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Design and Construction of Automated Stamping Machine for Small Scale Industries

Mauton Gbededo[1 2] and Olayinka Awopetu[2]
1. Department of Mechatronics Engineering, Bells University of Technology, Ota, Ogun-State, Nigeria
2. Department of Mechanical Engineering, Federal University of Technology, Akure, Ondo-State, Nigeria

Abstract - **Packaging is one of the end process of every manufacturing industries as outputs are required to be stored, protected and shipped according to customers' requirements. Most small scale industries have outsourced the end process of manufacturing due to high cost of using automated means of stamping cartons, papers and nylons. Small scale industries have been accustomed to manual methods of stamping with low machine efficiency, longer delivery time, high labour costs in a quest to meet customers' requirements. This current trend of stamping problems has made the small scale enterprises to lose large number of market share to the large scale manufacturing outfits. The need to make stamping process affordable, using easy to maintain machines and also complying to rood regulatory bodies necessitated the need for this work. An Automated Stamping Machine driven by pneumatic systems that consists of air compressor, directional control valves, air service unit was designed, fabricated, tested and operated. The FluidSim software made by Festo didactic using the cascade method was adopted in the design and stimulation of the pneumatic circuit. The selection of materials as well as methods in relation to engineering properties and design parameters such safety factor, force of rotation, stress analysis, bending moments and speed of travels were derived during the fabrication processes. Before starting the stamping operation, the pre packed product is positioned at the beginning of the belt travel and the belt guide prevents the packed job from moving out of its travel due to any external constraints.**

The job to be imprinted was loaded in the stock hold plate on the cylinder A. The compressor and the start button of the electric motor were switched on. The motor drives the roller over which runs the conveyor belt that carries the job. The compressed air flows into the system from a compressor. The compressed air entered the system and passes through the Filter-Regulator – Lubricator unit. The FRL unit prepares the compressed air for utilization by the pneumatic components. Once exiting the FRL unit is started and the compressed air led into the manifold or the air distributor, immediately the manifold takes in the compressed air and splits it into the required number depending on the number of components used and the compressed air is sent to the components from the manifold. The compressed air flows to the direction control valve that controls the cylinders. The stamping machine utilizes two pneumatic cylinders to carry out the stamping and ejection of the prepackaged items. The two cylinders are configured to operate in a controlled sequential manner in order to execute the required operations.

Keywords: Small Scale Industries, Automated Stamping machine, Packaging, Pneumatic Circuit, Manufacturing industries, Filter-Regulator-Lubricator unit.

INTRODUCTION

Packaging is one of the most important production processes. It is a value adding activity which the manufacturer often uses to effectively project its brands. The stamping process is incorporated in packaging operation to identify and confirm to important data like product registration number, manufacturing date and expiration date that meets legal and statutory requirements of the food industries. The importance of packaging can therefore cannot be over emphasized. [1]

In the modern fast world of new and latest technologies, everyone goes for perfection and quickness. The present practice in food packaging industries is that, stamping is manually done by operatives and may require up to seven operatives per line if one need to achieve a higher output. This single action is time consuming, generate higher expenditure and also result to poor finishing by operatives during manual stamping process to meet production target. In order to achieve higher productivity and safe tremendous cost there is need for automatic stamping if small scale industries are to remain competitive while maximizing profit.

Automation has been defined as "the use of control systems such as pneumatics, hydraulics, electrical, electronics and computers to control industrial machinery and processes, reducing the use of human intervention. In small-scale and medium scale food packaging industries there are frequent need of stamping machine to imprint images or data on their cartons after packaging. [2]

By automating the machine, it could achieve a fully automated state where there is no worker interface till the inventory on the machine is exhausted hence a worker is removed from the machine cell and employed in a cell where a worker is needed. Here the manual system would have been replaced by pneumatics system as it is cheaper so that the overall cost of the automated machine is lowered and the machine is easily available for the small scale industries.

The ever increasing use of cartons for product identity in the food packaging industries cannot be over-emphasized. The small scale industries cannot afford to buy and maintain an imported automated stamping machines. At the same time, they cannot depend on the few industries that has stamping machines to achieve their production targets because of high transportation cost, cost of automation, labour cost, etc. Besides, the stamping machines in industries are operating at low capacity because of frequent breakdown as a result of lack of spare parts for worn-out parts, which are imported. These problems necessitated the need for this work with the aim of designing and fabricating a low cost automated stamping machine. By the application of pneumatics, the pneumatics cylinder with piston, which is operated by an air compressor, it is excepted that the automated stamping machine will give the successive action to quickly imprint images on material with ease, less bottleneck and human error.

The main objectives of this project is:

(a) to design and produce a low cost automated stamping machine as a modification to the existing coding machine and injet printers used in large-scale food packaging industries which are controlled by Programmable Logic Control and are quite expensive,
(b) to design and fabricate a machine with improved technical efficiency and technology simplicity than the existing stamping machines through the introduction of belt and rollers to increase the speed of the machine and also the incorporation of a pneumatics control systems to perform automatic stamping through an inserted rubber ink and;
(c) to build/manufacture a product that complies with food regulatory body in Nigeria.

MATERIAL AND METHOD

This section analyses the design description, design consideration and design analysis and method used for the construction of an automated stamping machine.

Design description

The working principle and description of the prototype automated stamping machine for this work is as follow.

Before starting the stamping operation, the pre-packed product is positioned at the beginning of the belt travel and the belt guide prevents the packed job from moving out of its travel due to any external constraints.

The job to be imprinted was loaded in the stock hold plate on the cylinder A. The compressor and the start button of the electric motor are switched on. The motor drives the roller over which runs the conveyor belt that carries the job. The compressed air flows into the system from a compressor. The compressed air entered the system and passes through the Filter-Regulator–Lubricator (FRL) unit . The FRL unit prepares the compressed air for utilization by the pneumatic components. Once exiting the FRL unit is started and the compressed air led into the manifold or the air distributor, immediately the manifold takes in the compressed air and splits it into the required number depending on the number of components used and the compressed air is sent to the components from the manifold. The compressed air flows to the Direction Control Valve (DCV) that controls the cylinders. The stamping machine utilizes two pneumatic cylinders to carry out the stamping and ejection of the prepackaged items. The two cylinders are configured to operate in a controlled sequential manner in order to execute the required operations.

Method

In order to execute the required operations, sequential motion circuits involving the use of more than one actuator can be designed using any of several available methods. These include the following:

i. Cascade method.
ii. Classic or intuitive method.
iii. Step counter method.
iv. Karnaugh Veitch method.
v. Combinatorial circuit design.

The cascade method has been selected for use in the design of this stamping machine. The cascade method was designed to overcome the problem of “opposed signals”, which often occur when sequential control circuits are designed using the intuitive approach. It is the simplest and most straightforward approach for these types of design problems. [3]

The following step by step procedure need to be followed when using the cascade method.

i. Each cylinder is represented by a letter such as A, B, C. the required movement sequence is then written with (+) representing the forward stroke of the actuators (cylinders), while (-) is used to represent the return stroke of the actuator.
ii. The given sequence is split into a minimum number of groups as follows:
   - The first group is split where the first change in stroke occurs.
   - Subsequent groups are formed such that no letter is repeated within any group.
   - The groups are given the identity group 1, group 2, group 3 etc.
iii. Each group is assigned a pressure manifold such that the number of groups equals the number of manifolds.
iv. Each pneumatic cylinder is provided with two limit switches to detect the full forward and full retracted positions of the actuator.
v. Each pneumatic cylinder is provided with a double piloted 4/2 way or 5/2-way valve for movement control.
vi. Reversing valves, also double piloted 4/2 or 5/2 way valves, are provided to distribute air supply among the different groups. The number of reversing valves is one less than the number of groups.

The valve connections are made as follows;

- The output of each limit switch is connected to the pilot input corresponding to the next sequence step.
- The limit switch responsible for the last step of the given group is connected to the pilot line of the reversing valve so as to switch supply to the subsequent group.
- The manifold line is then connected to the pilot line corresponding to the first step of the next group.

Following the above step by step procedure, we arrive at the following sequence of actions by the pneumatic cylinders; A+, A-, B+, B-. That is, we have two cylinders A and B. as the packet comes into the stamping machine, cylinder A, which carries out the stamping operation, advances to make contact with the package, thereby placing the required mark, for example batch number, on the package. After this, it retracts. Cylinder B, which serves as an ejector then advances to push

the package out of the stamping tunnel, before retracting to make way for the next package to come into the tunnel. Then sequence is then ready for repetition, and continues as long as there is supply of packages from the attached conveyor.
Breaking down these sequence into groups, we have;

- A+=group 1.
- A-, B+ as group 2.
- B- as group 3.

Thus we have three groups in total. The number of reversing valves is then 3-1=2. The complete pneumatic circuit diagram for this control operation is shown in figure 1. The circuit was simulated using the software Fluidsim version 4.2 from FESTO, and it successfully exhibited all expected behavior. [4]

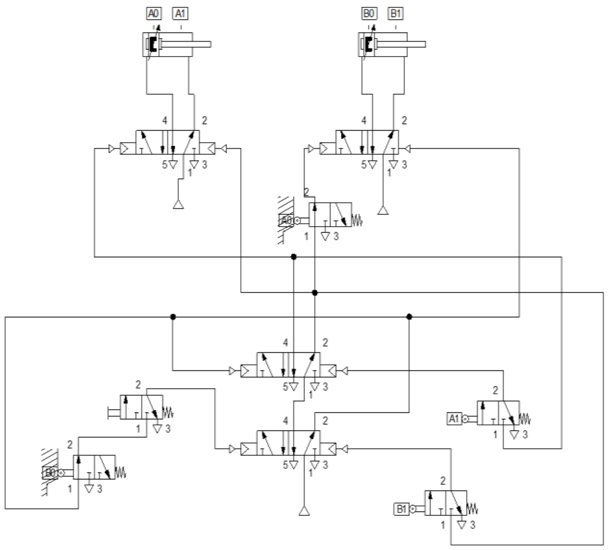

Fig. 3.1: Pneumatic circuit for sequential control of the motion; A+A-B+B-.

Design Consideration

The design of a machine requires the inter-related consideration of a number of factors, such as material and heat treatment, strength for power and loading requirements, pressure, volume, weight and space limitations etc. With the objectives of this project in mind, the design and fabrication of the machine is meant to ensure compliance to food and safety regulation and guarantee higher efficiency at a minimum cost. [5]

Therefore, the following design considerations were made:

i. The construction of the machine should be at minimum cost compatible with its efficiency.
ii. The labour requirement in operating the machine should be minimal
iii. There should simplicity in the design and fabrication
iv. The component parts should be easily replaceable in case of any damage or wear.

Design Assumptions

For the ease of design, the following assumptions were made:

i. An electric motor of 0.5 HP and 75rpm will be used.
ii. Maximum pressure of the cylinder will be 0.1MP
iii. Density of steel=7.86 x 10^3 kg/m^3Service factor of the belt=1.4
iv. The specifications mostly used were those of American Society of Mechanical Engineers (ASME) code.

Material Selection

Components' materials used in the cause of this work are selected based on the following factors:

a. Properties: The materials selected must possess the necessary properties for the proposed application. The various requirements to be satisfied can be weight, surface finish, rigidity, ability to withstand environment attack from chemicals, service life, reliability etc. The following four types of principle properties of materials decisively affect their selection.

- Physics
- Mechanical
- From manufacturing point of view
- Chemical

The various physical properties concerned are melting point, thermal conductivity, specific heat, efficient of thermal expansion, specific conductivity magnetic purpose etc.

The various mechanical properties concerned are strength in tensile, comprehensive shear, bearing tensional and bucking load, fatigue resistance impact resistance, elastic limit, and modulus of elasticity, harness, wear resistance and sliding properties. [6]

The various properties concerned from the manufacturing point of view are.

- Cast ability
- Weld ability
- Bras ability
- Merchant ability,
- Surface properties,
- Shrinkage
- Deep drawing

b. Manufacturing Case: Sometime the demand for the lowest possible manufacturing cost or surface qualities obtainable by the applications of suitable substances may demand the use of special materials. [7]
c. Quality required: This generally affects the manufacturing process and ultimately the material. For example, it is never desirable to go for casing of a less number of components, which can be fabricated much more economically welding or hand forging the steel.
d. Availability of the Material: Some materials may be scarce or in short supply. It then becomes obligatory for the designer to use some other material, which though may not be perfect suitable for the designed.
e. Consideration: Sometimes high strength materials have to be selected because the forces involved are high while taking into accounts material limitations.
f. Cost: As in any other, in selection of material the cost of material plays an important part and should not be ignored. [8]

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Sometime factors like scrap utilization, appearance, and non-maintenance of the designed part are involved in the selection of proper material. The preferred food handling materials as recommended by Trading Standards agents worldwide, including National Agency for Food and Drug and Control (NAFDAC) are the non-corrosive types, such as tin plate and stainless steel.

Design Analysis of Automated Stamping Machine

a. Check for the safety of the designated frame: In order achieve appropriate result to confirm to safety requirements, the following design factors were made

Frame dimensions:

- Length of the frame (L)=1230mm
- Breath of the frame (B)=340mm
- Height of the frame (H)=420mm
- Weight of the rollers=12kg
- Weight of the cylinders=7.5kg
- Weight of other accessories=20kg
- Total weight on the bed=39.5kg
- The total weight can be assumed to be an Uniformly Directed Load DL loaded on a fixed beam
- Weight per unit length=39.5/1.23=32.11kg/m

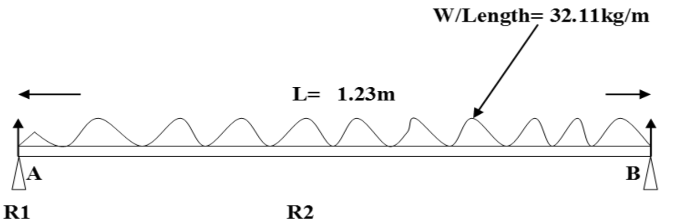

Figure 2: Determination of reactions at A and B

Calculations for the reactions at A and B

$\Sigma M = = -R\ L + wL\ \square\ L\ B\ AY \rightarrow R\ wL\ /\ 2\ A \therefore =$ (+ upwards)

Reaction at A=39.5/2=19.75N (1)

$+ \uparrow \Sigma F = 0 = R + R - wL = 0\ y\ Ay\ BY \rightarrow R\ wL\ /\ 2\ B \therefore =$ (+ upwards)

Reaction at B=39.5/2=19.75N (2)

Calculation of Bending moment diagram for the fixed beam

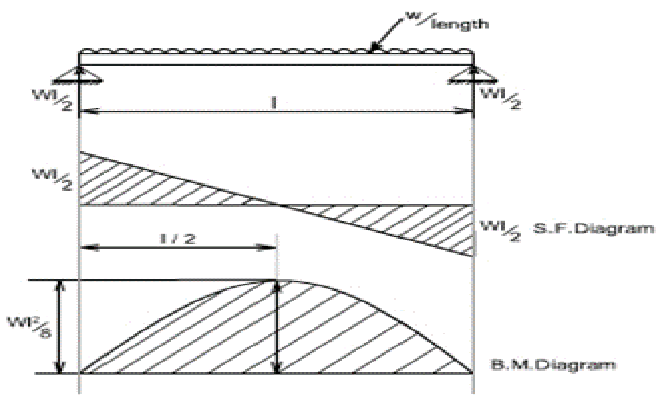

Figure 3: Bending moment diagram for Uniformly Distributed Load

(UCL)

M.max (-) =MA=-WL/12=39.5 x 1.23/12=4.04Nm (3)

M.min=WL/24 at x=L/2=39.5*1.23/24=2.02Nm (4)

The obtained bending moment at the centre and at the ends was within the permissible limits.

Hence the design was safe.

Design Analysis for Conveyor Belt

Formulae,

Length of belt=(2L) +(2 x π x R) (5)

where,

L= Center distance between the rollers
R= Radius of the rollers
Center distance between the rollers= 535mm
Diameter of the rollers= 50mm

Therefore,

Length = (2 x 535) + (2 x π x 25) = 1227.1mm (6)

The width of the belt was chosen according to the table size and the carton sample.

Width of the belt = 250mm.

Thus the length and width of the belt was calculated and order and purchased.

Design Analysis for electric Motor

The motor is the power source or provides the drive for the machine. The power of the motor can be determined as follow.

The motor, which is used to run the conveyor belt, only has to have a RPM of 60-100.

If the rpm is more, the job will vibrate.

Weight of the roller to be rotated =W= 12 kg

Let N be assumed as 75rpm
Rotation force, F of the roller =Mg
=12 x 9.81
= 117.72N (7)
Torque required =F x d

(where, d is the distance in meters)
= 117.72 x 0.535
= 62.9802Nm
Power required, P = (2 x π x T x N)/60
= (2 x 3.142 x 62.98 x75)/60

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$= 494.7w$

$1hp = 746\ w$

Power required, $P = 0.66hp$ (8)

Since there is power loss in the belt drive a motor of higher power is used.

Selection of DCV for the Cylinder

Calculations for the pneumatic components are listed below

The DCV selection depends on the flow rate of the air that should be given to the cylinder.

The stroke length of the cylinder must be 100 mm.

The time for the stroke = 2 sec

From equation of motion, we know that

$$S = u \times t + \tfrac{1}{2} \times a \times t^2 \quad (9)$$

where, S-stroke length

a-acceleration of the cylinder

u-initial velocity=0m/s

Substituting the values of the s and t, we get the value of a as:

$$0.10 = 0 + 0.5 \times a \times 2 \times 2$$

Therefore,

$$a = 0.05 m/s^2 \quad (10)$$

By equation of motion, we know that

$$V = u + (a \times t) \quad (11)$$

where, v- the final velocity of the cylinder

u- the initial velocity of the cylinder

a - acceleration of the cylinder

t – time taken

Substituting the value of u, a and t, we get

$$v = 0 + 0.05 \times 2$$

Therefore,

$$v = 0.1 m/s \quad (12)$$

Discharge is given by the formula

$$Q = A \times V$$

where, Q-discharge

A – area over which flow occurs

V – final velocity

Substituting values for A and v, we get

$$Q = (\pi/4) \times (D^2) \times 0.1$$

$$= (3.142/4) \times (8^2) \times 0.1$$

$$= 1.2568 m^3/sec \quad (13)$$

Thus for the calculated value the DCV was ordered and purchased from Festo Nigeria limited.

RESULTS AND DISCUSSION

The following specifications of materials were sourced and purchased in the local spare parts market in Nigeria based on availability, property consideration, method, and design analysis.

Pneumatic Components

i. Double-ended, Double-acting Pneumatic cylinder

The technical includes;

- Drive generates a linear movement
- Maker: Festo
- Quantity: 2
- Mode of operation: Double-acting.
- Medium: compressed air
- Shape of piston: Round
- Shape of piston rod: Round
- Piston diameter: 45 mm
- Piston rod: 15mm
- Stroke length: 50-100mm
- Optimal pressure: Min. = 2bar; Max = 12bar
- Ambient temperature: 0– 80°c

ii. Direction Control Valve (DCV)

The technical data used for purchase includes;

- Maker: Mozy
- Quantity: 2

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- Medium: compressed air
- No of ports: 5
- No of positions: 2
- Direction of flow: Non-reversible
- Operating principle: Disc seat
- Operating pressure: min= 1.15 bar; max= 8 bar
- Temperature: 0-40°c

Electric Motor (Prime mover)

The technical data used for purchase includes;

- Maker: Oriental Motor
- Quantity: 1
- Maximum Output: 35W
- Frequency: 50/60 Hz
- Speed: 100 rpm
- Voltage: 250VDC
- Current: 12A

Conveyor Belt

The technical data used for purchase includes;

- Maker: Lakodhia Material: Leather
- Size: 1230 x 250 mm

Engineering Bill of Material

The dimension and cost of materials selected for the fabrication of the automated stamping machine are as follows;

Table 1: Purchased spare parts

S/N	Name	Specification	Quantity	Unit Cost (N)	Total Cost(N)
1	Double acting cylinder	Bore = 100mm Outside dia. = 105mm Length = 250mm	2	6000	12000
2	5/2 way Direction control Valve	Operating pressure: Min= 1.15 bar; Max= 8 bar Temperature: 0 -40°c Pitch circle diameter = 0.0525mm	2	4000	8000
3	3/2 way Double piloted valve	Operating pressure: Min= 1 bar; Max= 7 bar Temperature: 0-40°c Pitch circle diameter = 0.02mm	2	3000	6500
4	Electric motor	Max output: 25WFrequency: 50/60HZSize : 200 X 60mm, Frequency: 50/60Hz, RPM: 100 Volt: 200VDC	1	7500	7500
5	3/2 way roller operated spring returned valve	Operating pressure: Min= 1.15 bar; Max= 8 bar Temperature: 0-40°c Pitch circle diameter = 0.0525mm	5	2000	10000
6	Air compressor unit	Operating pressure: Min= 1.5 bar; Max=bar Temperature: 0-40°c, Colour = Red	1	12000	12000
7	Bolts and Nuts	M10/4.6 grade	15	50	750
	Sub Total	N56,750.00			

Table 2: Construction Materials

S/N	Material	Size of Piece	Quantity	Unit Cost (₦)	Total Cost (₦)
1	Stainless sheet	2000* 1 * 8007 mm^2	2 pieces	7000	14000
2	Iron Sheet	3 * 2000 mm^3	6 pieces	400	2400
	Electrode	Gauge 10	7 dozens	250	1750
4	Angle Iron	Length = 2000 mm	3 pieces	1000	3000
5	Iron rod	ϕ 30mm length =700mm	2 pieces	1000	2000
6	Trflon bars	3 * 2000mm^2	600	400	2400
7	Iron Pipe	Length = 2000mm	2 pieces	700	1400
8	Saw blade	4 to 24 tp	2	200	400
	Sub Total	N27,350.00			

Table 3: Machining Jobs

S/No	Material	Type of Job	Machine Used	Labour Cost/Hour (₦)
1	Stainless Sheet (Drum)	Welding and Cutting	Welding Machine and Cutting Machine	2000
2	Rollers	Turning &Boring	Lathe Machine & Drilling Machine	1000
3	Angle Iron (frame support)	Cutting, Drilling and Welding.	Hack Saw, Drilling Machine and Welding Machine	1200
4	Iron Rod (Shaft)	Cutting & Turning	Cutting Machine and Lathe Machine	1000
5	Iron Pipe (Bicycle frame)	Cutting & Welding	Hack Saw and Welding Machine	400
6	Stamping holder	Cutting & Welding	Hack Saw and Welding Machine	500
	Sub Total	N 6,100.00		

Tble 4: Non-Machining Jobs

S/N	Job	Labour Cost	Total Cost
1	Transportation	1,500	1500
2	Cutting	1,000	1,000
3	Filing	1,500	1,500
4	Machine Assembly	1,500	1,500
	Sub Tota1=	N 5,500.00	

Total Cost = 56,750 + 27,350 + 6,100 + 5,500 = N95,700

Conclusion

The automatic stamping machine was designed, fabricated and tested meeting the safety and regulatory requirement of food industries in accordance to National Agency for Food, and Drug and Administration and Control (NAFDAC) in Nigeria. The automated stamping machine was an effective means of imprinting coded data on a pre-packaged product. This design is less expensive, meets the requirement of hygienic food handling, and it is maintenance friendly, in that all the parts are replaceable when the need arises.

Users of this machine will find it interesting to operate. It can be operated by anyone who has the little energy required to drive the pedals.

I believe that the new improved automated machine can still be improved upon, especially in a more advanced future, but at this moment, I am satisfied with this user friendly machine.

Nonetheless, I will like to recommend that alternative means such as cams and levers should be used to actuate the cylinders instead of compressed air generated by electrically powered compressor in order to curtail the present problem of intermittent power supply in Nigeria since this machine is mostly designed for small scale food industries who may not afford paying higher electrical bills.

REFERENCES

[1] Joseph, E.S. (1989). *Mechanical Engineering Design* (Fifth edition). (Pp 333-345.) Library of Congress Cataloging in Publication Data, Singapore.
[2] Kalakarthi Achagam. (2005). PSG Design Book for Engineers (Second edition), pp.213-230, Cambridge University Press, New Delhi, Orileede, India.
[3] Art Systems, (2006): FluidSim 4, HANDBUSH, (Third Edition) Festo Didactic, GmbH & Co KG, Germany
[4] Pneumatic Catalogue. (2001). Festo Controls (P) Limited Controls Ltd (Third edition), Germany.
[5] S. Ilango, and V. Soundaranjan (2011): Introduction to Hydraulics and Pneumatics by PHI Learning Pvt. Ltd., India
[6] Khurmi and Gupta (2007) "Theory of Machine" Third Edition pp. 106-107, Eurasia Publishing house, New Delhi, DL 110055, India.
[7] Tyler G. Hicks. 2006. Handbook of Mechanical Engineering Calculations: Shafts, Flywheels, Pulleys, and Belts for Power Transmission (Second Edition). (McGraw-Hill Professional Engineering, New Delhi DL, India.
[8] V. B. Bhandari, (2006) "Design of machine Elements", Third Edition, Tata McGraw Hill Publishing Co. New Delhi., DL, India

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Finally, my sincere gratitude goes to my parents, Chief & Mrs. G. M Gbededo for their immeasurable contributions and support given to me throughout the duration of my course.

Figures

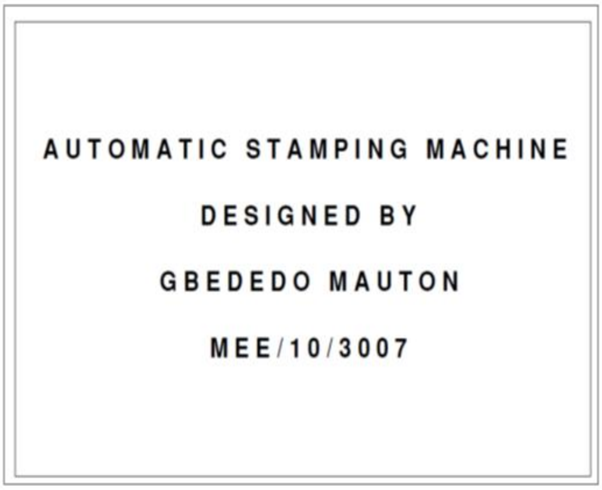

Figure 4: Title page of the Designed drawing for Automatic Stamping Machine

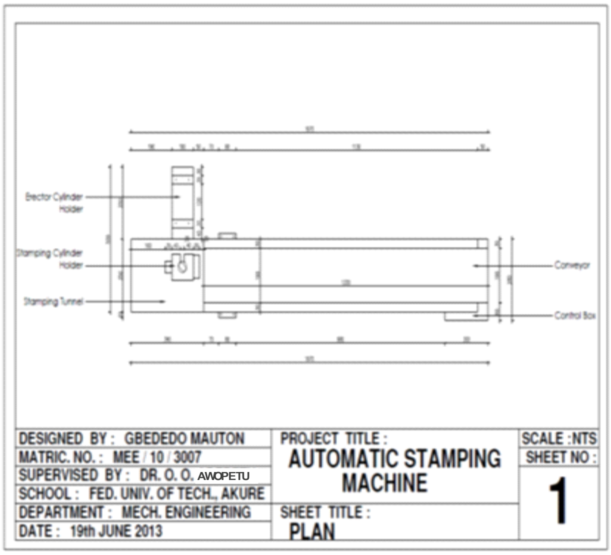

Figure 5: Plan View of the Designed drawing for Automatic Stamping Machine

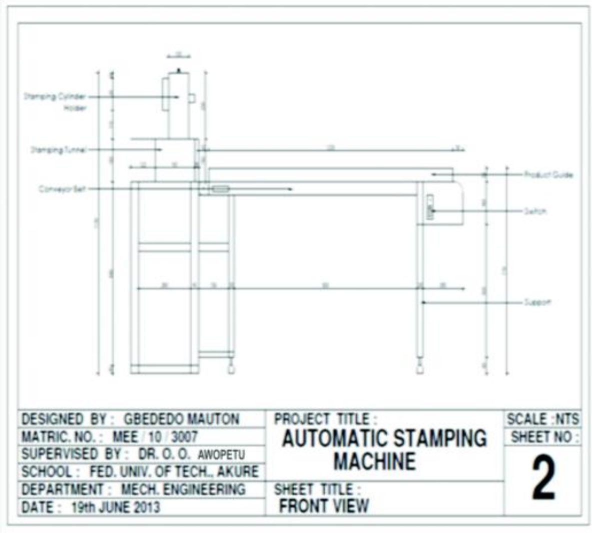

Figure 6: Front View of the Designed drawing for Automatic Stamping Machine

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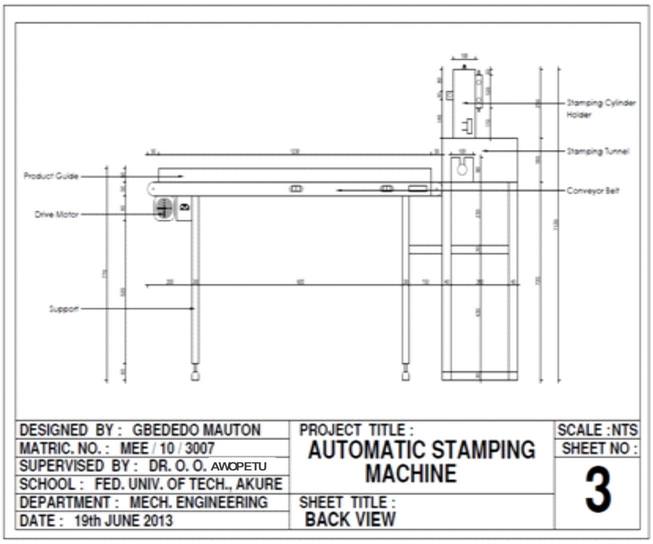

Figure 7: Back View of the Designed drawing for Automatic Stamping Machine

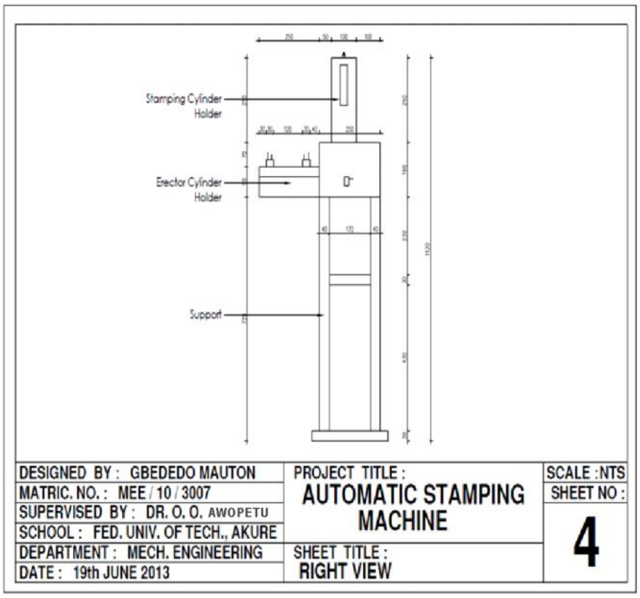

Figure 8: Right View of the Designed drawing for Automatic Stamping Machine

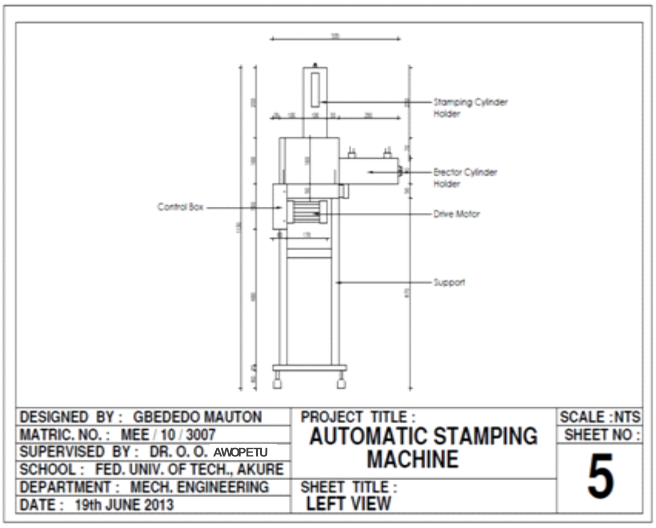

Figure 9: Left View of the Designed drawing for Automatic Stamping Machine

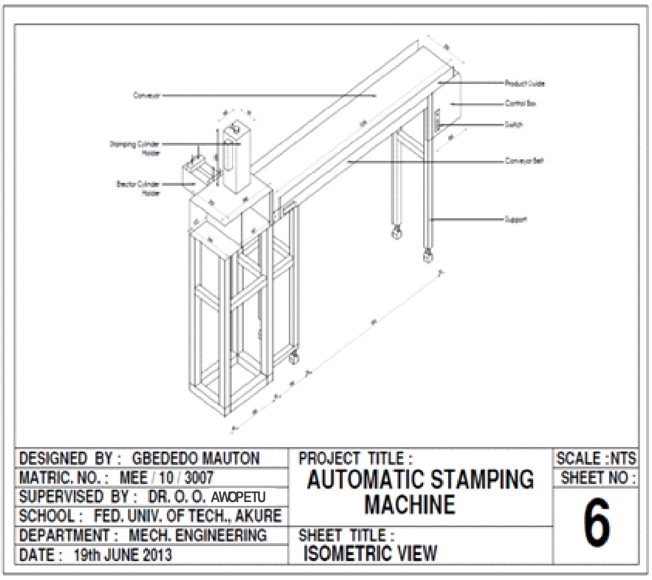

Figure 10: Isometric View of the Designed drawing for Automatic Stamping Machine