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DESIGN AND SIMULATION OF ROBOTIC ARM FOR LOADING ZINC PALLETS USING WORKSPACE SIMULATION SOFTWARE

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ABSTRACT

The aim of this paper is to conform the importance of loading Zinc Pallets and automation in Galvanization process in steel industry. Normally the loading is done manually. This project deals with designing the robotic arm and end effector for the loading purpose. The CAD model of robotic arm, end effector, layouts is made using PTC-Creo and CATIA software and its simulation performed on WORKSPACE simulation software. Later in this paper we will also study the introductory part of the workspace simulation software, its features, benefits and applications. The objective of this project is to overcome the problems at industry by designing and simulating a robot arm to perform the task. By simulating, the process of loading of Zinc pallets more effectively. Workspace LT is the software used in this project

Keywords- *Robotic arm, simulation, Hot dip galvanization, Workspace LT, zinc pallets etc.*

1. INTRODUCTION

JSW ISPAT is an integrated steel plant producing galvanized sheets products, and cold rolled coils at Kalmeshwar, Nagpur. For galvanization of steel Hot dip galvanization process is used. **Hot-dip galvanization** is a process of coating iron and steel with a layer of zinc by immersing the metal in a bath of molten zinc at a temperature of around 840 °F (449 °C) .There are 4-Hot dip galvanization stations in JSW ISPAT. Zinc is immersed in the form of rectangular Zinc Pallets (432*216*45mm) in the molten zinc pot.

In most of the ISPAT industries the loading of zinc pallets is carried manually.

In such hazardous condition zinc pallets are being loaded manually in to the pot of molten zinc.

There are two types of workspace simulation software. One is workspace LT which is used for educational simulation solutions and other is workspace 5 which is used for industrial simulation solutions. We will see all the details of workspace LT further in this paper.

Robotic simulation is a approach that involves the design, analysis and offline programming of robotic work cells. It captures the visualization of how the robot moves based on series of predefined geometric points. The simulation is basically depending upon CAD software like PTC-Creo, CATIA.

2. CAD MODEL OF LAYOUT OF WORK AREA, PALLETS

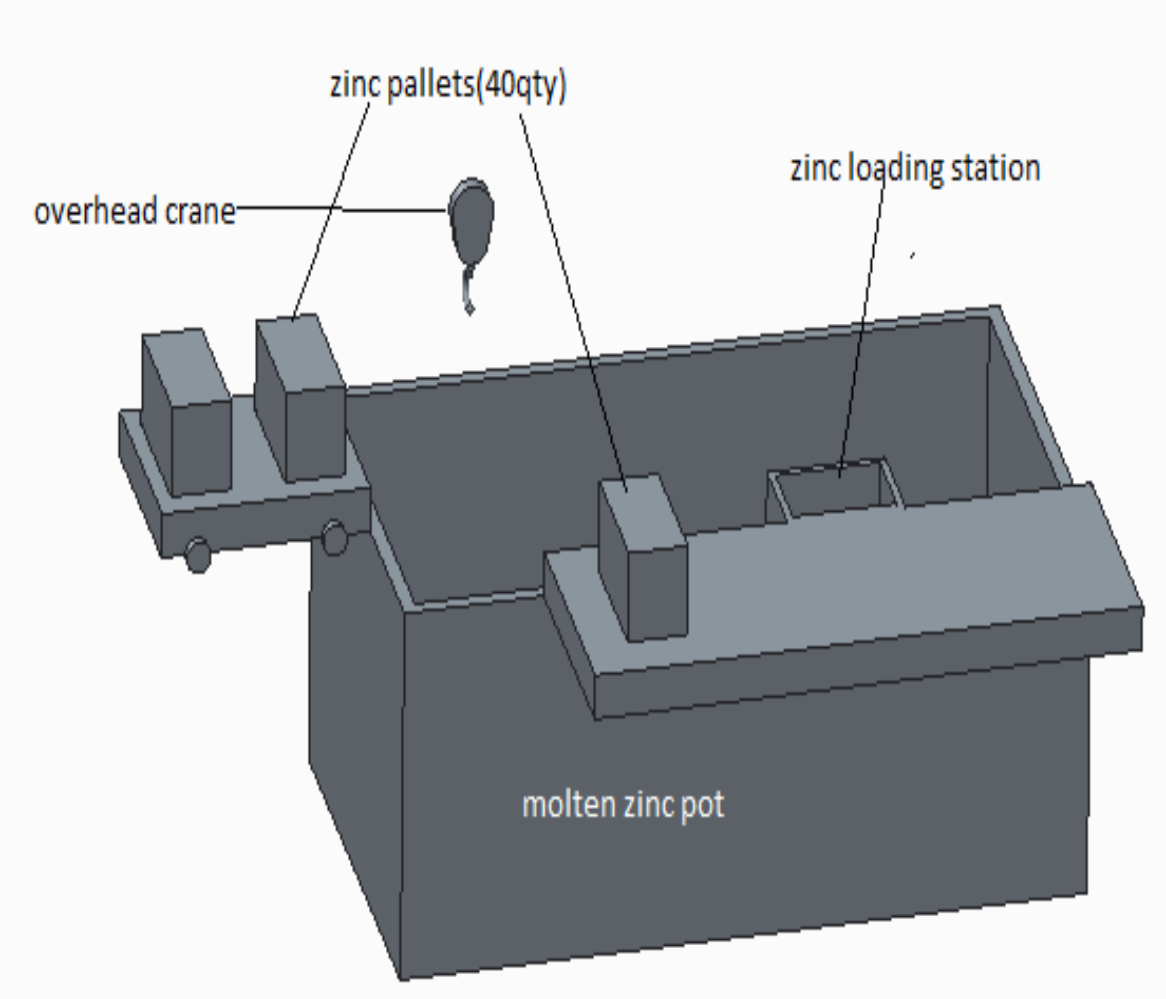


Figure 1. CAD model of layout in PTC-Creo

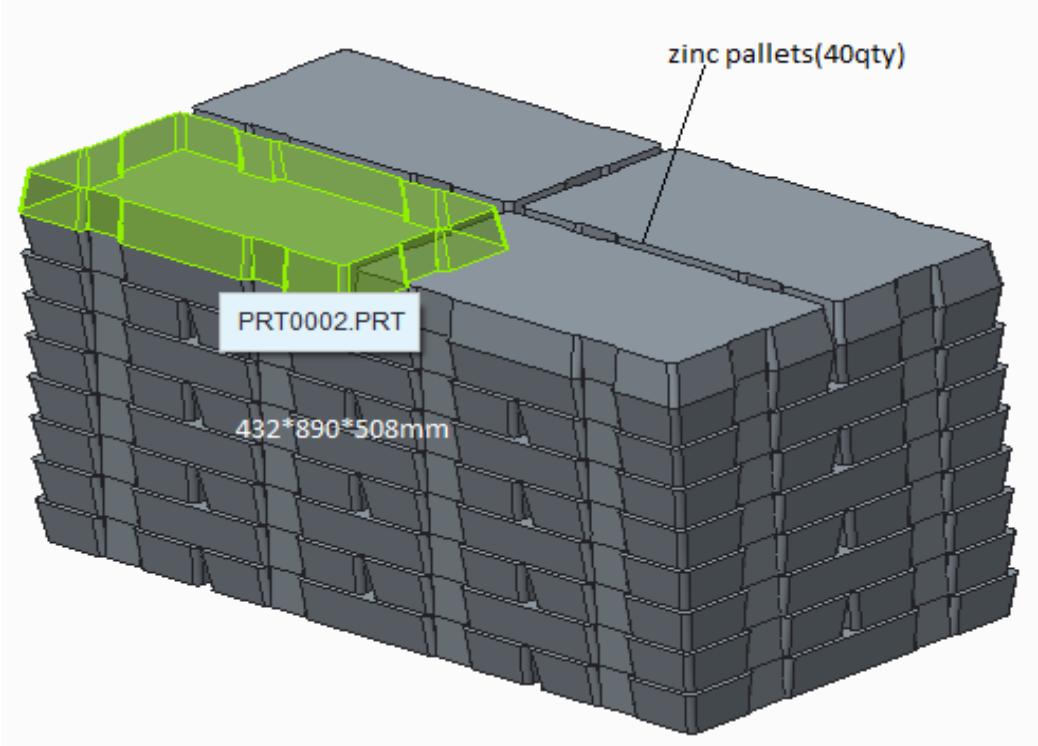


Figure 2. CAD model of zinc pallets (40qty)

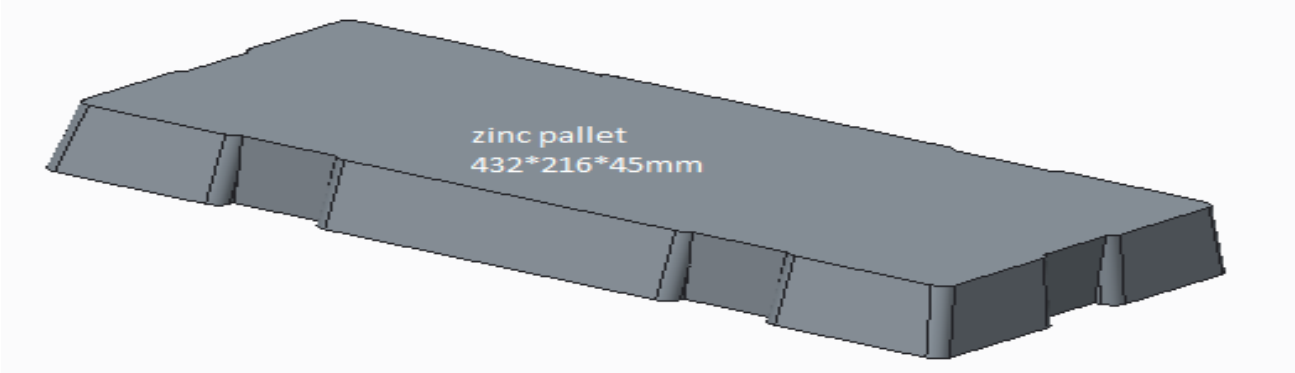


Figure 3. CAD model of Zinc pallet in PTC-Creo

Properties of Zinc Pallet:

zinc pallet	Specifications
weight	25kg
dimensions	432*216*45mm
shape	Rectangular
surface	Rough
property	non-magnetic

3. ROBOT CONFIGURATION

Parameters of robot selection:

1. Degrees of freedom
2. Work volume
3. Load carrying capacity
4. Accuracy and Repeatability
5. Control system

Robotic configuration gives us the exact idea of work volume and space of operation of robot. As per the joint and link movements, the configurations are of different types. Following are the basic configurations used for designing robots.

A. Polar configuration

The robot has rotary base and pivot that can be used to raise and lower a telescoping arm.

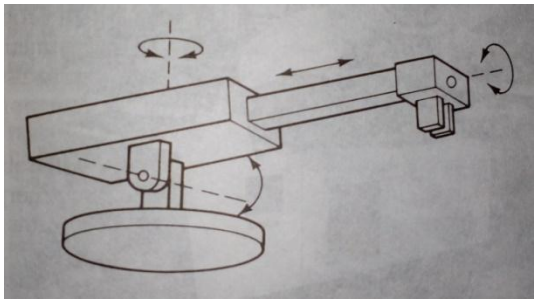


Figure 2- Polar configuration

B. Cylindrical configuration

The arm consists of several orthogonal slides which allow the arm to be moved up or down and in and out with respect to body.

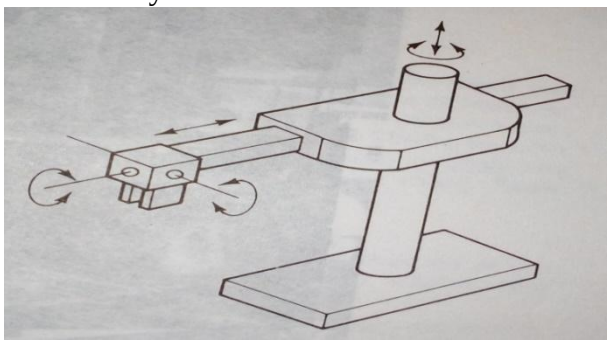


Figure 3- Cylindrical configuration

C. Jointed arm configuration

The arm consists of several straight members connected by joints which are analogous to human shoulder, elbow and wrist

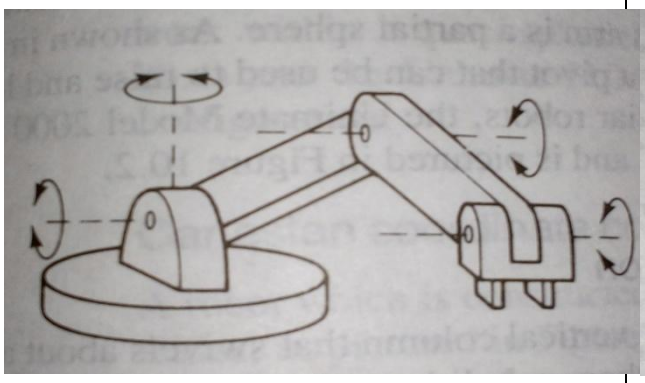


Figure 4- Jointed arm configuration

D. Cartesian configuration

The three slides are parallel to x, y and z axes. By appropriate movements of these slides, the robot is capable of moving its arm to any point.

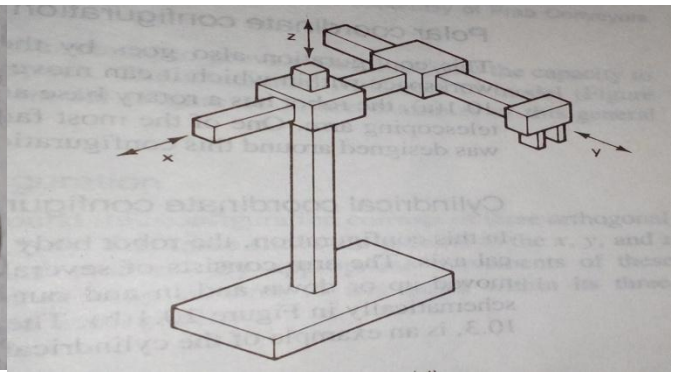


Figure 5- Cartesian configuration

For our concept we used combination of **cylindrical and Cartesian** configurations. The proposed robotic arm will have six axis motions. (3 for Robot and 3 for end effector)

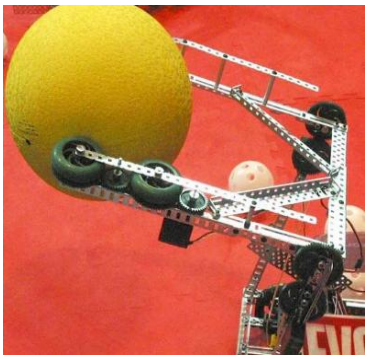
4. DIFFERENT TYPES OF END EFFECTORS:-

1. MECHANICAL GRIPPERS:

A mechanical gripper is used as an *end effector* in a robot for grasping the objects with its *mechanically* operated fingers. A robot requires either hydraulic, electric, or pneumatic drive system to create the input power. The power produced is sent to the gripper for making the fingers react. It also allows the fingers to perform open and close actions. Most importantly, a *sufficient force* must be given to hold the object.

In a mechanical gripper, the holding of an object can be done by *two different methods* such as:

- Using the finger pads as like the shape of the work part.
- Using soft material finger pads.



Customized Roller Gripper

Advantages:

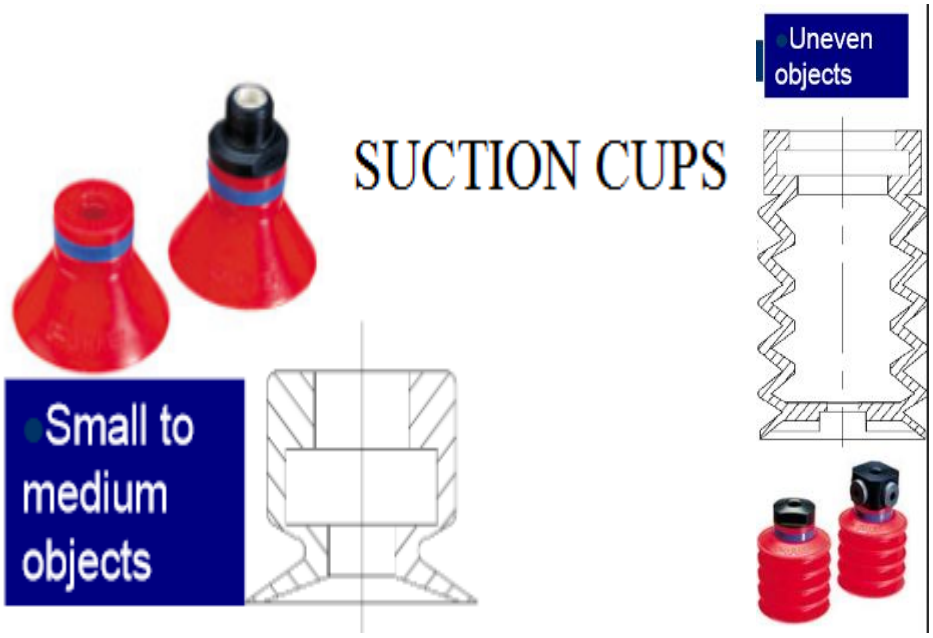
- Temperature resistant
- High weight
- Low power requirement
- Multiple varieties of objects can be handled
- Customization is possible

Disadvantages:

- Dynamic forces and moments when sizing a gripper.
- Failure (Gripper could drop part with loss in air pressure)
- Frictional damage
- Wear and fatigue of component

2. SUCTION GRIPPERS:

Vaccum is used to create grip and so used to lift objects



Disadvantages:

- Consumes lot of power
- Can't work in high temperature
- Suitable for smooth surface only
- Only in low temperature

Advantages:

- No damage to the object
- High load carrying capacity

3. MAGNETIC GRIPPERS:

A type of end effector that uses electromagnets or permanent magnets to pick up metallic objects.

Disadvantages:

- Only suitable for magnetic parts
- Magnets fail at high temperature

Advantages:

- High reliability and least failure
- High weight carrying capacity

4. ADHESIVE GRIPPERS:

Adhesive substance used to hold flexible material

Disadvantages:

- Low weight carrying capacity
- Flexible material only

Advantages:

- Low cost
- Suitable for light objects

5. HOOKS AND SPOOKS

Hooks and scoops are the simplest type of end effectors that can be classes as grippers.
A scoop or ladle is commonly used to scoop up molten metal and transfer it to the mould.
A hook may be all that is needed to lift a part especially if precise positioning in not required and if it is only to be dipped into a liquid.

Hook

6. COMPARISON AND SELECTION OF END EFFECTOR:-

COMPARISON:

As robot needs to pick the zinc pallet, grippers are to be used as an end effector.

SELECTION OF END EFFECTOR

TYPES: ↓ PARAMETERS →

SR.NO		Capacity (upto)	PART SIZE (dia.)	COSTS	CYCLES TO FAILURE	SURFACE REQUIRED	ACCURACY	HIGH TEMPERATURE	PART TYPE	CONCLUSION
1	MECHANICAL GRIPPER	725KG	upto 1000mm	5-50k	upto million (less failure)	any surface	high	yes	any type(metals)	ACCEPTED
2	VACCUM GRIPPER	136KG	upto 457mm	3-30k	less failure	smooth surface only	high	failure	any type with smooth surface	REJECTED
3	MAGNETIC GRIPPER	500KG	450mm	5-50k	less failure	magnetic	high	failure	only magnetic	REJECTED
4	ADHESIVE	5-50KG	small	5-20k	more failure	sticky	low	failure	any type with sticky surface	REJECTED
5	HOOKS	500+KG	upto 1000mm	2-20k	less failure	with holes	high	yes	any type with holes	REJECTED
PART: ZINC PALLET		25KG	400mm(approx)		no failure (disastrous)	rough surface (rectangl	high	upto 460c	non-magnetic metal	mechanical gripper

zinc pallet	specifications
weight	25kg
dimensions	432*216
shape	rectangular
surface	rough
property	non-magnetic

Comparison done in excel sheet

As the zinc pallet is non-magnetic, we **rule out magnetic gripper**
Temperature of work is very high, **adhvesives and vaccum grippers would not work**
Zinc Pallet is rectangular, without any holes so **hooks can't be used**

SELECTION:

Thus, **Customized Mechanical gripper** is suitable for loading of zinc pallet

Properties these grippers should have:

- Temperature resistant material
- Minimum size and weight
- High gripping force (As failure could result in explosion in molten zinc pot)
- Sub system for slowly and gradually insertion of zinc pallet in molten zinc pot (Roller grip can be used)
- Failure consideration (No failure)

7. DESIGN AND CALCULATIONS OF END EFFECTOR:-

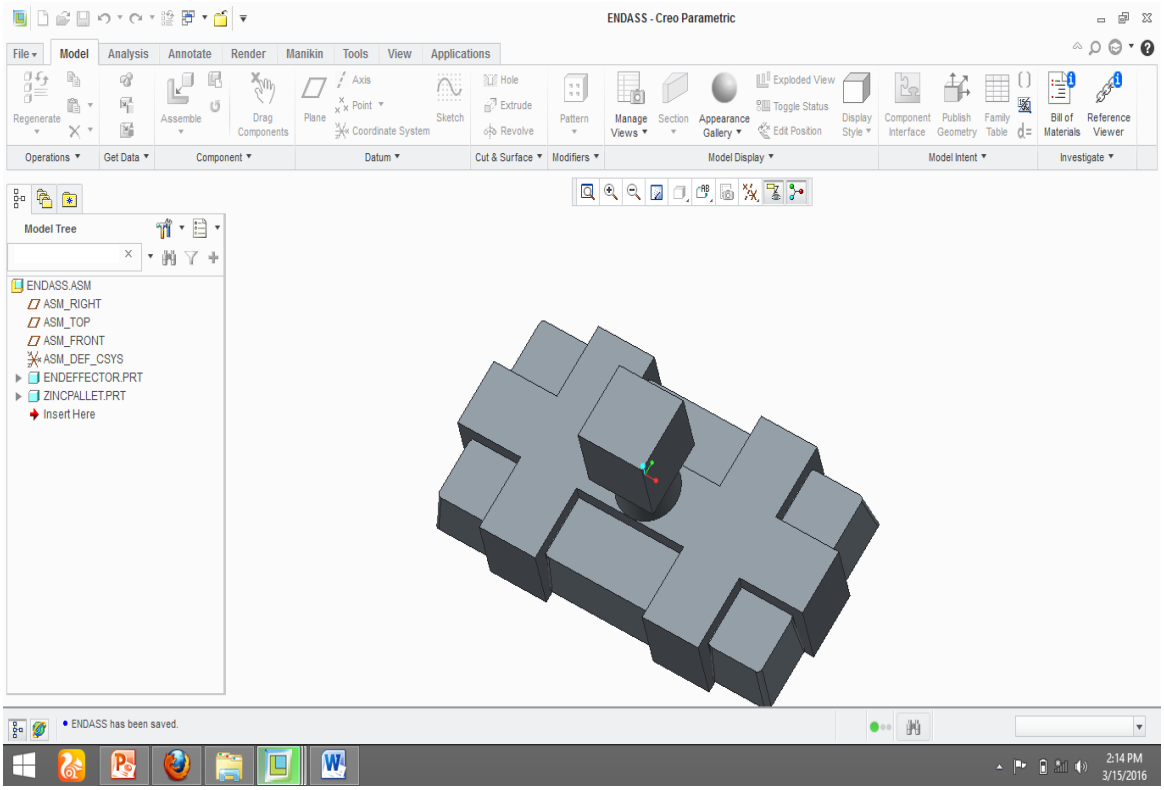


Figure 4. CAD model of End effector in PTC-Creo

Dimensions: 500*250*60mm

Gripping force: uWng

For 25kg zinc Pallet= 0.2*25*9.8*3
= 882N(approx.)

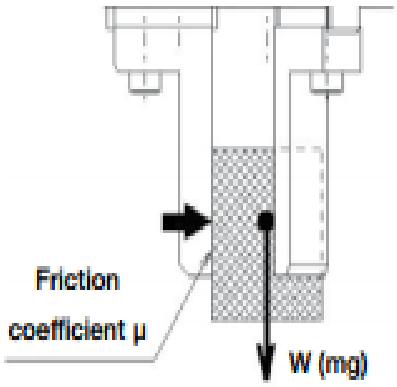
u: coef. of friction (0.2 for Steel and zinc)
W=weight of the object

n=number of fingers (n=4 Fingers)

g=multiplication factor (g=2 for horizontal,

g=3 for upward against gravity)

F* μ > W (weight of pallet)



F= (W/μ) * factor of safety

= (25*9.8)/0.2 * 2

= 2450 N

Force at each finger = 2450 N / 6

= 466.16 N

8. PROPOSED ROBOT :-

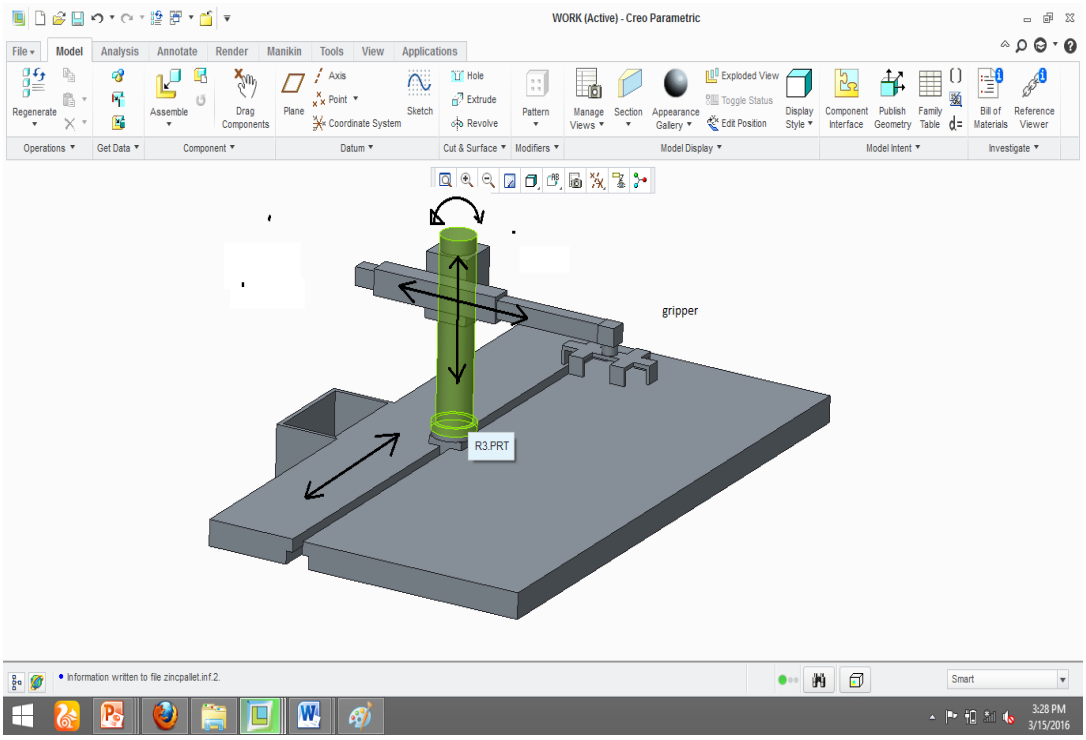


Figure 5. CAD model of 4axis robot in PTC-Creo

- **ROBOT ARM DESIGN:**

Link 1:

Height: 700mm

Diameter: 200mm

Link 2:

Length: 1200mm

Width: 150mm

Thickness: 150mm

9. LAYOUT OF ACTUAL WORKSPACE :-

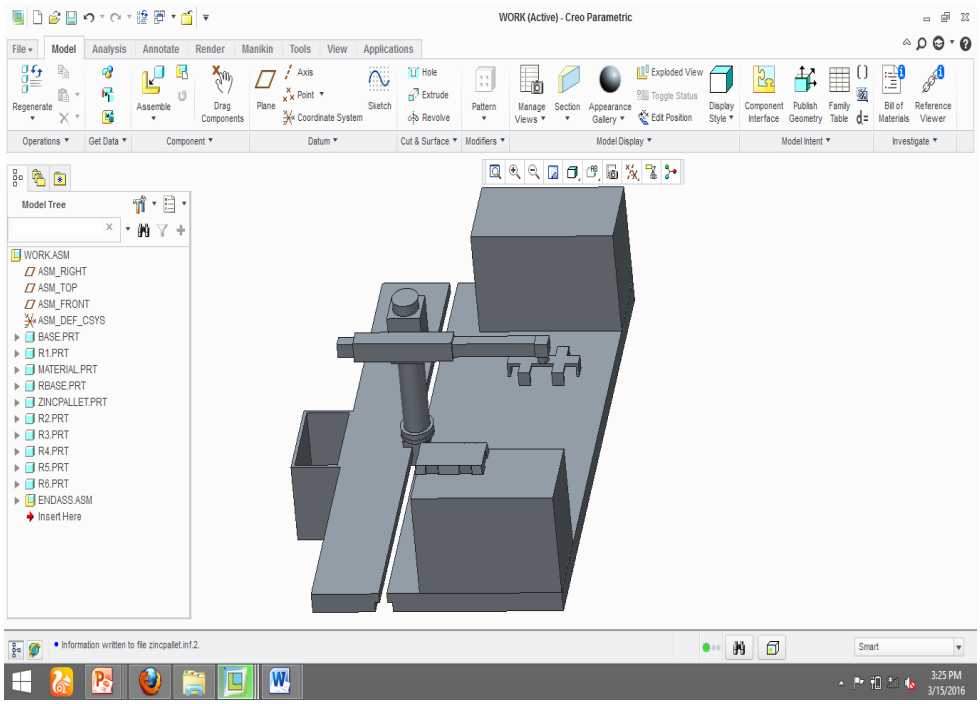


Figure 6. CAD model of actual work layout in PTC-Creo

10. WORKSPACE LT:-

1. This simulation software is Industrial grade and specially used for educational purpose.
2. It allows full offline programming and has the ability to simulate more complex work cells with more than two robots.
3. Before reach the production stage, you can visualize the robotic and automation process very easily.

FEATURES:-

- CAD modeling
- 3D mouse support
- Offline programming
- Tool path tracer
- Anti collision detection

BENEFITS:-

- Minimize Costs
- Minimize Production Downtime
- Improved flexibility
- Improve Cycle Time
- Accelerate Work cell Design

11. CONCLUSION

In this paper, we discussed the various gripping systems that are being used in industries. Considering the temperature, shape and surface of the zinc pallet, we feel that customized mechanical gripper with high heat resistant would be a better choice and a designed a gripper. And we have also discussed about the advantages of the automation in the industry using robotic arm. Robotic simulation provides highly detailed 3 dimension view of work cell and allow user to identify any interference between robot and object. It also provided with cycle time monitoring to verify how long a robot will complete a given task. Programming a robot with minimum cycle time will ensure higher productivity of a production. And further in this project we will design and simulate the robotic system as per the requirement.

12. ACKNOWLEDGEMENT

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