Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 07, July-2016

Modelling and Simulation of Servo Feeder Mechanism for Punch Press

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Abstract: **In the present experimental work, an attempt has been made to model and simulate servo feeder mechanism for punch press. Common method of feeding stock material in press is by passing it through pair of feed rollers which apply friction to material and rotate in cooperative manner to feed stock in punch press. Synchronizing rotation of feed rollers to the speed of press, stock material is fed to punch press at proper rate. Rollers of Servo feeder adjust itself according to thickness of material to be passed through it. The micro-processor based control can be used to program move patterns and to perform self-diagnostics and auto correction. The modelling and simulation performed, successfully reduces scrap produced by servo feeder and production cost involved in the process.**

Keywords: Design, Analysis, Closed-loop system, Finite, Friction, Hydraulic.

I. INTRODUCTION

Servo feeder mechanism has many benefits in terms of saving material thereby saving cost as well as smooth non vibratory feeding mechanism which also can contribute to reduction of noise pollution up to some extent. One major aspect of this project is that it's an experimental project. Feeding mechanism coming along with punch press are still based on pneumatic or hydraulic principle. If the servo feeder which we are going to design can successfully reduce the scrap and thereby saving the material and cost, we can regain our investment (investment made for servo feeder) and can have the benefits further.

II. METHODOLOGY

2.1 Roller Type Servo feeder Components are as follows:

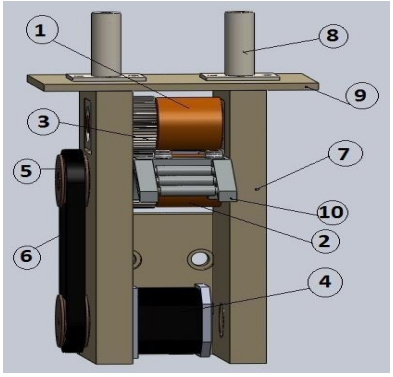

Fig 2.1 Roller type servo feeder components

1. Idle roller
2 Active roller
3. Spur gear
4. Servo motor
5. Pulley
6. Flat belt
7. Vertical frame
8. Hydraulic cylinder
9. Base plate
10. Guide tray and roller

2.1.1 Servo motor:

Servo motor is the main component of servo feeder which is connected to active roller through belt and pulley arrangement. Servo motor used consist of AC induction motor and it is connected to eco-controller. It receives signal from eco controller and produces Torque. Torque produced is then transmitted to belt drives which is connected to servo motor with the help of shaft.

2.1.2 Eco-Controller:

Eco-Controller is a programmable unit which takes inputs and control servo motor as well as gives signal to hydraulic cylinders. Inputs needed to be given to Eco-Controller are required RPM of motor and ideal time period between subsequent turns.

2.1.3 Rollers:

Rollers are used for clamping and feeding material to the punch press. One of the roller is active roller which is connected to belt and pulley arrangement and it rotates when torque is transmitted to it by belt and pulley arrangement. Another roller is passive roller which is connected to hydraulic cylinder and moves up and down with help of hydraulic cylinder. Rollers have maximum hardness and smooth surface finish to avoid damage to stock material.

2.1.4 Hydraulic Cylinder:

It causes up and down movement of active roller based on compression and expansion of piston in cylinder. Pump is used for pumping fluid at high pressure in case of hydraulic cylinder.

International Journal of Engineering Research & Technology (IJERT)
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Vol. 5 Issue 07, July-2016

2.1.5 Guide tray and roller:
It is used for proper gripping of stock material.

2.1.6 Drive Circuit:
It adapts input power according to requirement or rating of servomotor.

2.1.7 Flat belt:
Flat belt is used in servo feeder as they do not require precise alignment of shaft and pulleys. It can be used in dusty and abrasive atmosphere and is simple and inexpensive. As the belt has high efficiency it saves large amount of energy.

2.1.8 Pulley:
Two pulleys rotate in synchronized manner and enables flat belt mounted over it to rotate. Pulley enable flat belt to transmit power to passive roller.

2.1.9 Spur gears:
Spur gears have straight teeth parallel to the axes and thus are not subjected to axial thrust due to tooth load. They use no intermediate link or connector and transmit motion by direct contact.

2.1.10 Vertical frame and Base plate:
Vertical frame supports entire structure, this frame is made up of mild carbon steel. Base plate mainly supports vertical frame and is used for mounting hydraulic cylinders.

2.2 Servo feeder Mechanism:

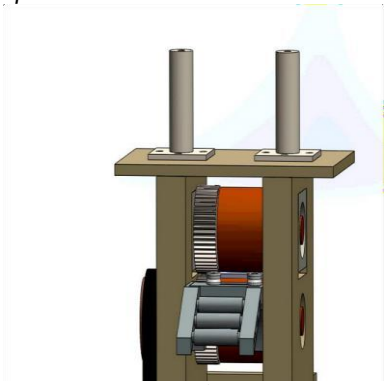


Fig 2.2 Servo feeder Mechanism

To begin with 230 v ac power is supplied to drive circuit of servo feeder. Drive circuit adapts power according to requirement and rating of servomotor. Eco-controller take inputs from drive circuit, besides RPM of servomotor and delay period is fed to eco-controller as it is a programmable unit. Servo motor which is connected to eco-controller receives signals from it and produces torque which is then transmitted to active roller with the help of belt and pulley arrangement. The active roller rotates when torque is transmitted to it by servo motor. The hydraulic cylinder moves up and down due to compression and expansion of piston in cylinder caused mainly due to pumping of fluid at high pressure. Besides hydraulic cylinder also receives signals from eco-controller. The passive rollers are connected to this cylinder which moves up and down with cylinder. Thus both active and passive rollers work in proper coordination to apply friction to stock material. Pair of rollers help in feeding stock material to the punching press. Servo feeder is attached to punching press, and both work in coordination so that stock material can be fed to punching press and punching at desired rate could be obtained.

III. ANALYSIS OF COMPONENTS:

3.1 Analysis of Belt:

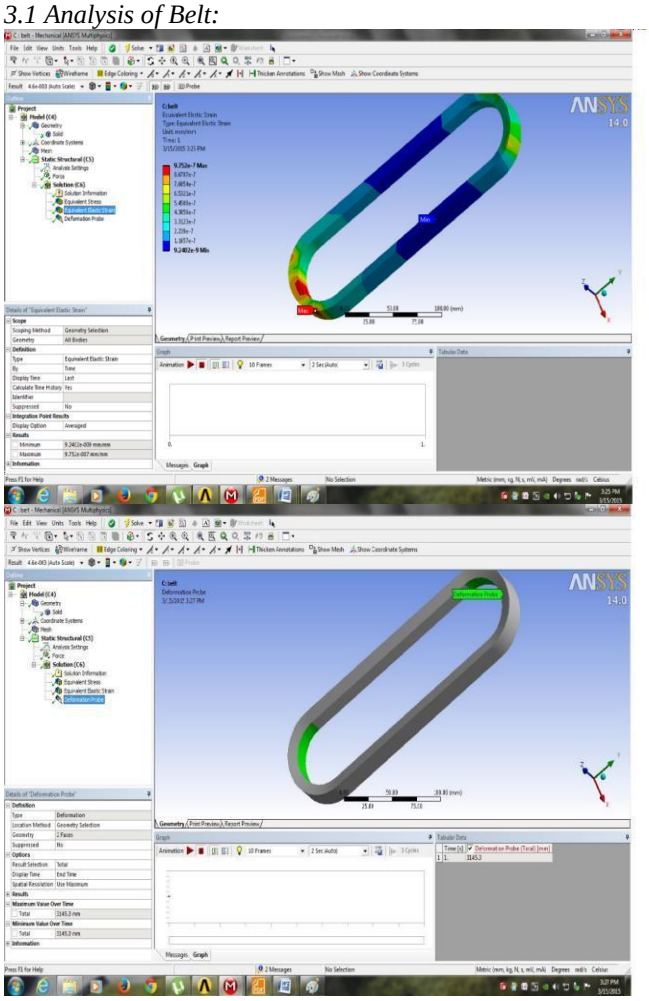
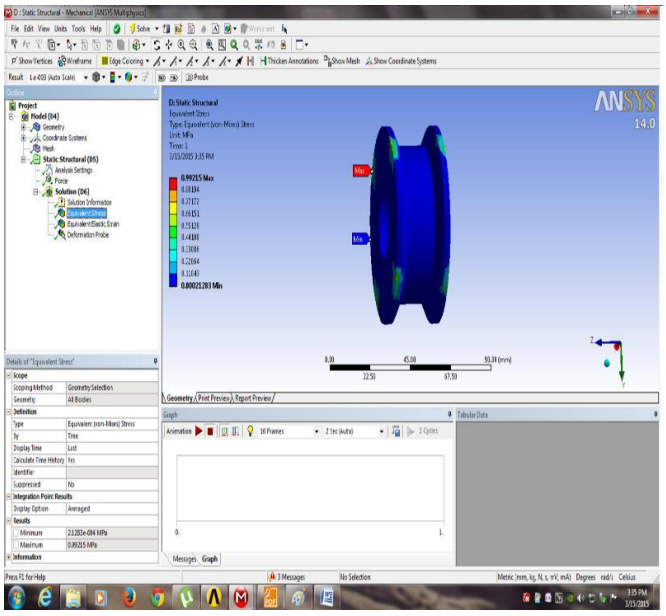


Fig 3.1 Analysis of Belt

3.2 Analysis of Pulley:



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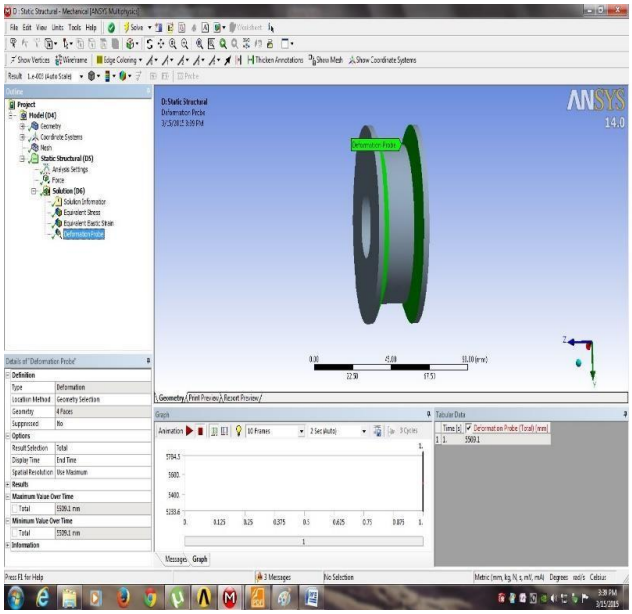


Fig 3.2 Analysis of pulley

3.3 *Analysis of Piston*

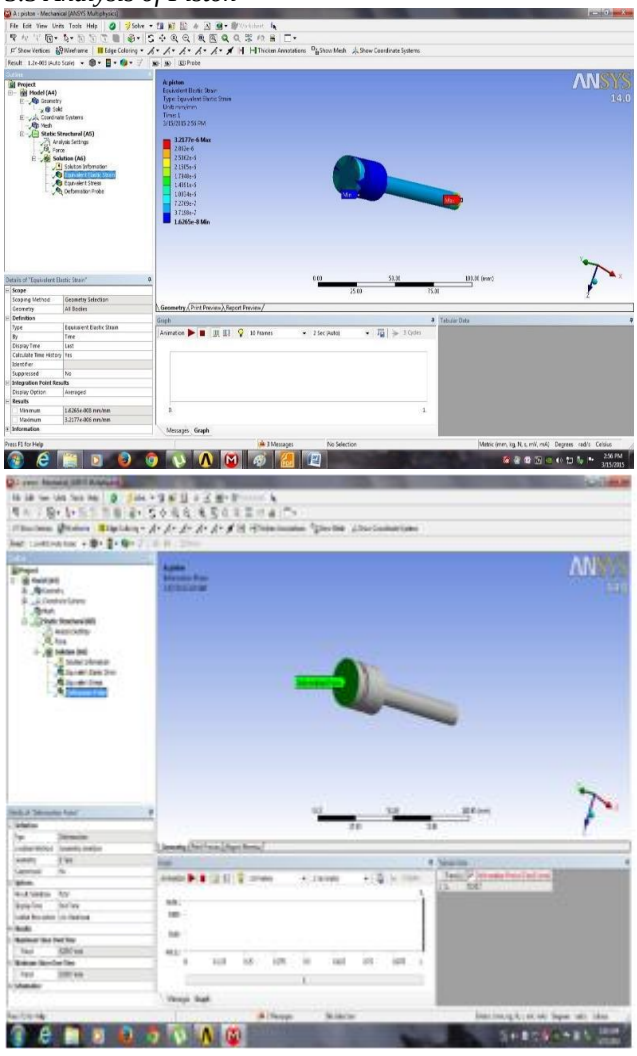
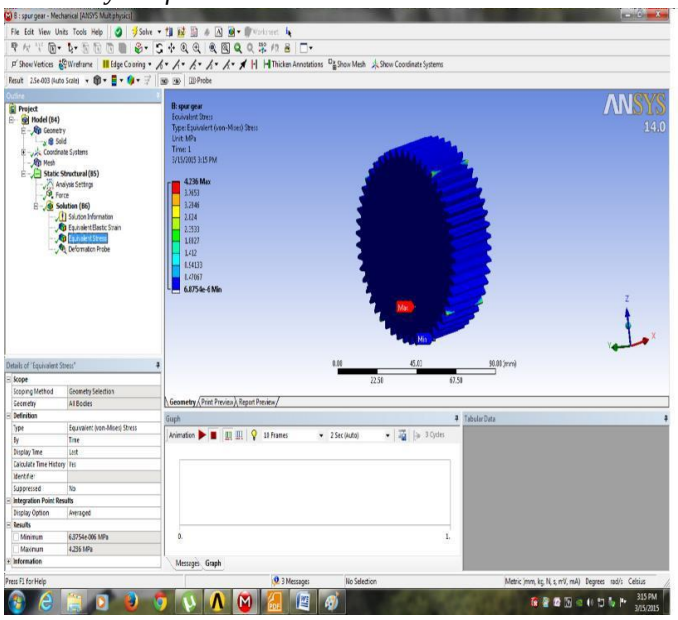


Fig 3.3 Analysis of Piston

3.4 Analysis of Gear



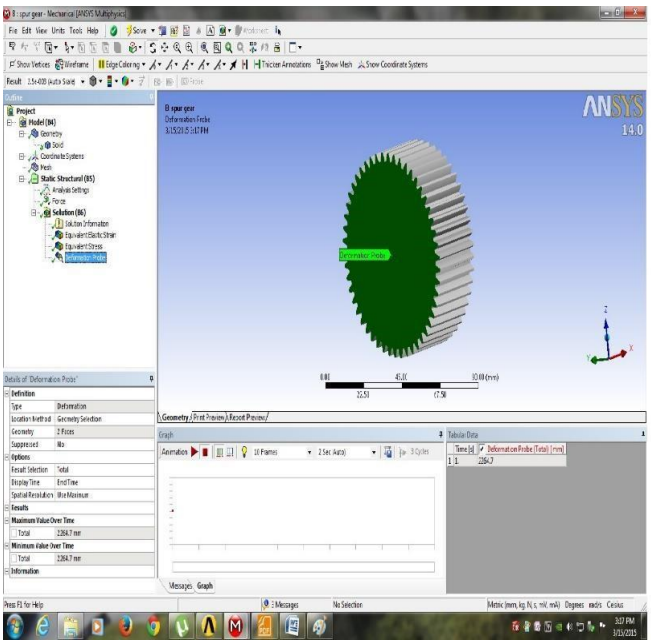


Fig 3.4 Analysis of Gear

IV. COST ESTIMATION:

component	Price (INR)
Servo motor	3500
Drive circuit	10500
Eco controller	8500
Other (frame, roller, manufacturing cost)	20000
Total	42500

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Whereas traditional pneumatic feeder cost up to 2 to 3 Lakh Rupees and need more maintenance.

V. CALCULATION OF WASTE REDUCTION:

As per observer (company person) initial wastage of strip due to traditional Pneumatic feeder= 6-8 mm.

As per our prediction, by eliminating all the possible errors and introducing programmable control, waste of the strip can be reduced to 1mm to 2mm.

Therefore, total saving of metal strip/stock material =6-2 = 4 mm.

VI. TOTAL COST SAVING:

New modelled and simulated servo feeder can reduce scrap by 5mm
Cost of metal strip = INR 15 per meter.

Production rate of pieces =120 per min.

So, total no of pieces produced= (120×20 hrs.)×60= 144000 pieces.

Waste reduced per piece = 5 mm

So, total amount of waste saved= 144000×5
=720000mm
=720 m
Amount of cost saved = 720×15 = INR 10800 per day.

VII. ANALYSIS RESULT OF COMPONENTS:

7.1 *Gear:*
i. Torque (kg-cm): 25
ii. Stress (MPa): Max 4.236
Min 6.8754e0.006
iii. Strain (mm/mm): Max 2.118e-5
Min 1.1834e-10
iv. Deformation (mm): 2264.7
7.2 *Belt:*
i. Torque (kg-cm): 25
ii. Stress (MPa): Max 0.18159
Min 0.0009403
iii. Strain (mm/mm): Max 9.752e-7
Min 9.2402e-9
iv. Deformation (mm): 3145.3
7.3 *Piston:*
i. Torque (kg-cm): 252
ii. Stress (MPa): Max 0.58756
Min 2.4808e0.003
iii. Strain (mm/mm): Max 3.2177e-006
Min 1.6265e008
iv. Deformation (mm): 5170.7
7.4 *Pulley:*
i. Torque (kg-cm): 25
ii. Stress (MPa): Max 0.99215
Min 0.00021283
iii. Strain (mm/mm): Max 9.752e-7
Min 9.2402e-9
iv. Deformation (mm): 3145.3

VIII. CONCLUSIONS:

By replacing pneumatic and hydraulic feeding mechanism by servo feeder we can vary the speed of the feed according to punch-press strokes. Making some slight changes in electrical servo motor by programming we can use it with any punch press if required. Material can be saved by using servo feeder mechanism. It will minimize the error and feed more accurate length of material to power press.

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