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REVIEW ON DESIGN AND FABRICATION OF PNEUMATIC GRIPPER FOR MATERIAL HANDLING

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ABSTRACT

This paper deals with design and fabrication of end effectors of robot to perform pick and place activity. For material handling in industries robot with special purpose end effectors plays a great role to reduce cycle time and cost of production. The design of gripper is propelled by the requirement for grasping of sheet metal parts in stamping and fording industry. The design has focused on provincial general purpose gripper having kinematic and dexterousness similar to human hand (humanoid). The pneumatic grippers are easy to handle easy to maintain and cost effective. Kinematic analysis of gripper is made to support this novice design using ansys software. The gripper is successfully designed, manufactured and tested for different loads and shapes.

Keywords: ***Anasys, Automation, End-effectors, Flexibility, Pro-E, Pneumatic Gripper, Robot.***

I. INTRODUCTION

Now-a-days for automation for material handling, industries are using robotic arms which are highly efficient and increases productivity. There are different types of gripper mechanisms found in industries like mechanical gripper, electromagnetic, hydraulic and pneumatic gripper. Pneumatic grippers are gaining interest of designers for end effectors of robot because of their easy to handle and low maintenance. Grippers are the mechanical interface between robot and its environment. Without it robot cannot perform pick and place activity. Robotic gripper has the capability to grasp definite objects and then reposition it to desired place. The robotic gripper has two basic parts

1. Manipulators
2. End effectors

Manipulators are the working arm of the robot which helps to manipulate end effectors. Generally these are connected with replaceable end effectors so that flexibility of robot increases. End effectors are the devices which are connected to en of robotic arm. End effectors are so designed to act as wrist of a robot which will interact with material to be handled. System flexibility greatly depends upon these end effectors. Material used for these end effectors is light weight and can be reused in future. End effectors include

1. Sensors
2. Tools

3. Drills
4. Grippers
5. Magnets
6. Welding guns
7. Screw drivers

If robot has to perform pick and place activity end effectors must be a gripper. Grippers are the main functional end effectors.This paper concentrates on material handling in stamping and forging industry on mechanical press machine to reduce cycle time. In stamping and forging industry sheet metal parts are manufactured by punching, piercing, blanking, coining, embossing, bending, flanging. Here we are working on pneumatic grippers. The pneumatic grippers fit in our aspects of design as it is moderate in cost, easy to reproduce. The accessories required are less for pneumatic gripper.

II. LITERATURE REVIEW

A article presented on the approaches taken to integrate a novel anthropomorphic robot into a humanoid robot by G. BRETTHAER, D. OSSWALD, MARTIN, C. BURQHART, R. MIKUT, H. WORN [1]. Which enables a robot hand to be used in and environment built for human are presented. Starting from a design that look like the human hand regarding size and moving ability. A mechatronical low level control system is provided with reliable and stable controllers for joint angles and torques. A high level system is connected with a low level system to coordinate fingers of humanoid robot are presented. CHIARA LAMNI and MACRO CECCAVELLI has analyzed the mechanisms in two-finger gripper to create an optimum design procedure [2]. The design has optimized by using fundamental characteristics of grasping mechanisms. Originally a multi objective optimum algorithm was used by considering four different functions. Those objective functions include encumbrance of grasping mechanism, acceleration and velocity of gripper. This new algorithm achieves a kinematically optimized design of gripper mechanism.

III. WORKING PRINCIPLE

The pneumatic gripper can be connected with multiple fingers as load increases and size of sheets increases. As like mechanical grippers, fingers cannot move independently in pneumatic gripper. The arrangement of suction pad cannot be changed while working so the arrangement made is suitable to grip part precisely. The pneumatic gripper perform a manual control to steer the gripper must be possible for enabling the highest flexibility. The fingers are used to actually make contact with the part to be grasped so that parts remain constant while movement of gripper. Fingers and suction pads are connected at a required angle so that flexibility of gripper increases. Carefully considerations are made while designing the gripper to reduce the size and gripping force to be needed.

IV. MATERIAL USED FOR FABRICATION

We have selected aluminium for material of gripper and plain carbon steel for nut and bolt. The main purpose behind choosing aluminium is to provide safety for die and punch. If accidently gripper caught between die and punch it should not damage die. Also aluminium is light in weight and have more machinability provides

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considerable strength and low cost. Plain carbon steel bolts have high strength and also further heat treated. Plain carbon steel bolts are typically not chrome plated so the result is dull black finish bolts. Plain carbon steel bolts are extremely strong but very brittle so workability is low.

V. BASIC DESIGN

To provide high flexibility to design of gripper for griping arbitrary size and shape of sheet we need to take in account various considerations. First of all, we are doing project in industry so the first consideration is to check the specification of robot provided. Also we need to take in consideration the plan of industry. We need to consider the dimensions of press machine. In our case robot used is KR120 R3900 ULTRA K (KR QUANTEC ULTRA)

5.1 Specification of robot:-

Payload	120 kg
Supplementary load on arm/ link arm/ rotating column	50 kg
Total distributed load	170 kg
Number of axes	6

Table 5.1.1 Specification of Robot

Also we need to consider raw material provided or sheets to be moved. The weight of sheet matters more. Here that will be the primary load and we need to take in account the operations to be performed on that sheet. Here raw sheet provided in press shop is of dimension 3 x 1025 x 1830. Generally we call it as blank.

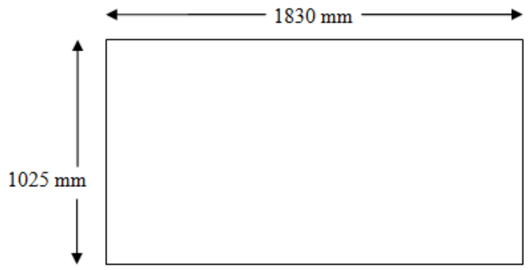

Fig. 5.1.1 Dimensions of blank

In press machine shop different type of die and punches are used of different dimension for different shape. To use same gripper for different shape we need to provide more flexibility in design. Considering the specification of robot we need to keep weight of robot below the supplementary load. From the net weight of gripper and parts and from the payload and supplementary load we can find factor of safety.

$$FOS = \frac{Failure\ Load}{Working\ Load}$$

VI. BASIC COMPONENTS OF GRIPPER

There will be main six components in gripper as

1. Swivel arm

2. Clamp
3. Suction pad attacher
4. Adapter clamp

6.1 Swivel Arm

The distance between die and punch is 2750.4 mm so from centre we have cross rod. From there we need to find out the distance up to the die. Die height changes according to different die used for different processes. Normally for bonnet we have height varying from 746 mm. so the distance remaining is 190 mm. we are using here standard size suction cups whose height is nearly about 150 mm. so the height will be remaining is 175 mm. From the fig 5.8 we get the dimension of 'X'. As the angle is always changing as per our requirement so we take it as 60^0 because it is highest angle that could be in bonnet operation.

COS 60 = 150/ X

X = 300 mm

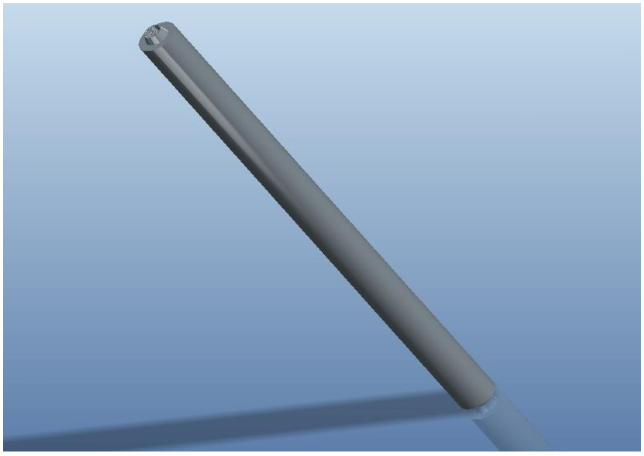

Fig 6.1.1 Swivel arm 3D model created in Pro-e.

6.2 Clamp

To join parts of gripper we need to attached clamps. In this case we cannot use ordinary type of clamps. So we design special type of clamps with one bolt at one side to provide more flexibility to design.

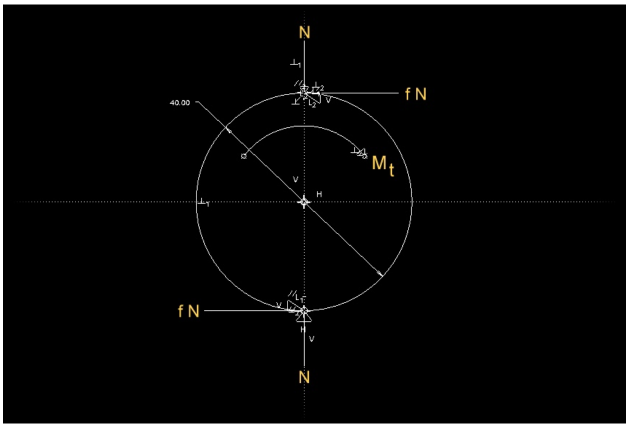

Fig. 6.2.1 Clamp

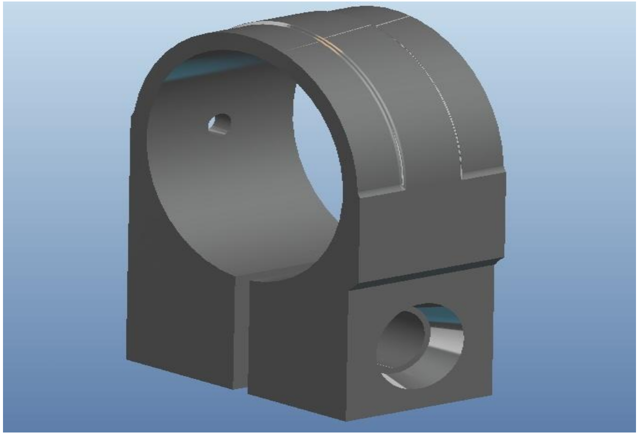

Fig. 6.2.2 Clamp 3D model created in Pro-e.

Checking safety of clamp

$\tau = \frac{310 \times 0.5}{2}$

$\tau = 77.5$ N/m^2

$77.5 = \frac{16\ Mt}{\pi d^3}$

$Mt = \frac{973.8937226}{6}$

Mt = 162.3156 N - m

Original torque acting on clamp is,

Mt = F sin60 x 0.38

Mt = 25.75 x 9.81 x 0.38

Mt = 95.99 ≈ 96

The torque acting originally is less than theoretical so the design is safe.

Dimensions of sleeve:-

D = Diameter of sleeve

d = Diameter of shaft

d_1 = Diameter of clamping bolt

D = 1.45 d

D = 1.45 x 40

D = 58 mm.

6.3 Suction Pad Attacher

We need to attach suction pad to clamp at different angles to grip arbitrary shaped objects. So we must add an extra part in gripper design to connect these suction pads. From Standard suction pad provided in market and from adapter clamp we get dimensions for suction pad attacher. Also we need to provide slot for mounting elements on suction pad attacher. We need to attach nut and bolt to restrict the movement of suction pad horizontally under dynamic loading. Dynamic load will apply on suction pad when gripper performs pick and place activity.

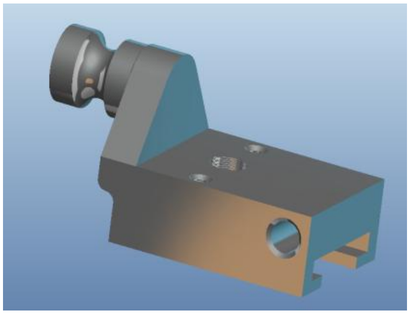

Fig. 6.3.1 Suction pad attacher 3D Model created in Pro-e.

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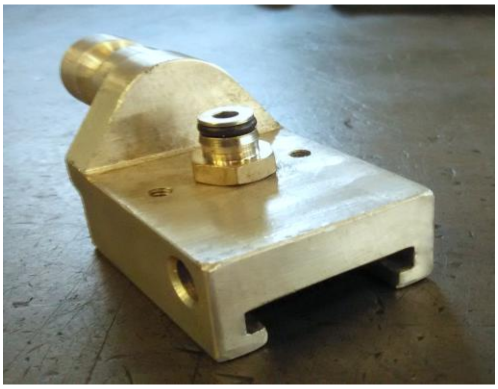

Fig.6.3.2 Manufactured suction pad attacher with mounting elements.

VII. STANDARD COMPONENTS OF GRIPPER

Here we have used vacuum system elements standard from market. Vacuum system consists of components as

1. Suction pad
2. Mounting elements
3. Vacuum generator
4. Valves
5. Switches
6. Filters and connectors

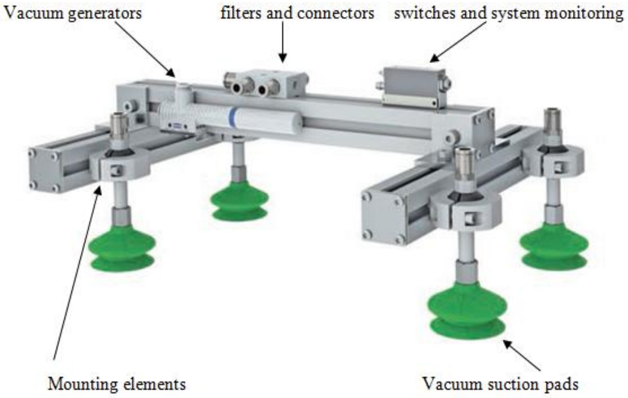

Fig. 7.1 Standard Components For Vacuum System.

7.1 Suction pads

There are two types of suction pads

1. Flat suction pads
2. Below suction pads

1. Flat suction pad:- These type s of suction pads are appropriate for handling flat or slightly curved object or material. They have lower inner volume and because of their flat shape they can be abandon quickly, therefore they can grip the work piece in short time. Which results in reducing time of handling.

2. Bellow suction pads:- These type of suction pads are used when arbitrary shape of material to be handled. The bellows are making these suction pads more flexible and adaptable.

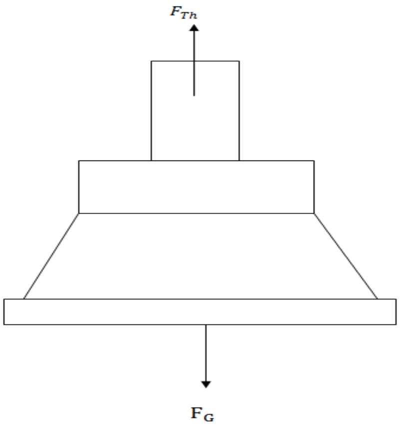

Fig. 7.1.1 Suction Pad

F = ΔP x A

F = Gripping force.

ΔP = Pressure difference.

A = Effective suction area.

Diameter of suction pads:-

$d_{(cm)}$ = 1.12 x $\sqrt{\frac{M \; x \; S}{P_U \; x \; n}}$

m = mass of work piece in Kg.

P_U = Vacuum in bar.

n = No. of suction pads.

μ = Friction coefficient.

s = Safety factor.

$d_{(cm)}$ = 1.12 x $\sqrt{\frac{14.75 \; x \; 2}{0.065 \; x \; 6}}$

$d_{(cm)}$ ≈ 10 cm.

The work piece is picked up from a pallet and move with a rotary motion at an acceleration of 5 M/J^2.

$F_{Th} = \frac{m}{\mu}$ x (g + a) x s

$F_{Th} = \frac{14.75}{0.15\mu}$ x (9.81 + 5) x 2

F_{Th} = 2912.633 N.

Calculation of the suction force F_s(N)

For individual suction pads

$F_s = \frac{F_{Th}}{n}$

$F_s = \frac{2912.6333}{6}$

F_s = 485.4388 N.

Calculation for evaluation time t (hr).

t = $\frac{V_G \; x \ln\left(\frac{P_a}{P_e}\right) x \; 1.3}{V}$

V_G = Volume to be evaluated [m^3]

P_a = Absolute start pressure.

P_e = Absolute final pressure.

V = suction rate of vacuum generator.

$V_G = V_1 + V_2 + V_3 + V_4 + V_5$.

V_1 = Volume of suction pads

V_2 = Volume of mounting elements.

V_3 = Volume of vacuum noses.

V_4 = Volume of distributer.

V_5 = Volume of air filter.

V_6 = Volume of solenoid valve.

V_G = 6 x 35 + 6 x 9.5 + 6 x 43 + 1 x 38.5 (Cm^3).

V_G = 564 Cm^3

V_G = 0.000564 M^3

$\frac{Absolute\ final\ pressure}{Absolute\ start\ pressure}$ = 60%

t = 0.35 sec.

VIII. ANALYSIS OF GRIPPER

For analysis of gripper we have used Anasys software. Steps performed

[1] Gripper 3D model designed in pro-e.

[2] Converted pro-e file into .stp file.

[3] Imported .stp files to Anasys workbench.

[4] Meshing is done with hexagonal type and element size is taken as 5mm.

[5] Medium meshing is performed on gripper model.

[6] Then simulation is done. In which static structural consideration is made.

[7] One end of swivel arm will be fixed support.

[8] Forces are applied on suction pad attacher to downward direction.

[9] Solution for total deformation and for stress intensity is found out.

8.1 Statistics

Bodies	4
Active Bodies	4
Nodes	90596
Elements	51001

Table no. 8.1.1 Nodes and Elements

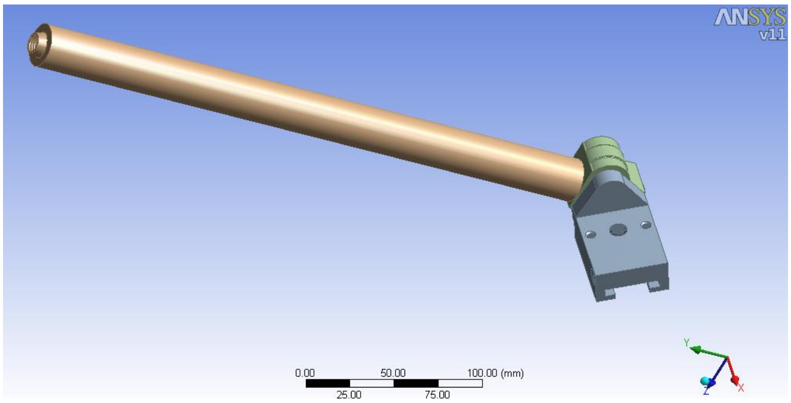

Fig.8.1.1 .stp file imported to anasys workbench.

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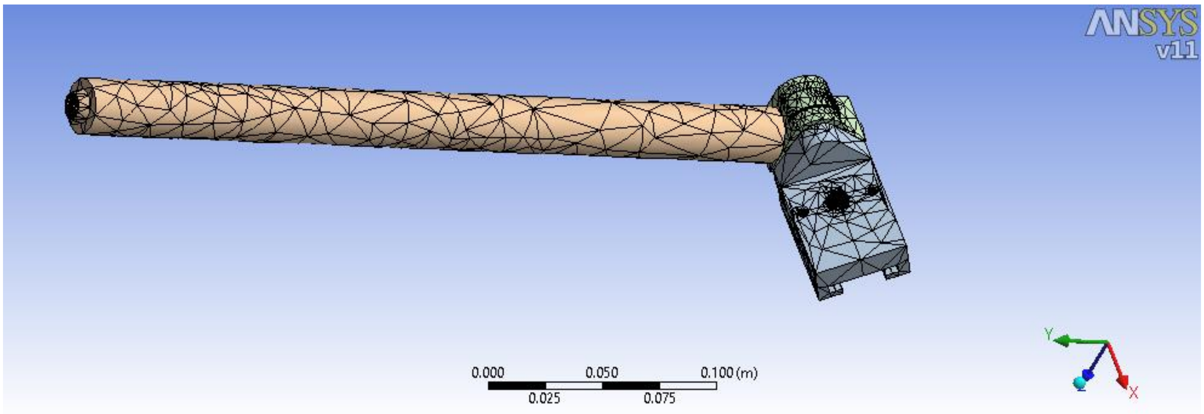

Fig 8.1.1 Meshing of imported model done in ansys.

8.2 Solution of analysis

Total deformation :-

Minimum	0. m	7898.2 Pa
Maximum	3.7932e-003 m	1.8313e+009 Pa
Minimum Occurs On	SWIVELARM	SUCTIONCUPATTACHER
Maximum Occurs On	SUCTIONCUPATTACHER	ARMBOLT

Table No. 8.2.1 Maximum and minimum deformation

Total stress intensity :-

Cycles	Alternating Stress Pa
1700.	2.758e+008
5000.	2.413e+008
34000	2.068e+008
1.4e+005	1.724e+008

Table No. 8.2.2 Stress induced in gripper per cycle.

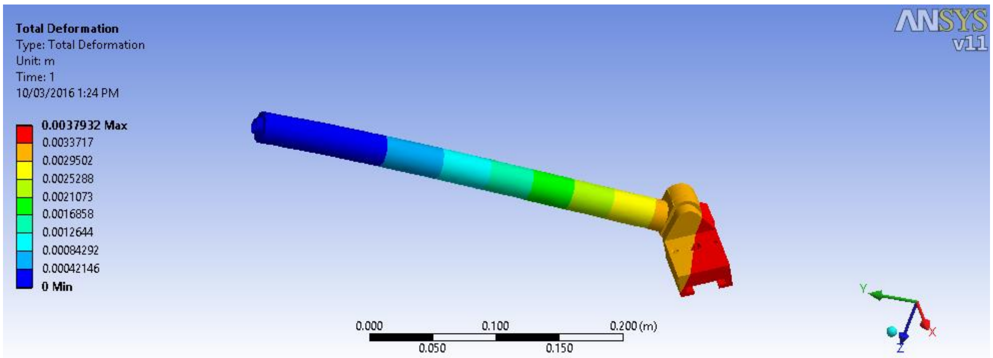

Fig. 8.2.1 Total deformation in model.

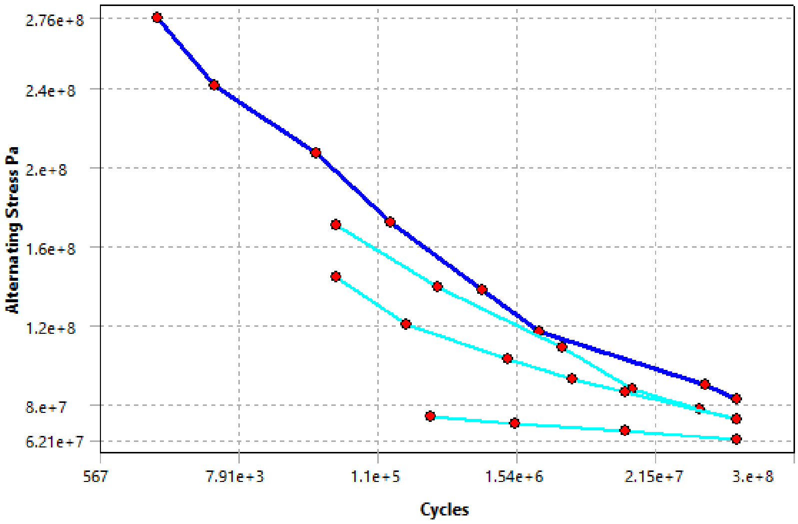

Fig. 8.2.2 Aluminium alloy material stress induced versus cycle graph.

IX. CONCLUSIONS

- The design of the gripper was indeed studied to identify the mechanisms that could be used, and which would be the most suitable.
- A material is selected by studying different materials thoroughly and then we selected aluminum (6061).
- Required changes were made according to the dynamic issues faced in the design.
- A basic design is made with 4 important parts i.e. swivel arm, clamp suction pad attacher, adapter clamp.
- Theoretical analysis is done by finding stresses developed in gripper parts.
- Analysis of parts is also done with ANASYS software.

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