference. For example, a belt conveyor system could also be employed for easier handling of materials beyond human capacity i.e., in terms of weight and height.

This project discusses the design calculations and considerations of belt conveyor systems for press machines, in terms of size, length, capacity, speed, roller diameter, power and tension, idler spacing, variety of drive units, diameter, location, and arrangement of the pulley, angle, and axis of rotation, control mode, intended application, product to be handled similarly its maximum loading capacity to ensure fast, continuous and efficient movement of material.[3]

Design and selecting the proper Conveyor belt

A Belt conveyor is the transportation of material from one location to different. The belt conveyor has a large load-carrying capacity, a higher length of carrying path, simpler design, easy maintenance, and high reliability of operation. The Belt Conveyor system is also utilized in material transport in foundry shops for the provision and distribution of molding sand, molds, and so the removal of waste, etc.

This paper provides to design of the conveyor system used which incorporates belt speed, belt width, motor selection, belt specification, shaft diameter, pulley, and gear box selection, with the assistance of standard model calculation.[4]

Dynamic Behavior of a Conveyor Belt Considering Non-Uniform Bulk Material Distribution for Speed Control

In this paper, an experimental facility for bulk material distribution measurement based on laser scanning technology is designed and constructed first. After acquiring the bulk material from the cross-sections in real-time, an uneven bulk material distribution model is proposed. Due to the bulk material on the conveyor belt is divided into a series of micro-units, this distribution model can describe the actual load distribution on a conveyor belt. Based on this, a high-precision longitudinal dynamic model to analyze the dynamic behavior of a belt conveyor is investigated. The paper represents the experimental verification and the results for the non-uniform bulk material distribution model and establishes a discrete simulation model of the belt conveyor system using MATLAB software. Then, it presents a simulation test on the different belt tensions, accelerations, and tensioning device displacements at the head and tail of the belt

conveyor system. [5]

Monitoring and Controlling of Components in a Conveyor using PLC and SCADA

The objective of this paper is to monitor and control the components that are being carried over the Belt Conveyor using PLC, and SCADA. The conveyor is operated by a DC motor. The components in the conveyor are identified by using sensors. The Conveyer is controlled through the PLC Programming for its Control process, monitoring how many Completed Components passed through the conveyer at a specified timealong with Power reduction using Energy-Efficient PLC Programming. The whole process is Monitoredand Controlled remotely using SCADA. The Report generation for the Conveyer process is programmed in SCADA like Conveyer Cycle time, and Conveyer Idle Time, and these data can be automatically saved in the Excel Data format. [6]

Automatic control and protection of CoalConveyor System using PIC

The Coal conveyor system forms an integral part of the Thermal Power plant because the overall efficiency of the plant is dependent on the rate at which the coal is carried to the crusher unit. This paper focuses on the control and protection of the coal conveyor system and employing a Microcontroller like PIC makes the controlling process much easier. The defects that occur in the conveyor system are mostly due to the temperature at which the coal is carried and also due to the attrition in the belt. Using a Temperature sensor and an IR sensor could be regularly monitored and during any abnormal situation, this initiates a Cooling fan just in case of hot temperature and signals an alarm whenever there's any fault within the system. This Proposed system which makes useof an Automatic system to regularly monitor the status of the Conveyor system is very efficient since the operation of the Conveyor system isn't in the least interrupted during the occurrence of any fault within the belt. The addition of the PIC microcontroller makes the overall system simple in design and operation. [7]

Conveyors Monitoring, Control and Protection Using Programmable Logic Controller

Conveyors are the foremost important transport media in transferring the coal from coal mines /storage areas to Boilers in thermal power stations. The monitoring and protection of those conveyors are important because the occurrence of faults may affect the entire power generation. The protection of the conveyors is carried out usingRelay Logic methods, which have several disadvantages, and hence there is a need for a new method. In this paper, they focus on monitoring, controlling, and protecting the conveyors from different sorts of faults by employing conveyors using a programmable logic controller (PLC). Four important types of faults that occur frequently in conveyors, like belt sway fault, pull chord fault, zerospeed fault, and fire protection is considered in this work. These faults are sensed and rectified by a programmable logic controller which has a highdegree of safety, and accuracy and is easy to maintain and monitor.[8]

CONTROL OF CONVEYOR USING PLC

This paper presents the automation of conveyor belt logic using a programmable logiccontroller. For this system s7-300 PLC (CPU 313c)is used and the software for programming used is thesematic manager. The development of programmable logic controller (PLC) makes it possible to try to do specific changes to the program without changing the electric circuit connections. The Siemens s7-300 series programmable logic controller is employed to mechanize the system. This proposal gives better accuracy, and reliable operation in Real-time. This proposal is to separate the products on the conveyor effectively.[9]

Belt Conveyor Monitoring and Fault Detecting Using PLC and SCADA

To ensure the belt conveyor operation is safe and reliable, centralized monitoring and control are very necessary. The main objective of this paperis to monitor and find the fault occurring in the coalconveyor employing delta series PLC and SCADA. To reduce accidents and for increasing further enhancements, automation is used. All parameters are going to be processed, controlled, and managed within the coal conveyor with help of sensors and PLC. Belt conveyors used in Thermal Power Plant are controlled using a Programmable Logic Controller, sensors Ultrasonic detectors, etc... Fromthe point of view of reducing human errors, PLCs are a vital part to design with more reliability and less power consumption for conveyor control operations. This proposal is an automatic fault detector in the conveyor. Thus, the control and monitoring process is completed to shield the coal conveyor.[10]

3. Monitoring and Controlling of ElectricOverhead Travelling Crane Using PLC

and SCADA

This paper presents PLC and SCADA as the two new approaches used to control the motion of an Electric Overhead traveling crane. Ladder logic diagrams for EOT Cranes are designed for traveling motion using variable frequency drives and contactor logic and performance of various parameters are verified and compared and images of
E.O.T crane are designed in SCADA software and communication between PLC and Scada is done with the help of a Siemens simulator. The System works during normal operation and greatly improved the automation processes with the employment of the PLC ladder diagram. The system performance can be improved with the simulation of an electric overhead traveling crane of higher capacity rating and this method is implemented in any of the existing contactor logic systems.[11]

Low cost wireless control and monitoring using PLC and SCADA

PLC is a controller employed to automate the industrial process and monitor itself. A programmable logic controller is used in many industries to control the whole process automatically with less human intervention and to avoid errors. With the rapid growth in technology wireless instrumentation has come into existence to avoid cabling infrastructure and to get efficient control. To have a wireless control the existing PLCs have to be replaced with wireless PLCs. PLCs are also utilizedin homes and small-scale industries to automate small process applications. So, it is undesirable to invest in wireless PLCs which are expensive for home-based applications. In this paper, they presented a completely unique approach to converting the existing wired PLC into wireless PLC by configuring XBEE in direct mode using X-CTU software as a communication interface between PLC and process, the process used here is a batch processand controlled through SCADA.

The main focus of this paper is replacing the existing home and small-scaled industries-based wired PLC system with a wireless PLC system using XBee as a communication interface by configuring it with x-ctu software because the wireless PLC modules are very costly and don't seem to be desiredin replacing for small applications. [12]

4. Material Handling Equipment and itsTypes

A wide range of material handling equipment is used for handling different types of materials. Material Handling Equipmentincludes:

(1) Transport Equipment
(2) Positioning material handling equipment
(3) Unit load formation equipment
(4) Storage material handling equipment
(5) Identification and Control Equipment

Out of the above categories there are someimportant equipment are discussed below:

3.1 Industrial Trucks

Industrial trucks can be divided into two types: non-powered and powered. Non- powered trucks are usually platforms with wheels that are pushed by human workers to move materials. Powered industrial trucks are steered manually by human workers. They provide mechanized movement of materials**.** Industrial trucks are used to both handling bulk loads and containers. Some Industrial Trucks used are Reach Stackers, Empty Container Handlers, Excavators, Forklifts, Dumpers, and Internal Transport Vehicles etc.,.

Conveyors

Conveyors constitute a large family of material transport equipment that is designed to move materials in this fixed path, generallyin massive quantities or volumes. Examples include roller, belt, and tow-line conveyors. Conveyors can be either powered or non- powered. Powered conveyors are distinguished from other sorts of powered material transport equipment in that the mechanical drive system into the fixed path. Non-powered conveyors are either activated manually or by the action of gravity.

Fig 1: Coal Conveyor System

Cranes

Cranes are used to transport loads over variable (horizontal and vertical) paths within a restricted area and when there's insufficient (or intermittent) flow volume such that the employment of a conveyor cannot be justified. Cranes have more flexibility in movement than conveyors because the quantity of loads handled is commonly more varied depending upon their shape and weight. Cranes provide less flexibility in movement than industrialtrucks because they only can operate within a

restricted area, though some can work on a transportable base. Most cranes utilize trolley- and-tracks for horizontal movement and hoists for vertical movement, although manipulators are often used if precise positioning of the load is required. The foremost common cranes include the jib, bridge, gantry, and stackercranes.

Common types of cranes used in the industry for handling different types of purposes be it bulk loads or containers. They are as follows:

- Rail Mounted Quay Crane
- Rubber Tired Gantry Crane
- Grab Ship Unloader and
- Mobile Harbor Crane etc..

Fig 2: Rail Mounted Quay Crane

5. MONITORING ANDCONTROLLING EQUIPMENT

The monitoring equipment differ from equipment to equipment as they serve different purposes but the control being same for every equipment. For controlling each of them PLCs of different kinds and models but they serve acommon purpose. The PLCs are so arranged to act independently in case of accidents or system malfunctioning. All the monitoring is governed by the PLC toact and are connected through it to provide control over the process.

Fig 3: PLC Arrangement in an MHE

Out of the Monitoring Equipment include variousdifferent types used include:

- RTDs
- Proximity Sensors
- Photo-Electric Sensors
- Zero Speed Sensors
- Limiters
- Belt Sway Switch
- Encoders, etc.

These equipment are used to protect the equipment as well as monitor the process against high temperatures, fires and accidents. They also act as safety devices to protect the human lives in case of human interference and protecting the anydamage to the property as well. Also, every equipment is equipped with an emergency stop to halt the operation in case of any emergency.

To know more about these equipment it is advisable to search in the web as their specifications can vary from equipment to equipment with their operation and purpose beingsame.

6. MODEL AND SIMULATION OF ATOWER CRANE

The Simulink model of a tower crane witha trolley and hoist is given below:

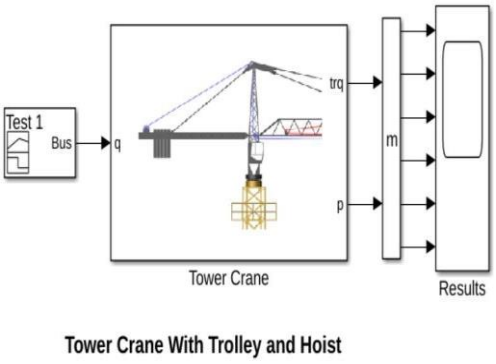

Fig 4: Simulink Model of Tower crane

The input to the input is provided by the signal builder which provides simultaneous commands to trolley, jib and hoist for operation. In this model instead of motor drive circuit a signal builder acts as input which provides mechanicalinput to the crane. There are no.of subsystems in themodel to perform the operation out of which Tower crane, Trolley and Hoist pulley system are more complex and have no. of subsystems to them as well. Each subsystem employs input and output ports, drums, belts and pulleys to them.

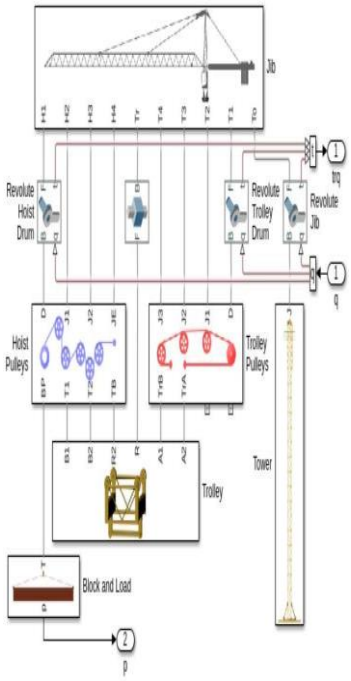

Fig 5: Model of Tower Crane Subsystem

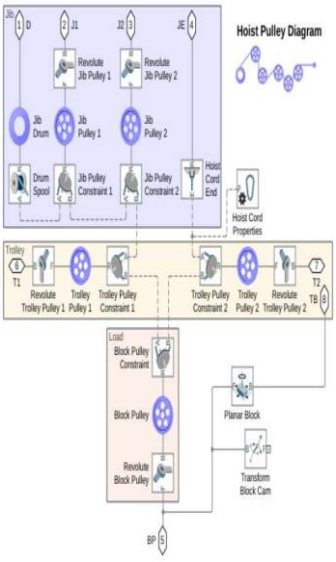

Fig 6: Hoists Pulley Subsystem

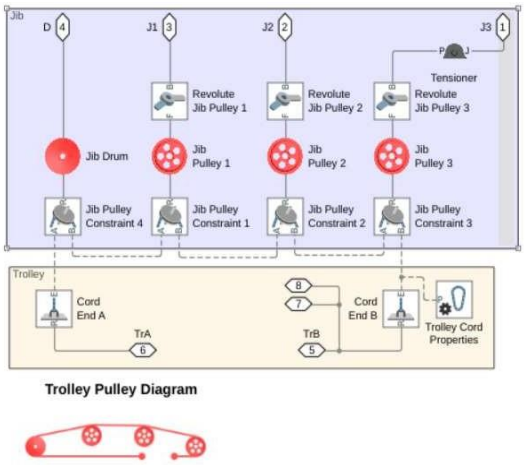

Fig 7: Trolley Pulley Subsystem

The model take torques of trolley, jib and hoist of the crane and load exerted on them respectively as output. In addition to that, this model generates a demo animation simulating the process carried out by the crane.

7. Results

The results that are obtained by simulating the model against different inputs are shown below:

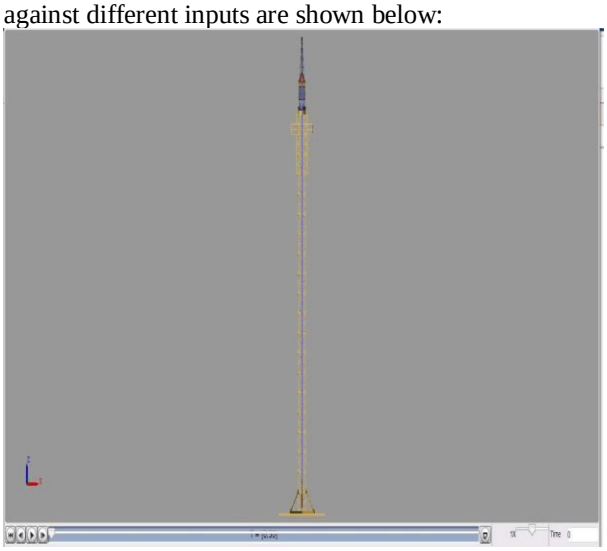

Fig 8: Initial Position of Crane

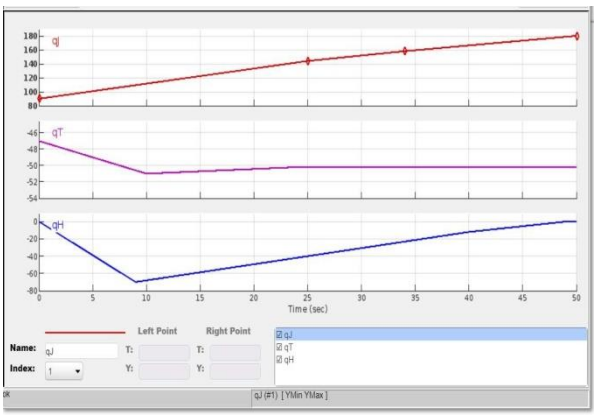

Fig 9: Inputs Applied to the Crane For Case1

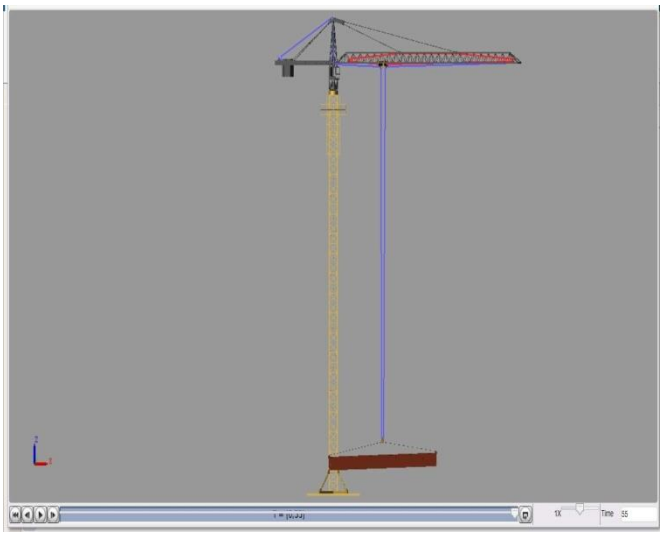

Fig 10: Final Position of Crane For Case1

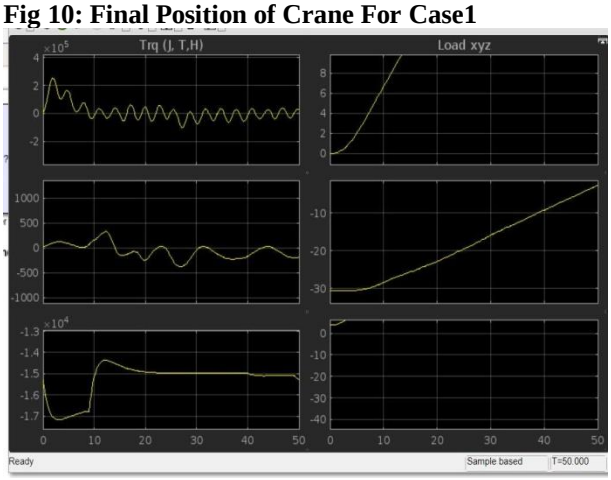

Fig 11: Plot of Torque and Load applied toCrane For Case1

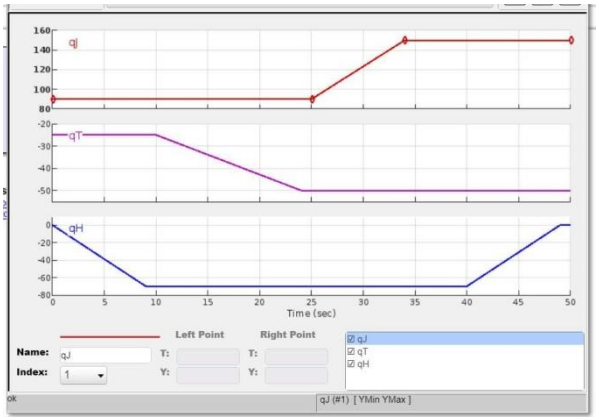

Fig 12: Inputs Applied to the Crane For Case2

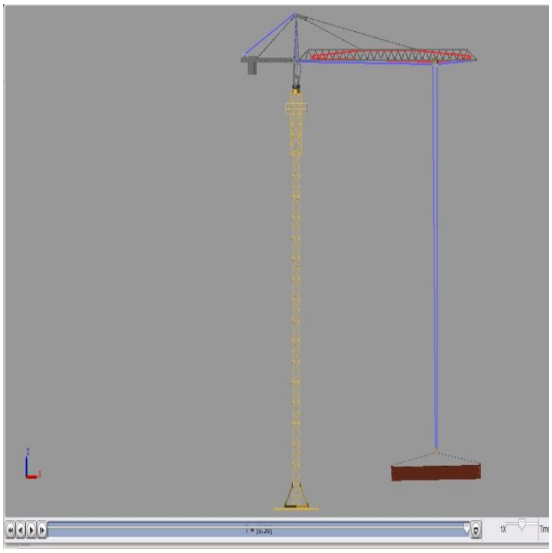

Fig 13: Final Position of Crane For Case2

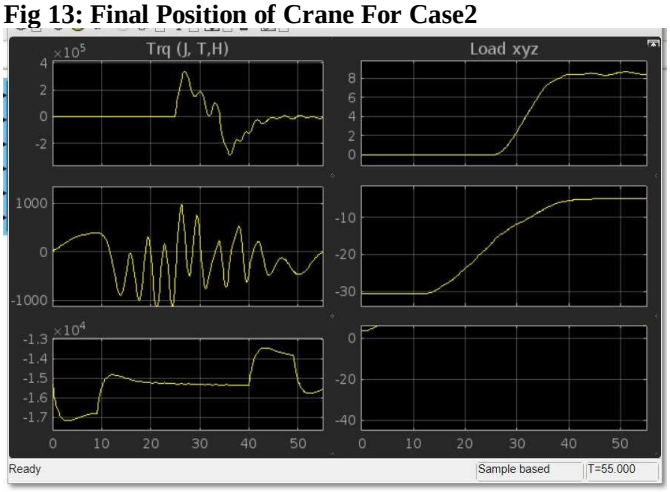

Fig 14: Plot of Torque and Load applied toCrane For Case2

8. Conclusion

This project is an attempt in understanding the equipment better and their working process. This would help the people understanding the MHE better and understand their working with the help ofsimple demo as animation for better reception as working is visualized. The current model employs signal builder as the input command to the tower crane.

The future scope for this project is the implementation of a variable voltage variablefrequency motor drive as the input to the crane instead of signal builder. Instead of using signal builder the motor drive implementation would allowto the user to visualize the process better and closer to reality. Also, it allows smooth variation of speed of the crane and would allow us to monitor and control the crane by controlling the motor.

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