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Design and Manufacturing of Automated System using Gantry Mechanism

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A B S T R A C T

Material handling is an important part of manufacturing processes. Production processes such as powder coating and dipping processes are done manually which are time-consuming and sometimes hazardous to laborers. There is a need for automation control in doing such processes to reduce labor costs, and time consumption, and increase accuracy which can keep up with other simultaneous manufacturing or transporting processes. The emergence of robotic automation has given a significant advantage to industries. The methodology used involves the automation of pickup-drop processes using a gantry mechanism. The automated system is designed using Arduino, and the pre-feeding of information to a machine is given for following the process path. We are using a gantry mechanism for lifting and placing products with the help of gripper technology. A moving Gripper plate is used a s a holder for picking the product. The positioning system in which coordinates are given through a machine for locating the desired picking and placing coordinates. It includes designing and manufacturing of rack & pinion, guideway shaft, lead screw, and gripper holder. The initial cost is high compared to setting up this mechanism but it has more advantages compared to manual processes. The result implies that using the gantry mechanism with automation reduces the cost of production and prevents human errors.

Keywords: Material Handling, Gantry Mechanism, Arduino Programming, Automated Systems.

Introduction

Robotic automation and machines will usher in a new era in the industry in 2023. Significant progress has been made in robotic applications across many product manufacturing industries over the past ten years. Although the initial cost of setting up machines and robots can be quite high, the modern industry cannot achieve the production effectiveness, variety, and level of detail that they provide with human capacity. A robot is a tool that follows a general set of rules or pre-defined instructions from a supervisor to perform automatic functions and movements. Robots have the potential to either augment and assist human abilities or take the place of humans in certain tasks. Material handling can be challenging, especially when handling dangerous or heavy products. Material handling is important function in Robotic automation and machines will usher in a new era in the industry in 2023. Significant progress has been made in robotic applications across many product manufacturing industries over the past ten years. Although the initial cost of setting up machines and robots can be quite high, the modern industry cannot achieve the production effectiveness, variety, and level of detail that they provide with human capacity. A robot is a tool that follows a general set of rules or pre-defined instructions from a supervisor to perform automatic functions and movements. Robots have the potential to either augment and assist human abilities or take the place of humans in certain tasks. Material handling can be challenging, especially when handling dangerous or heavy products. Material handling is important function in manufacturing and transportation industries. This calls for an understanding of the system's load distribution and load calculations. In this project given the input of the component's location, the operator or supervisor should be able to manage the workflow and oversee working of system. The XY gantry mechanism can increase workplace safety and efficiency while reducing accidents and eliminate coordination errors. The ongoing improvement and updating of product quality requirements have accelerated the research and development of futuristic robots. Robots can readily handle product diversity and finer details that humans find difficult to comprehend.

Literature Survey

1. Design and Fabrication of X-Y Gantry Mechanism using Python: A Review Dr. Chandrashekhar Kamargaonkar1, Vaibhavi Tiwari2 1Associate Professor, 2Mtech scholar, Department of Electronic and telecommunication, SSTC, Bhilai, C.G.: In this paper overhead crane automation is created using PC programming and distance computation. A controller is used to operate directions of crane. a sensor is used for monitoring the load position. The system operates on proper load distribution. The safety is considered while making this project as it deals with heavy objects and load swaying is major problem. The operator who has controller oversee the process and plays important role.

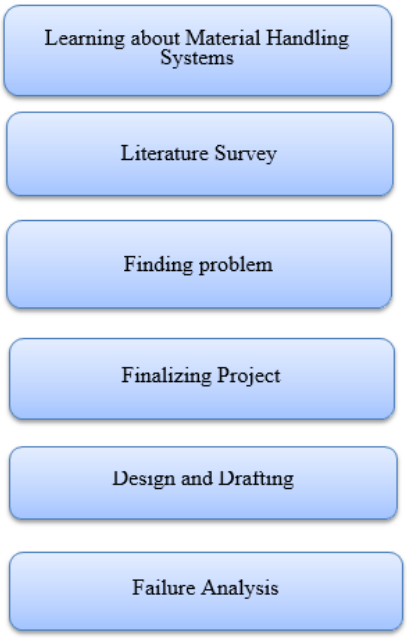
2. Shorya Awtar* and Gaurav Parmar Precision Systems Design Laboratory Mechanical Engineering, University of Michigan Ann Arbor MI 48109: In this project, we have observed how to utilize a nano positioning system in large range mechanism. This can help in achieving the setup of compact design for material handling with high quality motion.

3. Ravikumar Mourya. Amit Shelke, Sourabh Satpute, Sushant kakade, Manoj Botre, "Design and implementation of pick and place roboti c arm", Department of Mechanical Engineering, JSPM technical campus Pune, 2015, pp 232-240: -. This paper describes the operation of the four-degree-of-freedom robot. Robotic arms can be assessed along a wide range of criteria, including torque, payload, speed, range, repeatability, and cost, to mention a few. With reference to the several manipulators and mobile platforms that are now on the market, a viable design for a manipulator has been identified in this study. To model the desired manipulator, computer-aided design software such as creo1.0 and auto cad are utilized.

4. S. Premkumar, K.Surya Varman,b, R.Balamurugan, "Design and Implementation of multi handling Pick and Place Robotic Arm", Department of Mechanical Engineering, IFET College of Engineering, 2016 pp 164-166:- The efficient Design and Implementation of a multi-handling Pick and Place Robotic Arm has been carried out in this article. Numerous arm linkages have been rigorously examined for functionality, and the necessary remedial actions have been implemented. Therefore, the goal of creating a pick and place robot at a low cost was achieved, and it has been demonstrated that the robot's operating costs are also very low. With very little upfront cost, this will aid in reducing labor costs and increasing revenues. The proposed model is demonstrated using a real-life example. Based on the above merits and considering various merits, this project is considered to be applicable to the assembly industry. In conclusion, I would like to say that this project can be a factor influencing gathering areas.

5. Biswas Palok, S. Anandan Shanmugam, "Design and Development of a 3 axes Pneumatic Robotic Arm", Department of Electrical and Electronic Engineering, University of Nottingham Malaysia Campus, Malaysia, 2016, pp 1-8: - For use in industries where the use of electric components can be harmful, an articulated robot arm was designed in this paper employing pneumatic linear actuators. The crank mechanism used in the arm's design effectively translated linear joint displacement from actuation to angular joint displacement. Compared to a standard 5/3way directional control valve, a 5/3way proportional control valve was exceptionally effective in controlling the highly nonlinear arm .Previously impossible by PLC, closed loop control employing a microprocessor and feedback sensors offered accurate and enhanced control of the joint angle with great accuracy. Additionally, it was discovered that the force dynamically varies with the position of the articulated arm.

Methodology



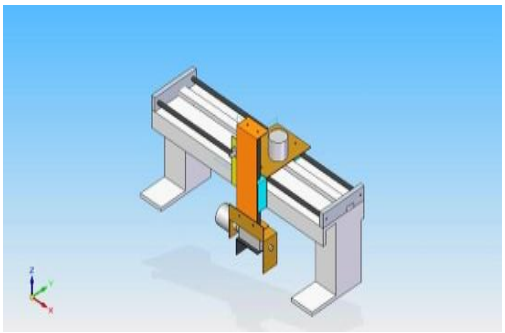
Component and Design

4.1 Components

1. Rack and Pinion: Rack is fixed on X direction fixed plate in horizontal direction and pinion moves along the direction of rack, Plastic is used as material for manufacturing of rack and pinion. The moving operation is linear in motion in horizontal direction and rotational in vertical direction. It converts rotary motion into linear motion. The load of the carried component by the gripper is distributed and supported by rack and pinion. Rack and pinion are subjected to failure.
2. Guideway Shaft: Guideway shaft is used in both horizontal and vertical direction in the system, shaft is used for supporting and balancing of system, to avoid system failure and deformation. For the movement of solid block structure to move along its path without any shake, guide rod is used. Based on load, material of the guide rod is chosen. There are several materials such as mild steel, EN8, EN19, EN24, aluminum. Mild steel cannot withstand heavy load whereas EN8 and EN24 can withstand heavy load. EN8 material is used here.
3. Lead Screw: Lead screw is used in vertical direction. It operates in direction of vertical guide shaft. It is selected for its anticorrosive and anti-lubricative properties. Mild steel is used for manufacturing of lead screw.
4. Gripper: Gripper is screw type moving plate, it is used for picking operation. A motor controls the movement of gripper. It fixed the component in between fixed plate and moving plate, preventing the component from swaying its position and prevents accidents.
5. Motor: We used three motors. The two DC motors of capacity 12 V, 2Amp and 10 rpm used in operation in Y direction and pick and place operation of gripper. We used the 30-rpm motor for X direction motion.
6. Arduino: Arduino is a very important part of this system; this is running element of machine. Direction and movements of robot is controlled using Arduino programming. Moving operations are controlled and manage using codes.

4.2 Design

1) 3D View



2) Actual Model

Calculations

1. Calculation of diameter for guide ways.

Material-Mild steel (MS)
Minimum Yield strength=55% of minimum Tensile strength
Tensile strength of MS= 340 N/ mm^2
Therefore, Yield strength (S_{yt}) =0.55 x 340
S_{yt} = 187 N/ mm^2
Now according to Maximum shear stress theory
$S_{sy} = 0.5 \times S_{yt}$
Permissible shear stress is,
$\tau = S_{sy} / FOS$
$\tau = 0.5 \times S_{yt} / FOS = 0.5 \times 187 / 2.5$
$\tau = 37.4$ N/ mm^2

SFD and BMD Calculations
Load = 1Kg
Force = 1 x 9.81 N
Central load of 9.81N acts on the two guide ways.
Hence, 4.91 N load acts on each.
Reactions at point A and B.
Simply supported beam with point load at centre
$R_A = R_B = F/ 2 = 2.45$ N
$S_{yt} = 187$ N/ mm^2
Now according to Maximum shear stress theory
$S_{sy} = 0.5 \times S_{yt}$
Permissible shear stress is,
$\tau = S_{sy} / FOS$
$\tau = 0.5 \times S_{yt} / FOS = 0.5 \times 187 / 2.5$
$\tau = 37.4$ N/ mm^2

2. Calculations for Gripping Force.

Gripper type- Screw type gripper
Assumption- We have to pick 50g of weight

$\mu \times n_f \times F_g = W$

$0.25 \times 2 \times F_g = 50 \times 9.81$

$F_g = 0.981$ N

Where,

μ = Coefficient of friction

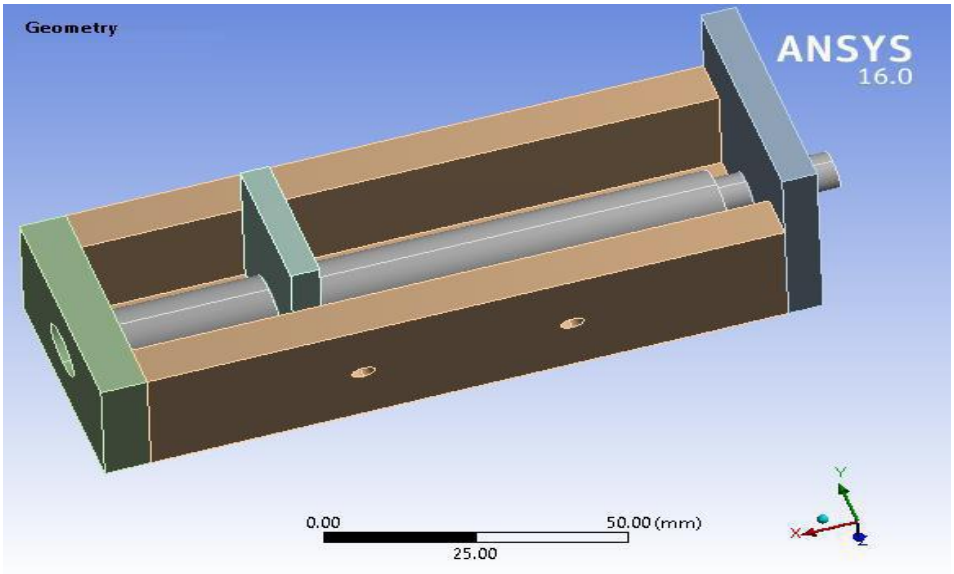
W = Weight of object

n_f = Number of fingers of gripper

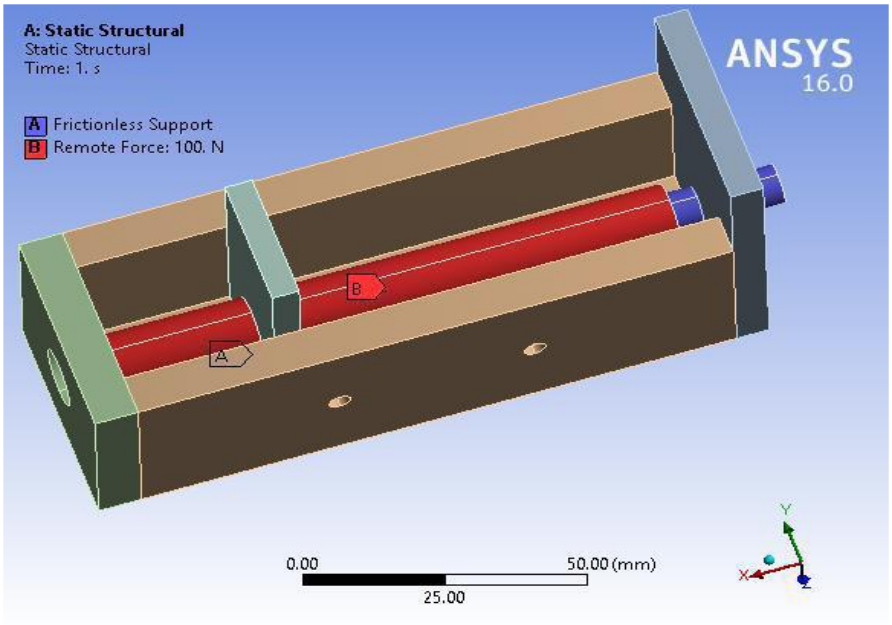
F_g = Gripping force

Failure Analysis

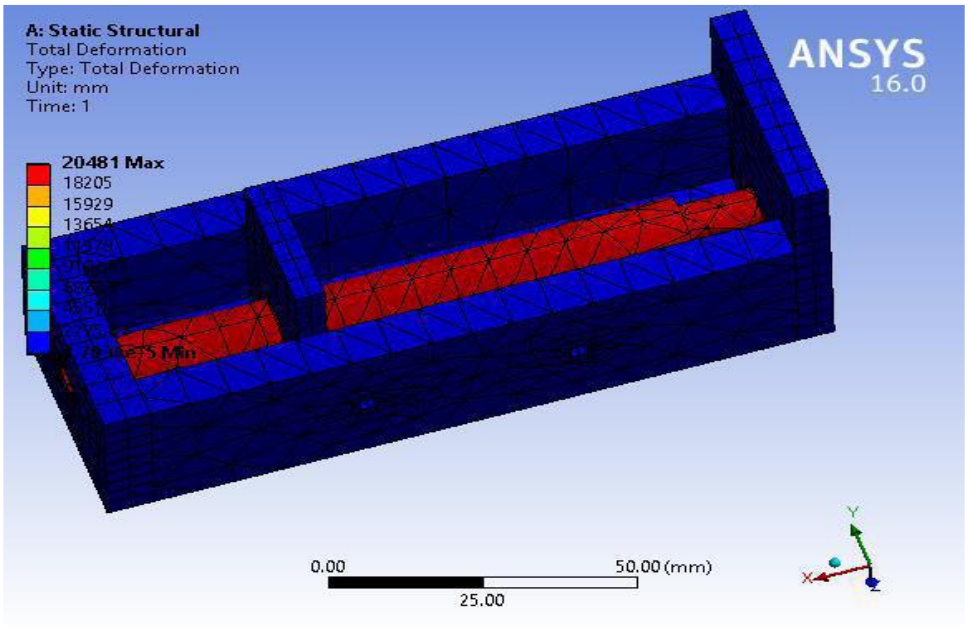
1) Geometry



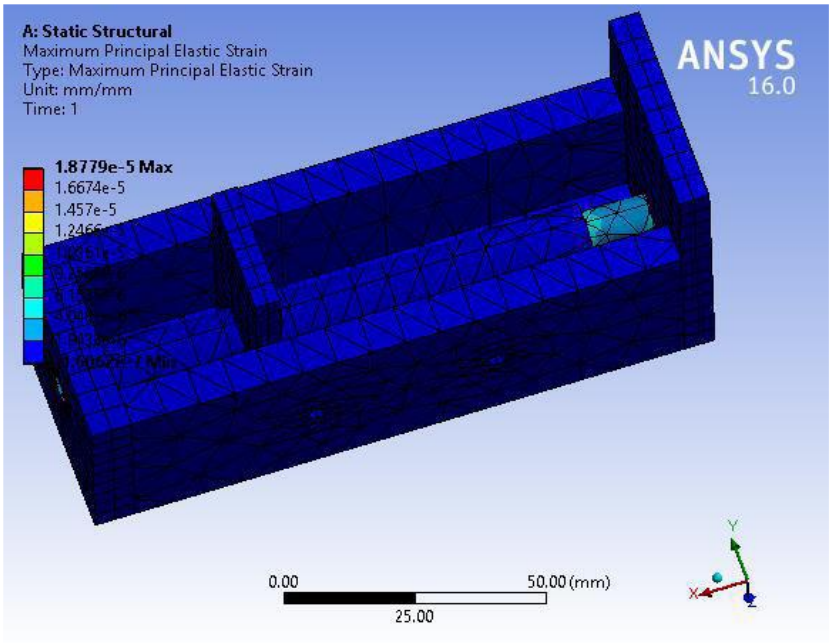
2) Static Structure



3) Total Deformation



4) Maximum Elastic Strain



Application, Advantages & Disadvantages

7.1 Application

1) Gantry Crane
2) Dipping Processes (Surface coating)
3) Pick and Place operation

7.2 Advantages

1) Improves safety and accidental prevention
2) Simple Structure
3) Reduce time consumption

7.3 Disadvantages

1) High Capital Cost
2) Require maintenance
3) External error can interfere in its line of action.

Materials

Material	***Properties***
1) Acrylic	***Rigid and Lightweight***
2) Plastic	***Anti-corrosive and Self lubricating***
3) Mild steel	***High tensile strength and durable***
4) Foam Sheet	***Strong and Reliable***

Conclusion

This design is secure and advantageous in use. This system's path of operation is predetermined. It is simple and transforms complex systems into straightforward mechanisms. The system has excellent safety standards, improves job productivity, and is effective to use. It needs to move back to its starting place in order to complete another task. This system is expandable to integrate other features. As it follows a set path, there are very little chances of error. This project can operate as a standalone material handling system or be integrated with any production system.

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