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DESIGN OF SPECIAL PURPOSE MANIPULATOR FOR HANDLING COMPONENT

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ABSTRACT

Robotics is an advance technology, which is widely used across all over the world.In this paper we discuss how the problem in the company can be solved by using this technology. The problem is,to pick up the component from the conveyor and to place it on the bed of the CNC machine worker use the overhanging crane and to hold the component they use V-belt. It is wrong way to handling of component and not safe to worker. At this location in company the automation is required. The solution is hydraulic manipulator. In this paper we discuss design parameters of manipulator, design of manipulator and its partsand some required calculations.

KEYWORDS: Robotics, Hydraulic Manipulator, Manipulator Design, Hydraulic Calculations

INTRODUCTION

Manual handling of heavy components is not a solution in company. For that they required special workers. It leads to increase in cost of the components and investment. Robotics gives a proper solution for that, advance technology in robotics makes it easier and cost effective. There are different techniques of handling system like overhanging cranes, conveyers, guided vehicles, manipulators etc.

OBJECTIVES

Design of hydraulic manipulator for handling castings

To carry out the handling of component with worker safety

To reduce handling time and increasing accuracy of work

PROBLEM

In company, they produce different types of castings and done many operations on casting to get finished final product. During performing the operations the company has to face many problems. Handling of components is one of them. For finishing of the castings they have CNC machines. To perform the operations on CNC machine the job or casting require to place on bed of machine in specified orientation.

The weight castings are above 70kg and pick up them from conveyer and to place on the bed of the machine is not easy manually. So for that purpose they need special purpose mechanism. Conventionally worker use overhanging cranes with V-belt for handling and moving of casting to bed of machine. This is not a safe technique to handle above 70kg casting. That will create some problems like accident, damage to worker or casting. So, that's why there is need of automation.

Figure 1: Manual Handling in Company

SIGHT MEASUREMENT

At the initial stage different measurements at sight are required to taken. These measurements reflect the initial and final position of the component. Also these measurements are reference to the height, length and size of the manipulator. These are as follow,

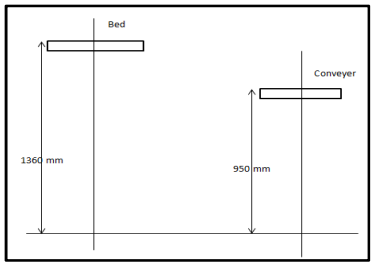

Figure 2: Front View

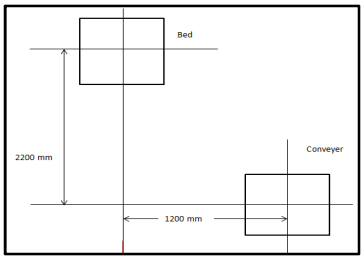

Figure 3: Top View

Then by referring the above measurements of the sight, it's clear from which position the component is picking up and to which position the component is place. Also by using top view measurements calculate the distance required to travel by the arm to place the component. It's difficult to travel 1000mm distance by arm with the component, so there is requirement to minimize the distance and the optimized position to where the manipulator is placed is in figure no. 4. Now the distance require to travel by the arm to place the component is 200mm only.

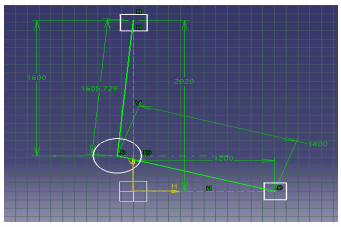

Figure 4: Optimized View

DESIGN OF MANIPULATOR

The design of manipulator requires many factors to taken in consideration.By considering these factors, sight measurements, some calculationsthe design of manipulator is completed. The sequence of manipulator design is as follow. At the initial stage the basic design of the manipulator is selected from the different ideas.

BASIC DESIGN

This is the basic 2D design of the manipulator is selected from the different ideas. This is the simple idea, which has following advantages:

- Easy to use
- Less cost
- Highly flexible
- Less cycle time
- Safe to worker

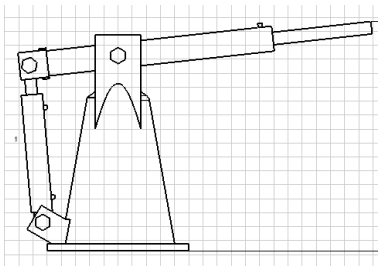

Figure 5: Basic 2D Design

CALCULATIONS

The main part of design is calculations. There are many factors which have to calculate and if these are within permissible limit only then the design is safe. Now some basic calculations are as follows.

Pressure

The figure 6 shows initial position of the manipulator from which the component is to be picking up. By using geometry calculate all angles and lengths.

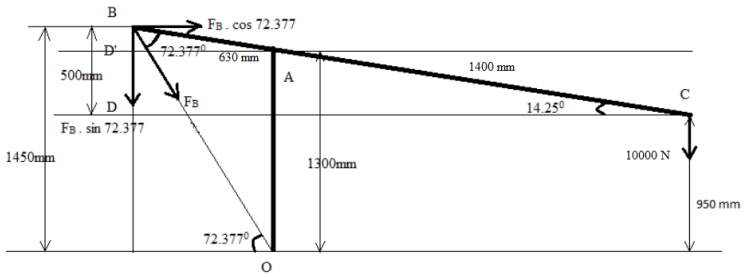

Figure 6: Position of Applied Forces On Manipulator

Weight to lift: 10000N

Taking Moment around point A

$(1400\times10000\times\cos14.25)+(F_B\times\cos72.377\times\sin14.25\times630)= (F_B\times\sin72.377\times\cos14.25\times630)$

$F_B\times581.95 - F_B\times46.9498 = 13569232.74$

F_B = 25363.043 N

Pressure Required Lifting the Load

D= 80mm, d= 45mm

P= F_B /A

= F_B / [(π/4) ×($D^2 - d^2$)]

= 25363.0423/ 3436.12

= **7.3813 N/mm^2**

P=1070.568 psi

Hydraulic Cylinder Calculations

Cylinder Blind End Area= PI x (Cylinder Radius) ^{2}

Diameter = 3.15inch

Radius is 1/2 of diameter = 1.57inch

Radius^2 = 1.57 x 1.57 = 2.465inch^2

π x (Cylinder Radius)^2 = 3.14 x $(1.57)^2$ = 3.14 x 2.465 = 7.7398 inch^2 = 4993.41 mm^2

Cylinder Rod End Area= Blind End Area - Rod Area

Cylinder Blind End Area = 7.7398 square inches

Rod Diameter = 1.772 inch

Radius is 1/2 of rod diameter = 0.886 inch

π x Radius^2 = 3.14 x 0.785 = 2.465 square inches

Blind End Area - Rod Area = 7.7398 – 2.465 = 5.2748 square inches =3403.22 mm^2

Cylinder Output Force= Pressure (in PSI) x Cylinder Area

Cylinder Blind End Area = 7.7398 square inches

Pressure = 1070.568 psi

Pressure x **Cylinder Area** = 1070.568 X 7.7398 = 8285.98 pounds =36.86 kN

GPM of Flow Needed for Cylinder Speed= Cylinder Area x Stroke Length in Inches ÷ 231 x 60 ÷ Time in seconds for one stroke

Cylinder Area = 5.33 square inches

Stroke Length = 15.7 inches

Time for 1 stroke = 30 seconds

Area x **Length** ÷ **231** x **60** ÷ **Time** = 5.33 x 15.7 ÷ 231 x 60 ÷ 30 = 0.8 ie. 1gpm

Cylinder Speed= (231 x GPM) ÷ (60 x Net Cylinder Area)

GPM = 1

Net Cylinder Area = 7.7398 square inches

(231 x GPM) ÷ (60 x Net Cylinder Area) =

= (231 x 1) ÷ (60 x 7.7398) = 0.497 inches per second =12.64 mm/sec

Hydraulic Pump Calculations

Horsepower Required to Drive Pump= GPM x PSI x .0007

GPM = 1

PSI = 1070.568

GPM x **PSI** x **.0007** = 1 x 1070.568 x .0007 = 0.75 = 1 horsepower

Pump Output Flow (in Gallons Per Minute)= RPM x Pump Displacement ÷ 231

RPM = 1500

Pump Displacement = 0.49 cubic inches

RPM x **Pump Displacement** ÷ **231**= 1500 x 0.49 ÷ 231 = 3.182= 3gpm

DESIGNED COMPONENTS

The main parts of the manipulator are three actuators, base and end effector. Design and basic information of these parts as follow.

Actuators

There are three actuators, from which two have to design and one can be directly purchase from market. The detailed information about actuatoris as follow.

Actuator 1

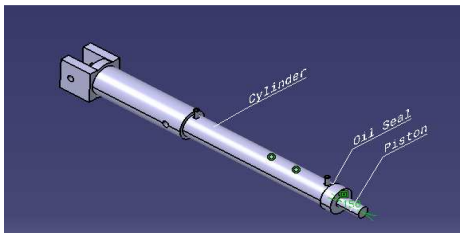

Figure 7: Actuator 1

Material

Cylinder tube:-Carbon Steel

Piston rod: - Carbon Steel

Piston: - Aluminum alloy

Stroke: - 0 to 600 mm

Bore size: - 100 mm

Piston Diameter: - 70 Mm

This is the main actuator, to which another actuator is attached at the rear end and end effector is attaches to piston tip of the actuator. This actuator is fixed at the middle area to the base, that's why it is behave as a laver, this will help to pick and place the components. There are two openings for the oil flow. There is oil seal to prevent the oil leakages. At the attachment bearing is used for frictionless movement.

Actuator 2

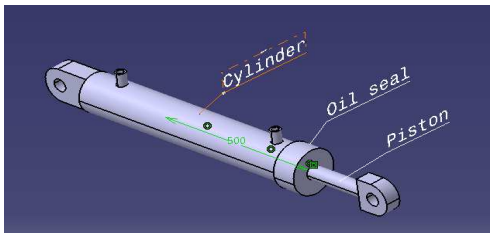

Figure 8: Actuator 2

Material

Cylinder tube:-Carbon Steel

Piston rod: - Carbon Steel

Piston: - Aluminum alloy

Stroke: -0 to 450mm

Bore size: -80 mm

Piston Diameter: -45 Mm

This is another actuator which attached at the rear end of the first actuator. This pulls the first actuator from rear side and because of the attachment of first actuator to the base the front side is moved upwards. So, because of this actuator pick and place of the component is done. There are two openings for the oil flow. There is oil seal to prevent the oil leakages. At the attachment bearing is used for frictionless movement.

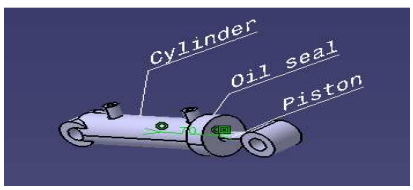

Figure 9: Actuator 3

Material

Cylinder tube:-Aluminum alloy

Piston rod:- Carbon Steel

Piston: - Aluminum alloy

Stroke: - 0 to 75 mm

Bore size: - 30 mm

Piston Diameter: -15 Mm

This is third actuator, which is attached to the end effector. Because of this actuator the end effector carry out its function. The actuator is attached to the two gripper holders with pins. There are two openings for the oil flow. There is oil seal to prevent the oil leakages.

Base

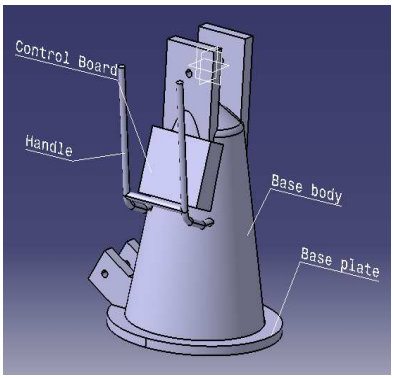

Figure 10: Base

Material: - CI

Parts: - Base plate, Handle, Base body,

Control board

Hollow

Manually movable

This is the base of the manipulator, to which other parts are attached i.e. two actuators. Also there are some other parts are available attached to base i.e. Control board, Handle, Base plate. This base is rotate manually with the help of handle. Also the controlling of the actuators is very close to the operator.

End Effector

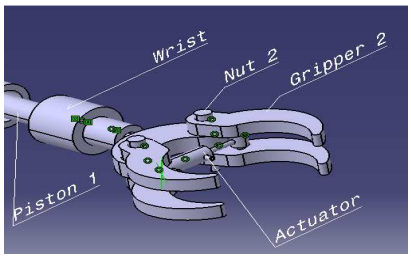

Figure 11: End Effector with Wrist

Material: - Aluminum alloy, Carbon steel

Parts: - Gripper, Actuator, Wrist, Nut

Pressure required: - 3.454 N/mm^2

This is the end effector, which can hold the component. The design of the gripper holder is by referring the component to be move. There is actuator which provides the desired motion. Also this end effector can be rotate at the wrist to gain desired orientation of the position of the component to be place.

By assembling these entire components, the manipulator is looks as shown in figure 12.

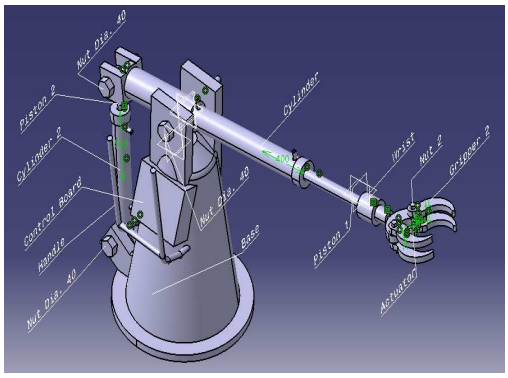

Figure 12: Assembly of Manipulator

Table 1: Bill of Material

Cr. No.	Component	Component Quantity	Cost
1)	Cylinder	3	40000
2)	Piston	3	15000
3)	Nut and bolt	3	5000
4)	Bearing	4	15000
5)	Base	1	10000
6)	Oil seals	4	20000
7)	Pipe nozzle	8	2000
8)	Pipes	8	10000
9)	Power pack	1	32000
10)	Base roller	6	3000

11)	Base plate	1	2000
12)	Handle	1	2000
13)	Flow Control valve	3	12000
14)	Pressure Control Valve	3	15000
15)	Board	1	1500
16)	Switch	1	1000
17)	End effector	1	20000
18)	Gripper	2	5000
19)	Other		10000

Total Cost = 2, 20, 500/-

The above cost of manipulator is optimum and it is affordable for the company. By referring the various companies and references we decide the costs.

CONCLUSIONS

- The conclusions from the above information are as follows,
- The hydraulic manipulator is required in the company at desired location.
- It is a semiautomatic manipulator and easy to operate.
- It is safe and cost effective solution for the problem facing the company. The cost of manipulator will nil within a year.
- The space requiredfor manipulator is less.

WORK TO BE DONE

- Proper selection of materials for parts
- Stress calculations on various points by Structural Analysis

REFERENCES

1. SebastienRubrecht, EktaSingla, Vincent Padois, Philippe Bidaud, Michel De Broissia “Evolutionary Design of a Robotic Manipulator for a Highly Constrained Environment” Springer, pp.109- 121, 24 Jul 2012
2. AlexandrKlimchik, Benoit Furet, Stéphane Caro, AnatolPashkevich, “Identification of the manipulator stiffness model parameters in industrial environment” Science Direct, Mechanism and Machine Theory 90 (2015) 1–22
3. M. Pellicciari, G. Berselli, F. Leali, A. Vergnano “A method for reducing the energy consumption of pick-and-place industrial robots” Science Direct, Mechatronics 23 (2013) 326–334
4. IsmaAkli, BrahimBouzouia, NouraAchour, “Motion analysis of a mobile manipulator executing pick-up tasks” Science Direct, Computers and Electrical Engineering 43 (2015) 257–269

5. Manfen Han, Yantao Song , Wenlong Zhao, Yong Cheng, Ji Xiang “Simulation and Optimization of Synchronization Control System for CFETR Water Hydraulic Manipulator Based on AMEsim” J Fusion Energ (2015) 34:566–570
6. Basic Hydraulics and components, Yuken Kogyo co., ltd.
7. Technical assistance for selecting the proper hydraulic fluid, 2004, interlube corporation.
8. Textbook, Industrial hydraulics, John Pippenger, Tyler Hicks.
9. Textbook, Oil Hydraulic Systems, Principles and maintenance, S. R. Majumdar.
10. Shilpa bhambure1, K.Jayarajan2, V.S.Narwane3, “Kinematic and Finite Element Analysis of a Master Slave Manipulator Gripper” jrdet (ISSN 2347-6435(Online) Volume 2, Issue 2, February 2014)