" "Automated Three Axis Machine for Manufacturing and Machining Process"" "

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Abstract

Over the years, it has been observed that numbers of operations are being done manually. Objective of given machine is to automate machining and manufacturing operation in industries. Automation is proper integration of components like PLC (Programmable Logic Control), microcontrollers, relays, motors, variety of sensors, drivers, host of switches, LED's etc. In industries continuous production can be done if all the processes are automated. The designed machine can be implemented for automation of various operations. Precision of the machine can be improved by using PLC and higher rated motors. Automation is the use of machines, control systems and information technologies to optimize productivity in the production of goods and delivery of services. Automation, the application of machines to tasks once performed by human beings or, increasingly, to task that would otherwise be impossible. Although the term mechanization is often used to refer to the simple replacement of human labour by machines, automation generally implies the integration of machines into a self-governing system. Automation has revolutionised those areas in which it has been introduced, and there is scarcely an aspect of modern life that has been unaffected by it. Automation technology, if used wisely and effectively, can yield substantial opportunities of the future. There is an opportunity to relive humans from repetitive, hazardous, and unpleasant labour in all forms and there is an opportunity for future automation technologies to provide a growing social and economic environment in which humans can enjoy a higher standard of living and a better way of life.

Index Terms: *Automation, Lead Screw, Linear Actuators, etc.*

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1. INTRODUCTION

Though the turn of the countries may still be a few years away, the world's leading manufacturers are already into advanced stages of using automated systems for manufacturing, assembly, material handling processes. Luckily, the times when we needed to explain why we need a Computer & Automation are history. Manufacturing industry witnessed not only a tremendous modernisation in technology but also adoption of Information Technology & Computer Science in massive scale.

Automobile companies face significant challenges to remain competitive in today's industry, including supplying innovative automobiles at the right price, controlling margins, enhancing brand image, building customer loyalty and expanding business horizons. To unleash the creativity of the component designers, Computer Aided Design Technology and Automation is being used more and more in mechanical sector (both in automatic and manual machines). Today, with the introduction of CAD, Automation and its many software capabilities, the possibilities are endless. The challenges can be faced by combining solutions such as CAD/CAM and 3D technologies with Internet tools to provide optimal solutions for meeting all requirements, from collection design to visual merchandising through production.

Computers have influenced every sphere of our life in one way or other. Computers are making human life easier and comfortable. Computers are helping to design, analyse and manufacture the product within a short span of time in engineering applications. Computer is an electronic machine that can perform mathematical and logical calculations and data process functions in accordance with a predetermined program of instructions. Computer is a tool to increase productivity in many aspects of our life. The various physical components are: Hardware and Software; where software consists of programs and instructions which are used to control the working of a computer.

Automation involves all the processes of conceptualizing, designing, analysing, prototyping and actual manufacturing with Computer's assistance. As Automation can be said as "A process without direct human activity in the process". The purpose of automation is usually to reduce and replace as much as possible labour intensive and dangerous assembly operations with automated ones. The productivity and quality can be improved. The aim is to have monotonous and similar in type operation or such causing fatigue, stress and production trauma, gradually replaced by automated assembly cycles, means and techniques. This usually- widely involves industrial robots and handlers. Higher productivity, lower cost and higher quality of assembled products are usually required here.

1.1.Main Objectives

1) Low labour cost.
2) Saves required time.
3) Improves productivity.
4) Skilled labour is not required.
5) High degree of accuracy is obtained.

2. LITERATURE SURVEY

The word automation was originally coined by an engineering manager of Ford Motor Company, D.S. Harder, in 1936 in order to describe the variety of feed device mechanism and automatic transfer devices. It described the increased use of automatic devices and controls in mechanized production lines. "Automation is a technique of automatically controlled operation of an apparatus, system or process by mechanical or electronic devices that takes place of human organs of observation, efforts and decision".

The term- Automation is used widely in a manufacturing context, but it can also be applied outside manufacturing with a variety of systems in which there is a significant substitution of mechanical, electrical, or computerized action for human effort and intelligence.

Automation technology has matured to a point where a number of other technologies have developed from it and have achieved a recognition and status of their own. Robotics is one of these technologies; it is a specialized branch of automation in which the automated machine possesses certain anthropomorphic, or human like characteristics. The most typical human like characteristic of a modern industrial robot is its powered mechanical arm. The robot's arm can be programmed to move through a sequence of motions to perform useful tasks, such as loading and unloading parts at a production machine or making a sequence of spot-welds on the sheet-metal parts of an automobile body during assembly. It can even be utilised for arc welding. As these examples suggest, industrial robots are typically used to replace human workers in factory operations.

The industry has been onshore/offshore drilling capabilities to minimize risk, create a more efficient, safe and environmentally complete business to keep up with the ever increasing global demand for energy. Drilling System Automation offers the opportunity to make a significant advancement in all these aspects. Safety - Remove humans from safety critical areas. Responsiveness - Speed of interpretations and actions beyond human capability. Consistency - Repetitive operations reduce spread/programmed response in place of human interpretation.

Worker safety is an important reason for automation in industrial operations. Automated systems often remove workers from the workplace, thus safeguarding them against the hazards of the factory environment. In the United States the Occupational Safety and Health Act of 1970 (OSHA) was enacted with the national objective of making worker safer and protecting the physical well-being of the worker. Occupational Safety and Health Act, OSHA has had the effect of promoting the use of automation and robotics in the factory. Another benefit of automation is the reduction in the number of hours worked on average per week by factory workers. About 1900 the average workweek was approximately 70 hours. This has gradually been reduced to a standard workweek in the United States of about 40 hours. Mechanization and automation have played a significant role in this reduction.

3.DESIGN OF MACHINE

3.1. Design Consideration

To prepare any machine part, the type of raw material and finished material should be properly selected, considering design, safety and following points.

The selection of material for manufacturing our project for engineering application is given by the following factors:

1) Availability of the materials.
2) Suitability of the material for the required components.
3) Suitability of the material for the desired working conditions
4) Costs of materials.

3.2. Machine and system design

Design consists of application of scientific principles, technical information and imagination for development of new or improvised machine or mechanism to perform a specific function with max economy and efficiency. Hence a careful design approach has to be adopted.

The total design work has been split up into two parts:

- System Design
- Mechanical Design

System design mainly concerns the various physical constraints and ergonomics, space requirements, arrangement of various components on main frame at system, man and machine interactions, number of controls, position of controls, working environment of machine, chances of failure, safety measures to be provided, servicing aids, ease of maintenance, scope of improvement, weight of machine from ground level, total weight of machine and a lot more.

In mechanical design the components are listed down and stored on the basis of their procurement, design in two categories namely,

i. Designed parts -

For designed parts detached design is done and distinctions thus obtained are compared to next highest dimensions which are readily available in market. This amplifies the assembly as well as postproduction servicing works. The various tolerances on the works are specified. The process charts are prepared and passed on to the manufacturing stage.

ii. Parts to be purchased -

The parts which are to be purchased directly are selected from various catalogues and specified so that anybody can purchase the same from the retail shop with given specifications.

3.2.1. System Design

In system design we mainly concentrate on the following parameters:-

i. System selection based on physical constraints: While selecting any machine it must be checked whether it is going to be used in a large-scale industry or a small-scale industry. In our case it is to be used by a small-scale industry. So space is a major constrain. The system is to be very compact so that it can be adjusted to corner of a room. The mechanical design has direct norms with the system design. Hence the foremost job is to control the physical parameters, so that the distinction obtained after mechanical design can be well fitted into that.

ii. Arrangement of various components: Keeping into the space restrictions the components should be laid such that their easy removal or servicing is possible. More over every component should be easily seem none should be hidden. Every possible space is utilized in component arrangements.

iii. Components of systems: As already stated the system should be compact enough so that it can be accommodated at a corner of a room. All the moving parts should be well closed and compact. A compact system design gives a high weighted structure which is desired.

iv. Man Machine interaction: The friendliness of a machine with the operator that is operating is an important criterion of design. It is application of anatomical and psychological principles to solve problems arising from Man-Machine relationship.

v. Chances of failure: The losses incurred by owner in care of any failure are important criteria of design. Factor safety while doing mechanical design is kept high so that there are less chances of failure. Moreover periodic maintenance is required to keep unit healthy.

vi. Servicing facility: The layout of components should be such that easy servicing is possible. Especially those components which require frequents servicing can be easily disassembled.

vii. Scope of future improvement: Arrangement should be provided to expand the scope of work in future. Such as to convert the machine motor operated; the system can be easily configured to required one. The die and punch can be changed if required for other shapes of notches etc.

viii. Height of machine from ground: For ease and comfort of operator the height of machine should be properly decided so that he may not get tired during operation. The machine should be slightly higher than the waist level, also enough clearance should be provided from the ground for cleaning purpose.

ix. Weight of machine: The total weight depends upon the selection of material components as well as the dimension of components. A higher weighted machine is difficult in transportation and in case of

major breakdown; it is difficult to take it to workshop because of more weight.

3.2.2. Machine design-

Column, lead screw and bearing is designed with respect to standard procedure.

i. Design of Column

Column is a supporting element in any structure. We have designed column for supporting the top frame and X-axis mechanism.

Input data:-

Length of the column = L

Internal diameter = d_i

Wall thickness = t

Outer Diameter (d_o) = d_i + (t X 2)

Now, $P = \frac{\pi^2 EI}{(Le)^2}$

where,

P = Buckling load

E = Modulus of Elasticity

= 165GPa (for G.I pipe)

I = Moment of inertia = $\frac{\pi}{64}(do^4 - di^4)$

L_e = Effective length

Conditions for effective length:

Table 3.1: End conditions for effective length

SR. NO.	CONDITION	EFFECTIVE LENGTH L_e
1.	Both ends are fixed	$\frac{L}{2}$
2.	Both ends are hinged	L
3.	One end is fixed and one end is hinged	$\frac{L}{\sqrt{2}}$
4.	One end is fixed and one is free	2L

As the both ends are fixed $L_e = \frac{L}{2}$

Where ,

L = Length of column

$L_e = \frac{L}{2}$

$P = \frac{\pi^2 EI}{(Le)^2}$

Estimated mass of assumed assembly = M, kg

I.e. M X 9.81 = W, N

Load on each column = $\frac{W}{4}$

ii. Design of lead screw

Lead screw is a machine element which is used to transmit motion. Lead screw converts the rotary motion of the motor to which it is coupled into linear motion of nut. We have designed lead screw for providing X, Y, Z-axis movement to the system i.e. prototype.

Table 3.2: Material Combination for Screw- Nut Pair

SCREW	NUT
Mild Steel	Cast Iron
Hardened Steel	Cast Iron
Mild Steel	Bronze
Hardened Steel	Bronze

For light duty Application we selected Mild Steel and Cast Iron Screw-nut pair.

For Mild Steel: σ_{all} = 448MPa

τ_{all} = 224MPa

Assuming Load = L, Kg

= L X g

= L_1, kN

For core diameter d_c :

$$dc = \sqrt{\frac{L1}{\frac{\pi}{4} X \frac{\sigma}{F.O.S}}}$$

Table 3.3: Standard table for lead screw diameter and pitch (Examples)

Nominal diameter (mm)	Core diameter (mm)	Pitch (mm)
24	19	5
26	21	5
28	23	5

Therefore from standard table,

Nominal Diameter = d, mm

Core diameter = d_c, mm

Pitch = p, mm

Mean diameter d_m = $\frac{d+dc}{2}$

l = no. of starts X pitch

Checking for safety of the lead screw:-

Torque T = $\frac{LXdm\ (l+\pi dm)}{2\ (\pi dm-l)}$

Now $\sigma = \frac{4L}{(\pi X\ dc^2)}$

And $\tau = \frac{16T}{(\pi X\ dc^3)}$

For above calculations: - $\sigma < \sigma_{all}$ & $\tau < \tau_{all}$

Then design is safe in tension and shear.

iii. Design of Ball Bearing

Bearing is a mechanical element which supports another moving machine element. It permits a relative motion between the contact surfaces of the members, while carrying the load. We have designed bearing to support X and Y-axis lead screws and to permit relative motion between them.

According to the lead screw design,

Core diameter of lead screw = d_c

Calculations for Bearing life -

$L_{10} = L_{h10} X \frac{60 X 10^3}{10^6}$ million revolutions

Generally, L_{h10} = 12000 to 20000 for machines used for 8hrs per day;

Therefore, L_{10} = 12000 X $\frac{60 X 10^3}{10^6}$ million revolutions

L_{10} = 720 million revolutions

Calculations for Load life relationship-

$L_{10} = \frac{C^a}{Pe^a}$

a = 3 for ball bearing

a = $\frac{10}{3}$ for roller bearing

Equivalent dynamic load = P_e

In this way bearing is designed.

4. CONSTRUCTION

4.1. Modelling of the Machine in CATIA

- Top frame consist of a metallic square frame with four short pipes welded at the four vertices. Wooden square sheet is bolted to the square frame. As this structure is used to provides foundation to mechanism to be mounted.

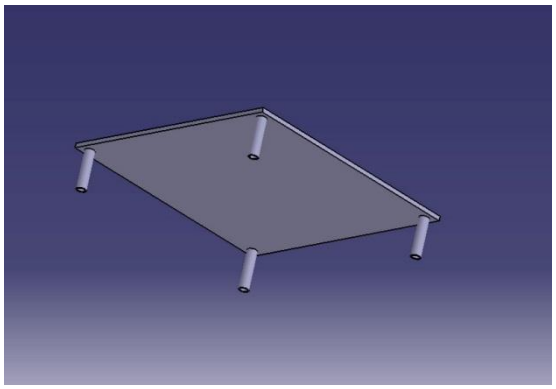

Fig. 4.1: Isometric view of top frame

- Base is made up of layers. At the bottom is the square frame same as the top followed by a square wooden plywood sheet. It is followed square acrylic sheets (provided to increase height of base) and another square plywood sheet.

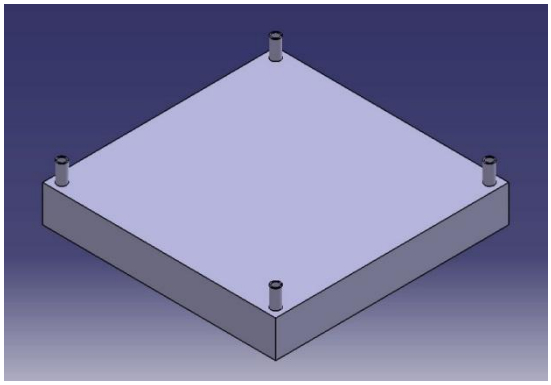

Fig. 4.2: Isometric view of base

- G.I hollow pipes are used to support the structure. These hollow pipes are inserted into base frame and top frame. So that proposed design becomes more rigid and stable.

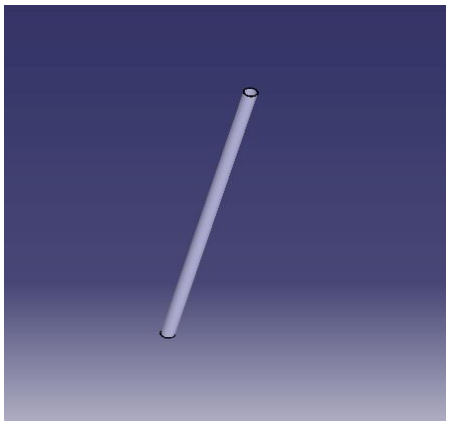

Fig. 4.3: Isometric view of rod

- After assembling given parts will get the given machine as design shown below. Where a lead screw with required load capacity should be designed. This linear actuator will satisfy the x-axis motion requirement. So that it will move whole mechanism mounted in frame along x-axis.

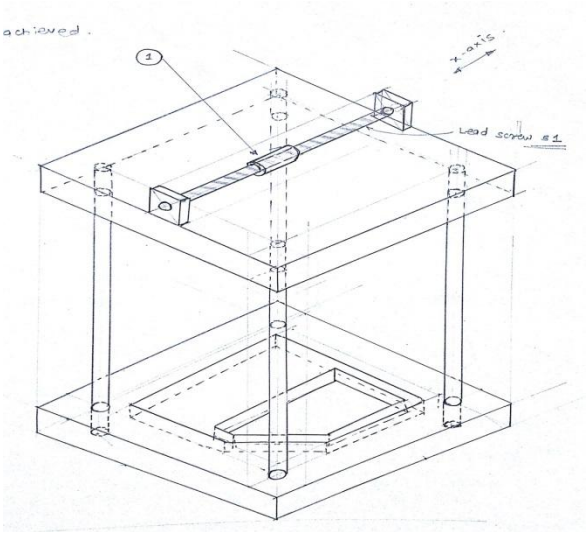

Fig. 4.4: Isometric view of machine assembly (satisfying x-axis motion requirement)

- The box frame is made of wooden plywood (rigid material such metal sheets etc. can be used) cut according to required dimensions. This frame is to be mounted between top and bottom frame structure.As discussed in earlier point.

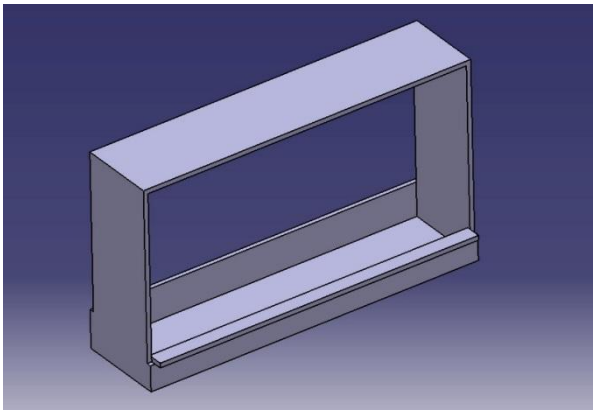

Fig. 4.5: Isometric view of Frame

- For the housing, any machine mechanism can be mounted as shown. The nut of lead screw and parallel bar are welded on a mild steel strip for providing linear motion to the operating tool of particular operation. Following adjustment is provided to use linear actuators effectively. This assembly is mounted vertically to satisfy z-axis motion requirement.

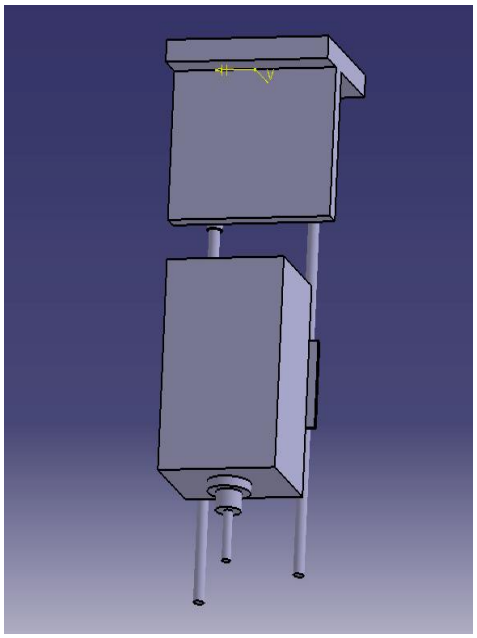

Fig. 4.6: Isometric view of Z-axis arrangement

By assembling above parts, the entire assembly can be depicted as below. The frame is mounted on lead screw provided on top frame (shown in fig.4.4). The assembly can do any operation effectively in three axes with help of linear actuators.

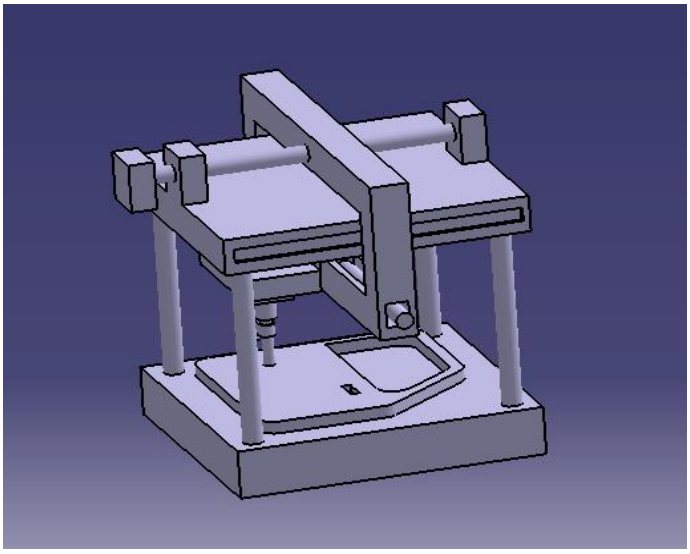

Fig. 4.7: Isometric view of assembly

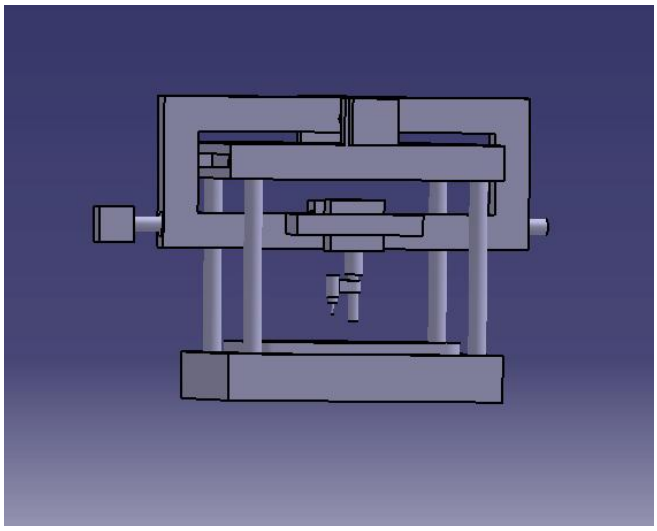

Fig. 4.8: Front view of assembly

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CONCLUSION

After assessing the given designed machine, following conclusions are made:

i. Minimal human efforts required to drill perform various operation as compared to manual operation.
ii. Labour Cost saved.
iii. Simple in operation.

iv. Overcomes the problem of employing many workers at a single station.

FUTURE SCOPE

There is always a scope for the modification and development of the machines, as no machine is 100% efficient. In the field of engineering, everyday new products and their modifications are introduced. It is not possible to include all the ideas into the project due to time constraint and limited funds. Following are points regarding the future scope, modification and development of the machine:

i. The designed machine can be improved in terms of precision for multiple operations.
ii. Instead of microcontroller, PLC could be used which enable input of random variables in the defined workspace.
iii. Higher torque providing servo motors could be incorporated which would increase speed and accuracy of operation.

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