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Design of Robotic Arm for Forging Machine

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Abstract- The robotic arm because of its several degrees of freedom and single velocity unit which, under the control of Programmable Logic Controller is connected to one of the axis position control units and one of the motors in accordance. Motor codes can be used to generate an online function to control the robotic arm in real time and with considerable accuracy. The mechanism allows us to locate the motor at the base, so that the weight of the motor is not a major concern. Thus, the production rate can be increased up to 5 times. Hence, our aim was to increase the production by reducing manpower with maximum efficiency. The proposed design is to provide industrial automation, which is useful for monitoring the devices from any distance. A micro controller is used which monitors are the components according to the given message, with the sensed information sent from the sensors. As the automation is microcontroller based it automatically regulates the temperature changes. The main focus of this project was to design and develop the mechanism for robotic arm for lifting and placing. The robotic arm was designed with six degrees of freedom and programmed to accomplish accurately simple light material lifting task to assist in the production line in any industry. The device should be able to consistently pick up and place objects in a smooth manner. i.e., the motion of the device should be smooth enough to not drop the objects that are being lifted. Therefore, any device that can lift and move an object from one place to another without losing any grip would meet the criteria.

Key words- Degrees of freedom, Programmable Logic Controller, Production rate, Industrial Automation, Micro Controller

1. INTRODUCTION

Hydraulic hot forging press is the process of shaping a hot workpiece that is placed in a die by applying hydraulic pressure.

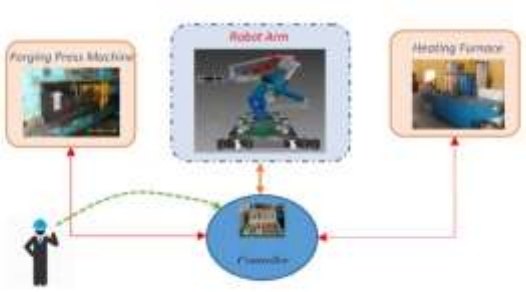
One of the most important aspects of the manufacturing process is related to the material transfer which significantly impacts on the productivity and the safety issue for workers. A robotic arm is invented to help various industries to perform a task or work instead of using workforce**.** As for costs of using robots in industries, it is reported that as robot production has increased, costs have gone down. Over the past 30 years, the average robot price has fallen by half in real terms, and even further relative to labor costs. These critical issues have motivated and encouraged the implementation of innovative robot design for the material handling. However, designing a robot arm for the mentioned application usually copes with challenges since the robot usually

suffers from a heavy payload at the arm tip, and it must operate at high speed in a large operational space. As for the given forging press workshop under consideration in this research, the designed robot is required to handle workpiece weighted about 1 kg. It must transfer a heated workpiece along a distance of 2.5m, the distance between the heating furnace and the press machine, within a limited time period of 20sec. This is a critical task for the design of robot. Additionally, the workpiece is always oriented in either vertical or horizontal plane only so that it increases the stability and stiffness of arm while moving a heated workpiece at high speed. The design of the arm is then validated via kinematic performance analysis, quasi-static modelling and analysis, and structural performance simulation.

2. Methodology

a. Market Survey
b. Specify functions of elements
c. Select suitable material for element
d. Determine geometric dimensions of the element
e. Design of individual components
f. Prepare working drawing of element

3. Working of the robotic arm



The main functional requirements for the designed robot are that the robot must be capable of replacing workers to grasp, transfer and release hot and heavy workpiece among given places of the given forging workshop. It is required to operate at high speed in a large operational space so that the cycle time for the production is reduced. Initially, the workpiece is placed in the furnace. The workpiece is heated to a very temperature in the furnace. The furnace has certain sensors installed in it. The workpiece temperature is sensed by the sensors. The heat torch guides the

workpiece. The furnace has gates installed in it. After the set time the gates are opened and the workpiece is allowed to slide through the conveyor. The optical pyrometer tests the temperature of the workpiece on the conveyor. If the workpiece is within the desired temperature range, then the workpiece is stopped by the stopper which is installed in front of the front robot. If it is not in the desired temperature range, the workpiece slides down from the conveyor and goes for re-heating. The stopper is actuated and the job stops on the conveyor. Initially, the rear robot is in rest position and it is given commands. Thus, the rear robot is actuated and the gripper arm is in down position and it clamps the workpiece and the workpiece is picked and placed in the press machine. After placing the workpiece in the machine, the robotic arm returns to its initial position. The workpiece is pressed inside the machine forming the desired shape as per the mold. Now, the front robot moves in forward position in downward direction, picks the pressed workpiece from the machine. After picking the workpiece, it de-clamps it in conveyor. Thus, one cycle is completed. And the robot settles down in upward position.

5. The Pneumatic Circuit

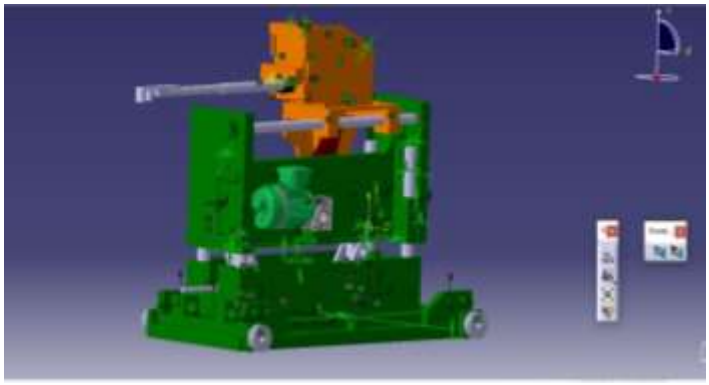
The atmospheric air is compressed into the central compressor up to the pressure of 10 kg/cm^2.

The compressed air is then stored into the reservoir tank at the pressure 2.5 kg/cm^2 and then supplied to the pneumatic circuit. The compressed air is then passed through the FRL unit where the air is filtered. Then its pressure is regulated up to a set pressure and then lubricated. In this circuit we have used 4 Direction control valves to actuate the 4-double acting pneumatic cylinders. The optical pyrometer, 4 solenoids operated DCV and position sensors are synchronized with PLC.

The temperature of the workpiece leaving the furnace sensed by the optical pyrometer and if the temperature is within the range then the PLC operates the direction control valve to grip the workpiece and the DCVs are operated by PLC with the help of PLC timer to complete the operations.

The operations include:

1 Gripping and releasing
2 Forward and reverse
3 Upward and reverse



4. DESIGN/ANALYSIS APPROACH

Force Required = (Pressure * Area) – Frictional Force

F1 = (P*A) – F2

Total Mass (m) = Mass of Pivot Plate (m1) + Mass of Robotic Arm(m2) =6.898+ 2.689

= 9.587 Kg

Velocity (V) = Stroke Length / Time

= 0.65 / 0.1

= 6.5 m/s

We know that,

Third equation of motion

$$V^2 = u^2 + 2as$$

Where,

V = Velocity in m/s

u = Initial Velocity in m/s

a = Acceleration in m/s2

s = stroke length

$$V^2 = u^2 + 2as$$

$$(6.5)^2 = 0^2 + 2 * a * 0.65$$

Therefore, a = 32.5 m/s2

Force Required (F1) = Total Mass (m) * Acceleration (a)

F1 = 9.587 * 32.5

F1 = 311.5775 N

Frictional Force (F2) = 10% of F1

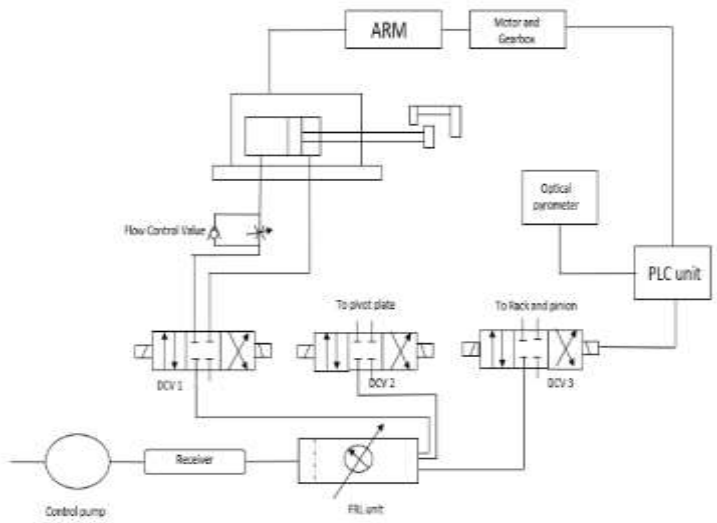
F2 = 31.1577 N

So, Total Force Required

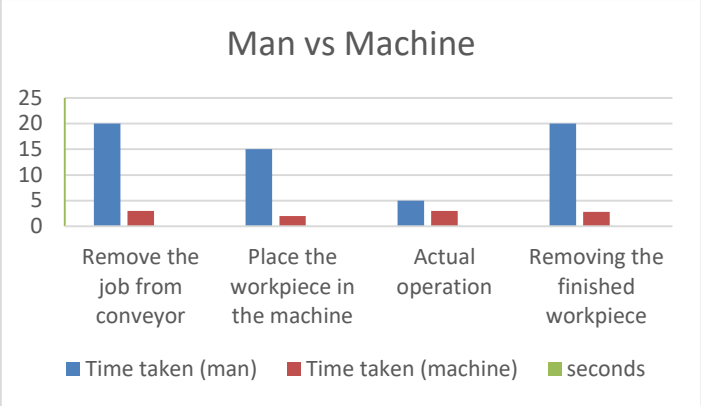
F = F1 + F2

= 311.5775 + 31.1577

= 342.73 N



6. Results



- The following chart offers a brief conclusion for completing one cycle.
- It approximates to 60 seconds as taken by man to 10 seconds as taken by machine viz automation.

7. CONCLUSION

i. The design and fabrication of pneumatic arm for pick and place can be completed with economic and effective considerations.
ii. It can be controlled by Programmable Logic Controller and Solenoid valve.
iii. Robotic arm movement and rotation is done by pneumatic cylinder.
iv. The gripper is also a pneumatic actuator which holds the products.
v. Initial availability of central compressor led us to the suggestion of using pneumatic system.
vi. To design working robotic arm with ability to perform sense-pick-and-place function.
vii. The design of the robotic arm was stared from the prototyping stage.
viii. Drawings and assembly schematics were generated as design data to be kept for future reference if improvements were to be done to enhance the developed device in any possible way.
ix. Therefore, the first and third objectives were achieved. The prototype of the robotic arm was successfully developed and it was able to sense-pick-and-place function.
x. It was tested to give a clearer image on its overall reliability.
xi. The overall successful rate of the robotic arm to perform its tasks correctly was 90%.
xii. The second objective of the project is to do analysis of mechanical properties of the design of the robotic arm.
xiii. Calculations were done for the required shear stress on the finger gripper connection hole.
xiv. This procedure was important to know about shear stress for the gripper. The second objective of the project was therefore achieved.

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