FABRICATION OF FOLDING MECHANISM AND ITS AUTOMATION

A Project work submitted in partial fulfilment of the requirement for the award of the degree of

BACHELOR OF TECHNOLOGY
IN
MECHANICAL ENGINEERING

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ABSTRACT

The modern-day industries constantly try to increase their production rate by reducing the wastage of time, man power, decreasing the operation costs and by optimizing the work to get ahead of their competition in this era. So, they often look for methods to automate various processes in their production line. One such industry is the packaging industry where most of the work is manually done because of the intricate shapes of packaging and distinct requirements of several clients, but requires automation to boost its production rate.

In the present work, fabrication of folding mechanism and its automation is taken into consideration. To make our machine as simple as possible, we decided to make it primarily linkage based by using both the graphical and analytical methods for linkage synthesis and with the aid of design software such as AUTODESK INVENTOR. The automation of this process is done such that the machine will take less time for production.

The modelling, simulation, fabrication and automation of the model is done. The total cost spent to fabricate the machine at a cost of Rs. 6,220/-, which affordable for small scale industries. The machine is automated, which reduced the manufacturing time by 4 seconds. Although it is very little but when a lot of 1000 boxes manufactured, approximately 1hr time is saved in total production time, in which more 500 boxes can be manufactured.

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INTRODUCTION

CHAPTER I

INTRODUCTION

Increasing the efficiency in production is a constant challenge for manufacturing industries. The efficiency can be increased in a number of ways. One way of increasing the efficiency is by making changes in the packing section. In industries, the packing of finished products is done by trained individuals who perform the cutting and folding operations on paper or other material.

Conventional packing involves a lot of time and effort, which not only results in a decline in production, but also the loss of money in paying wages to the workers for the packing. Automation is one of the methods employed by industries these days to achieve high production rates at low cost and less time.

1.1 Pneumatic Systems

Fluid power is the technology that the generation, control and transmission of power, using pressurized fluids. Pneumatics is a branch of fluid power technology, which deal with the study and application of use of pressurized gas to affect mechanical motion. Pneumatics system are extensively used in industry, where factories are commonly plumbed with compressed air or other compressed inert gases. This is because a centrally-located and electrically- powered compressed that powers cylinders and other pneumatic devices through lever operated valves in often able to provide motive power in a cheaper, safer, more flexible, and more reliable way than a large number of electric motors and actuators. Pneumatic system in fixed installation such as factories use compressed air because a sustainable supply can be made by compressing atmospheric air. The air usually has moisture moved and a small quantity of oil added at the compressor, to avoid corrosion of mechanical components and to lubricate them.

A pneumatic system is a system that uses compressed air to transmit and control energy. Pneumatic systems are used in controlling train doors, automatic production lines, and mechanical clamps

1.2 Main pneumatic components

Pneumatic components can be divided into two categories:

i) Components that produce and transport compressed air.

ii) Components that consume compressed air.

All main pneumatic components can be represented by simple pneumatic symbols. Each symbol shows only the function of the component it represents, but not its structure. Pneumatic symbols can be combined to form pneumatic diagrams. A pneumatic diagram describes the relations between each pneumatic component, that is, the design of the system.

1.3 Production of compressed air

Examples of components that produce and transport compressed air include compressors and pressure regulating components.

1.3.1 Compressor

A compressor can compress air to the required pressures. It can convert the mechanical energy from motors and engines into the potential energy in compressed air. A single central compressor can supply various pneumatic components with compressed air, which is transported through pipes from the cylinder to the pneumatic components. Compressors can be divided into two classes: reciprocating and rotary

Fig 1.1 Air Compressor

1.3.2 Pressure regulating component

Pressure regulating components are formed by various components, each of which has its own pneumatic symbol:

i. Filter – can remove impurities from compressed air before it is fed to the pneumatic components.
ii. Pressure regulator – to stabilise the pressure and regulate the operation of pneumatic components.
iii. Lubricator – To provide lubrication for pneumatic components

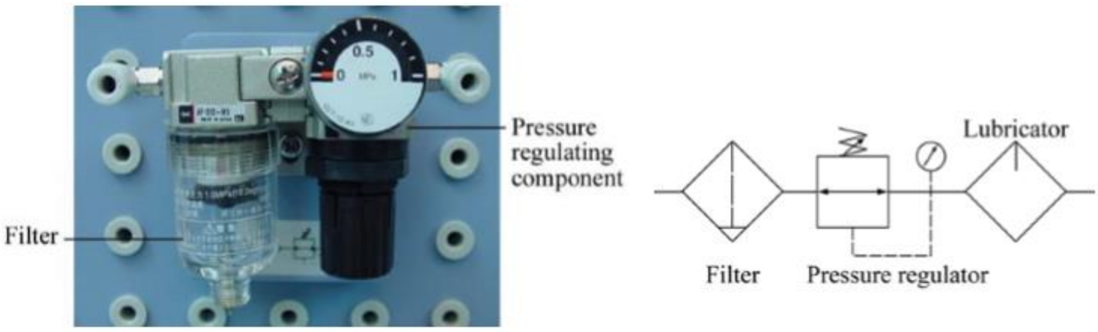


Fig 1.2 Pressure regulating component

1.4 The consumption of compressed air

Examples of components that consume compressed air include execution components (cylinders), directional control valves and assistant valves.

1.4.1 Execution component

Pneumatic execution components provide rectilinear or rotary movement. Examples of pneumatic execution components include cylinder pistons, pneumatic motors, etc. Rectilinear motion is produced by cylinder pistons, while pneumatic motors provide continuous rotations. There are many kinds of cylinders, such as single acting cylinders and double acting cylinders.

a) **Single acting cylinder:** A single acting cylinder has only one entrance that allows compressed air to flow through. Therefore, it can only produce thrust in one direction. The piston rod is propelled in the opposite direction by an internal spring, or by the external force provided by mechanical movement or weight of a load

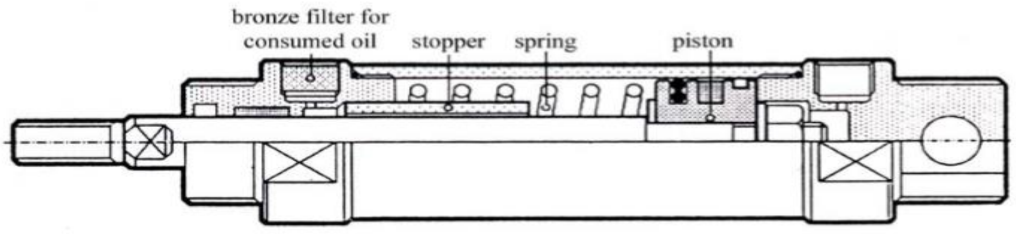


Fig 1.3 a) Cross section of single acting cylinder

Fig 1.3 b) Single acting cylinder

The thrust from the piston rod is greatly lowered because it has to overcome the force from the spring. Therefore, in order to provide the driving force for machines, the diameter of the cylinder should be increased. In order to match the length of the spring, the length of the cylinder should also be increased, thus limiting the length of the path. Single acting cylinders are used in stamping, printing, moving materials, etc.

b) **Double acting cylinder:** In a double acting cylinder, air pressure is applied alternately to the relative surface of the piston, producing a propelling force and a retracting force. As the effective area of the piston is small, the thrust produced during retraction is relatively weak. The impeccable tubes of double acting cylinders are usually made of steel. The working surfaces are also polished and coated with chromium to reduce friction.

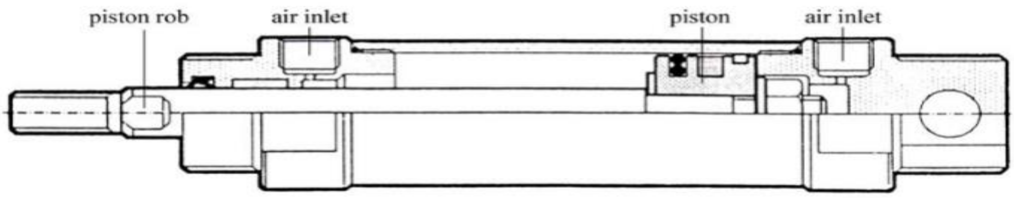


Fig 1.4 a) Cross section of a double acting cylinder

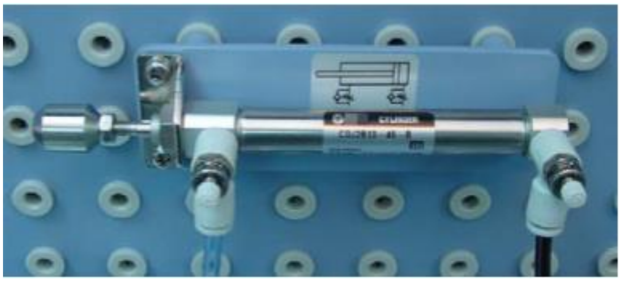


Fig 1.4 b) Double acting cylinder

c) **Spring return cylinder:** It is a cylinder in which a spring returns the piston assembly.

Fig 1.5 Spring return cylinder

d) **Ram cylinder:** It is a cylinder in which the movable element is the piston rod

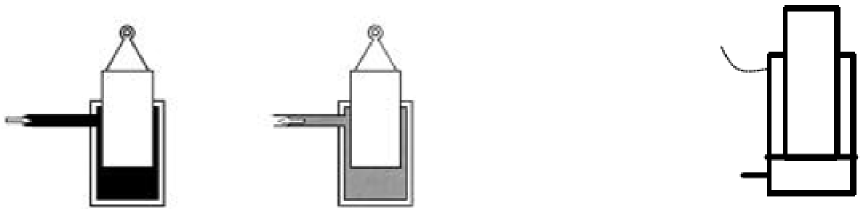


Fig 1.6 Ram cylinder

1.4.2 Design of single-acting cylinder with piston rod

A standard pneumatic cylinder consists of five modules/parts:

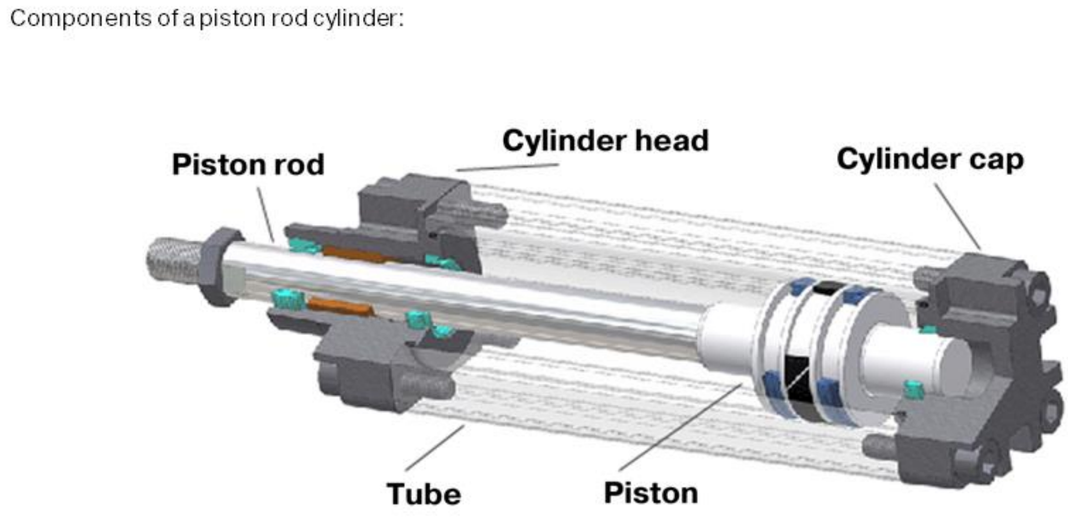


Fig 1.7 Pneumatic Cylinder

- Cylinder barrel
- Bearing cap
- End cap
- Piston
- Piston rod

1) **Cylinder barrels:** Originally, these really were "just" tubes. However, nowadays extruded profiles instead of a tube are used for most cylinders. The advantage is that a profile can also be used for additional functions.
2) **Piston rods:** The piston rod is the part which transmits the force and the movement of the cylinder to the outside. The tip of the piston rod generally has a thread so that other customer components can be attached to it.
3) **Pistons:** The piston, which is connected to the piston rod, carries out the actual movement in the cylinder. However, the piston needs to do more than just carry out a movement. It forms a seal between the front and rear cylinder chamber. In addition, the

piston has to convert the kinetic residual energy in the end position. The bearing and end caps also have their part to play.

4) **Bearing caps:** The bearing cap closes the cylinder (cylinder barrel) on one side and at the same time forms a bearing and sealing point for the piston rod. One of the air connections is generally located in the bearing cap.
5) **End caps:** The end cap closes the cylinder (cylinder barrel) on the other side. The second air connection is usually located in the end cap.

1.4.3 Directional control valve

Directional control valves ensure the flow of air between air ports by opening, closing and switching their internal connections. Their classification is determined by the number of ports, the number of switching positions, the normal position of the valve and its method of operation. Common types of directional control valves include 2/2, 3/2, 5/2, etc. The first number represents the number of ports; the second number represents the number of positions. A directional control valve that has two ports and five positions can be represented by the drawing in figure as well as its own unique pneumatic symbol.

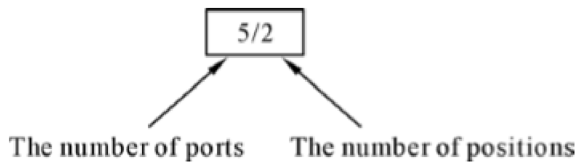
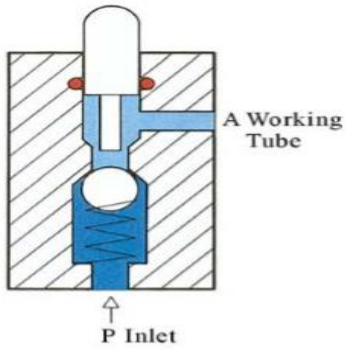


Fig 1.8 Describing a 5/2 directional control valve

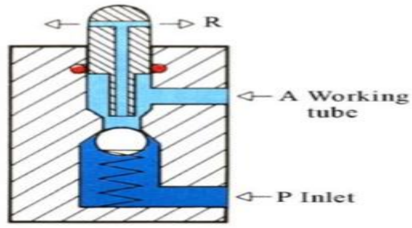
a) **2/2 Directional control valve:** The structure of a 2/2 directional control valve is very simple. It uses the thrust from the spring to open and close the valve, stopping compressed air from flowing towards working tube ‘A’ from air inlet ‘P’. When a force is applied to the control axis, the valve will be pushed open, connecting ‘P’ with ‘A’. The force applied to the control axis has to overcome both air pressure and the repulsive force of the spring. The control valve can be driven manually or mechanically, and restored to its original position by the spring.



a) 2/2 control valve b) Cross section c) Pneumatic symbol

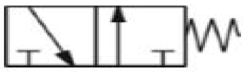
Fig 1.09 2/2 Direction Control Valve

b) **3/2 Directional control valve:** A 3/2 directional control valve can be used to control a single acting cylinder. The open valves in the middle will close until 'P' and 'A' are connected together. Then another valve will open the sealed base between 'A' and 'R' (exhaust). The valves can be driven manually, mechanically, electrically or pneumatically. 3/2 directional control valves can further be divided into two classes: Normally open type (N.O.) and normally closed type (N.C.)



a) 3/2 directional control valve b) Cross section

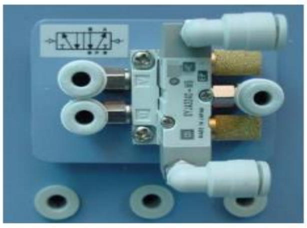
Fig 1.10 3/2 directional control valve

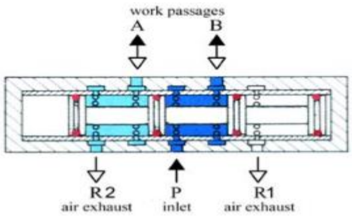


a) Normally closed type b) Normally open type

Fig 1.11 Pneumatic symbol of 3/2 directional control valve

b) **5/2 Directional control valve:** When a pressure pulse is input into the pressure control port 'P', the spool will move to the left, connecting inlet 'P' and work passage 'B'. Work passage 'A' will then make a release of air through 'R1' and 'R2'. The directional valves will remain in this operational position until signals of the contrary are received. Therefore, this type of directional control valves is said to have the function of 'memory'.





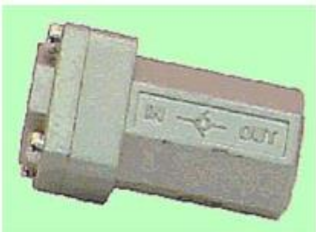
a) 5/2 control valve b) Cross section c) Pneumatic symbol

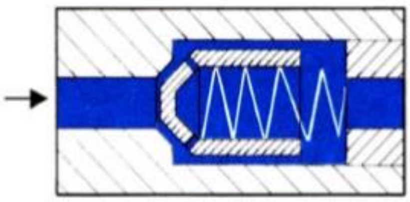
Fig 1.12 5/2 Directional control valve

1.4.4 Control valve

A control valve is a valve that controls the flow of air. Examples include non-return valves, flow control valves, shuttle valves, etc.

a) **Non-return valve:** A non-return valve allows air to flow in one direction only. When air flows in the opposite direction, the valve will close. Another name for non-return valve is poppet valve.

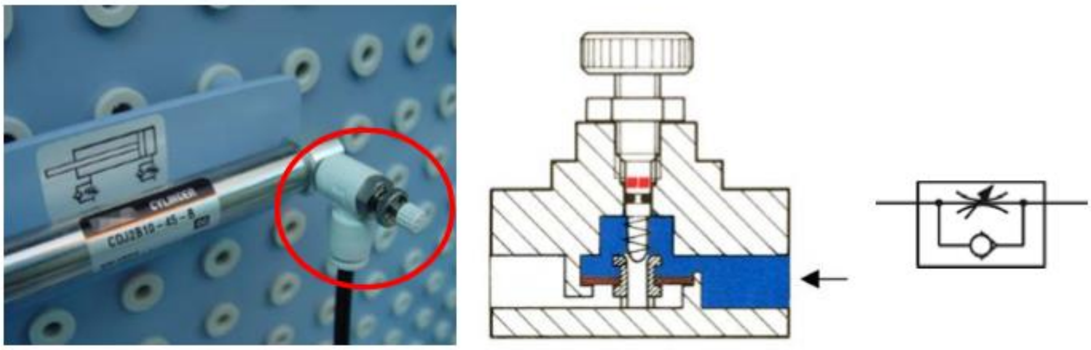




a) Non-return valve b) Cross section c) Pneumatic Symbol

Fig 1.13 Non-return valve

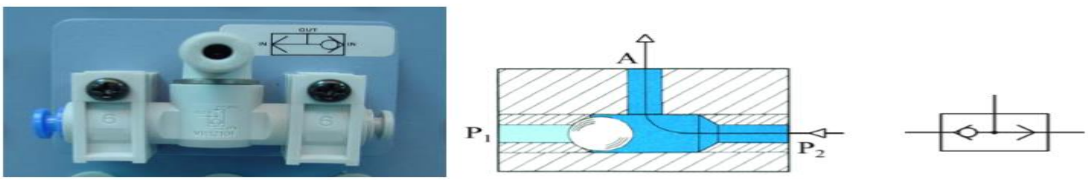
(a) **Flow control valve:** A flow control valve is formed by a non-return valve and a variable throttle



a) Flow control valve b) Cross section c) Pneumatic symbol

Fig 1.14 Flow control valve

(b) **Shuttle valve:** A shuttle valve has two air inlets ‘P1’ and ‘P2’ and one air outlet ‘A’. When compressed air enters through ‘P1’, the sphere will seal and block the other inlet ‘P2’. Air can then flow from ‘P1’ to ‘A’. When the contrary happens, the sphere will block inlet ‘P1’, allowing air to flow from ‘P2’ to ‘A’ only.



a) Shuttle valve b) Cross section c) Pneumatic symbol

Fig 1.15 Shuttle valve

1.5 Folding

The paper to be folded first undergoes feeding, punching and cutting operations. The cutting operation is done in such a way that the ends of the paper form foldable flaps. These flaps are folded according to the required specifications for the product to fit inside.

1.6 Linkage System

A mechanical linkage is an assembly of bodies connected to manage forces and movement. The movement of a body, or link, is studied using geometry so the link is considered to be rigid. The connections between links are modelled as providing ideal movement, pure rotation or sliding for example, and are called joints. A linkage modelled as a network of rigid links and ideal joints is called a kinematic chain.

Linkages may be constructed from open chains, closed chains, or a combination of open and closed chains. Each link in a chain is connected by a joint to one or more other links. Thus, a kinematic chain can be modelled as a graph in which the links are paths and the joints are vertices, which is called a linkage graph.

The movement of an ideal joint is generally associated with a subgroup of the group of Euclidean displacements. The number of parameters in the subgroup is called the degrees of freedom (DOF) of the joint. Mechanical linkages are usually designed to transform a given input force and movement into a desired output force and movement. The ratio of the output force to the input force is known as the mechanical advantage of the linkage, while the ratio of the input speed to the output speed is known as the speed ratio. The speed ratio and mechanical advantage are defined so they yield the same number in an ideal linkage.

A kinematic chain, in which one link is fixed or stationary, is called a mechanism, and a linkage designed to be stationary is called a structure.

We have designed a linkage system to fold the flaps of the box and the system is attached to a punch which is placed on the work table under which a spring is placed to restore the force and thereby the upward movement of spring automatically folds the flaps of the box.

1.7 Spring

A spring is an elastic object that stores mechanical energy. Springs are typically made of spring steel. The rate or spring constant of a spring is the change in the force it exerts, divided by the change in deflection of the spring. That is, it is the gradient of the force versus deflection curve.

Springs are made from a variety of elastic materials, the most common being spring steel. Small springs can be wound from pre-hardened stock, while larger ones are made from annealed steel and hardened after fabrication. Some non-ferrous metals are also used including phosphor bronze and titanium for parts requiring corrosion resistance and beryllium copper for springs carrying electrical current (because of its low electrical resistance).

Fig 1.16 A helical spring designed for compression and tension

We used a helical spring for attaining the required restoring force to fold the flaps of the box.

1.8 Need for Automation and its Advantages

Automation is the use of control systems and information technologies to reduce the need for human work in the production of goods and services. In the scope of industrialization, automation is a step beyond mechanization. Whereas mechanization provide human operators with machinery to assist them with the muscular requirements of work, automation greatly decreases the need for human sensory and mental requirements as well. Automation plays an increasingly important role in the world economy and in daily experience.

Manufacturing company usually produce hundred thousand products a day, and most of the time they rely on automation to meet their client's expectation and deadline in able to have good profit. Thousand manpower is very effective, new technologies today have important to increase the productivity of a certain company.

If you will choose between manufacturing hundreds of employees and maintaining machine, you will probably choose maintaining machines, you will probably choose maintaining machine because it is easier to handle machines then people who have different personalities. The ability of hundreds of people can be done by a single machine which means that you can save a lot of money in terms of using automated machines in manufacturing certain products less stress of those personnel that do have attitude problem on their work. Though machines are considered as one of the biggest investments that you will have for your business, this will soon worth all the cost you have incurred due to the productivity that can provide to your company.

All that is need is to have few people who are experienced enough in handling this kind of machines. A lot of times these machines contain program logic controller that are considered as the heart and brain of the machine's automation. Learning things about program logic controller is a big advantage regarding maintenance and trouble shooting.

Automation has been achieved by various means including mechanical, hydraulic, pneumatic, electrical, electronic devices and computers, usually in combination. Complicated systems, such as modern factories, airplanes and ships typically use all these combined techniques. The benefit of automation includes labor savings, savings in electricity costs, savings in material costs, and improvements to quality, accuracy and precision.

The main advantages of automation are:

1) Increased throughput or productivity.
2) Improved quality or increased predictability of quality.
3) Improved robustness (consistency), of processes or product.
4) Increased consistency of output.
5) Reduced direct human labor costs and expenses.
6) Installation in operations reduces cycle time.

7) Can complete tasks where a high degree of accuracy is required.
8) Replaces human operators in tasks that involve hard physical or monotonous work (e.g., using one forklift with a single driver instead of a team of multiple workers to lift a heavy object)
9) Reduces some occupational injuries (e.g., fewer strained backs from lifting heavy objects)
10) Replaces humans in tasks done in dangerous environments (i.e. fire, space, volcanoes, nuclear facilities, underwater, etc.)
11) Performs tasks that are beyond human capabilities of size, weight, speed, endurance, etc.
12) Reduces operation time and work handling time significantly.
13) Frees up workers to take on other roles.
14) Provides higher level jobs in the development, deployment, maintenance and running of the automated processes.

1.9 Components of Automation

For the present work, the automation is done using micro-controllers.

The components used in automation are:

a) **Arduino Uno:** Arduino is an open source platform that can be used to design various electronic projects. Arduino Uno is hardware which is based on microcontroller ATmega 328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button.

Fig 1.17 Arduino Uno

Arduino is a hardware which is used to connect computer and the project model so that we can control it by using Arduino code accordingly. Project model can be a robot, quadcopter or a sensor or also can be a digital pin

b) **Relay:** A relay is an electrically operated switch. comprises of an electromagnet and a contact unit. It receives electric signals from the switch, etc., and passes them to the output part such as motor.

a) Input b) Relay c) Output

Fig 1.18 Relay

Relays are classified into two types:

- Mechanical Relays
- Semi-Conductor Relays

In mechanical relays, the contact opens and shuts mechanically, whereas in semi-conductor relays the contact is a semi-conductor and does not open and shut mechanically.

a) Sensor: A sensor is a device used to detect changes in environment and send the information to other electronic devices. It converts the physical parameter such as temperature, speed etc., into an electrically measured signal.

Fig 1.19 commonly used sensors

Sensors can be classified into the following criteria:

- Primary Input quantity (Measurand)
- Transduction principles
- Material and Technology
- Property
- Application

1.10 Problem Definition

The modern-day industries always try to increase their production rate by reducing the wastage of time, man power, by decreasing the operation costs and by optimizing the work to get ahead of their competition in this era. So, they often look for methods to automate various processes in their production line. One such industry is the packaging industry where most of the work is manually done because of the intricate shapes of packaging and distinct requirements of several clients, but requires automation to boost its production rate. So, our team had decided to come up with an idea to overcome that problem by designing the mechanisms required to perform the sequential tasks automatically using micro-controllers.

1.11 Objective of the Project

The aim of our team is to design a folding mechanism required to fold the flaps of the box to be made which underwent feeding, punching and cutting operations. The folding mechanism that we are desired to design would be the one which do not need a manual operation and the automated linkage system is sketched by having an idea that how the flaps may get folded one after the other and when and where the glue to be applied. We have referred many research papers and literatures for getting an idea of how exactly we would make it done.

In this chapter, an introduction to various components that are used in the project have been discussed.

CHAPTER – II

LITERATURE

CHAPTER – II

LITERATURE

The background research of the existing literatures used for this project occurred in three stages. We first researched preexisting designs to gain an understanding of commercially available box-folding solutions. After completing a preliminary design and determining the mechanism would be primarily linkage based, it became paramount to find a motor that would be able to drive the linkages and accurately pause at predetermined angle steps. The final stage occurred when it became obvious that the folding and loading processes must take place at different locations. This realization forced us to consider different conveying options to transport the partially folded boxes.

2.1 Literature Review:

Nathan Spiegel and et al [1] carried out work on - "Design of Automated Packaging Machine". Due to a Chinese factory's pressing need to increase the speed of paperclip packaging and decrease operating costs, our team was assigned to design a machine that would fold boxes and load them with paperclips. With very few pre-existing designs for automated packaging/loading devices, we essentially had to come up with a design from scratch. To make our machine as simple as possible, we decided to make it primarily linkage based. Using both the graphical and analytical methods for linkage synthesis and with the aid of computer aided design software such as Pro/ENGINEER, we were able to determine the details of our linkages. Our results were encouraging, although the speed of \machine must increase in order to compete with the current method of packaging/loading. We found this process should be automated because it is a series of repeated actions and motions. If our work is continued and our machine is made more efficient, this could be a breakthrough for packaging/loading because it doesn't require the aid of a human at any point during the packaging phase and because of its relatively small size.

N. R. Patil et al [2] studied on “Automated Paper Bag Making Machine”. Carry bags has become a more convenient way to carry daily necessities and for packaging in small quantities. The well-known form of such bags is in the form of plastic bags. Despite of all known hazards of plastic pollution, it’s prevalent and pervasive in India. Plastic bags are one of the worst and most unnecessary plastic polluters of the earth. Plastic bags are used on a large scale by retailers for a simple reason that plastic bags are much cheaper than paper, cloth or other eco-friendly bags. This paper presents the designing and development of a system to automate the procedure of paper bags production so as to make its production cost comparable to plastic bags and inherently increase its production rate so as to fulfil the ever-increasing demand. We have used micro-controller-based design approach which has kept the cost of the system significantly low as compared to PLC based designs and have automated the manufacturing process

Alhade A. Algitta et al [3] carried out the study on “Automated Packaging Machine Using PLC”. Optimizing helps business to run like a well-oiled machine. Efficiency in operations directly translates positively in the company’s bottom line. The need for everchanging process innovations is persistently fuelled by rapid technology advancements and demands on organizations to improve their bottom-line. Installation of new machine or hiring more people doesn’t help the improvement always, but to align and streamlining the resources together is also very important. The research area belongs to manufacturing processes development and topic is study and optimization of automatic packaging machine. Primary objective of this research is to study and find the development areas in the flow production department of the case company, to find out performance boosters and suggest implementation process for the changes. Secondary objective is to provide the improved structure of flow production department in the greenhouse sector. In a nutshell, the research was a successful project for me and for Famifarm Oy. The company has decided to do some of the modifications to the machine as I suggested. The modification will help the company to achieve their targeted benefit.

Alex Berger et al [4] carried out the study on “Paper Folding Device”. Team Catalyst has taken it upon themselves to design and manufacture a device to assist in the task of zfolding a Wally's & Wimpy's Football Digest to less than 5/8" thick for a broad range of handicapped employees at SW Resources in Parkersburg, WV. We researched, designed, prototyped, tested, and refined a manually operated folding device that incorporates an automated roller all inside a safe, transportable unit. Based on team testing the device is capable of increasing production from 170 papers/hr to 240 papers/hr while also allowing workers with more severe disabilities to complete the task due to the simple operation of the machine.

Abdullah Y. Alshahrani [5] carried out the study on "Paper Airplane Building Machine: Paper Folding Mechanism". The project was motivated by an ASME 2016 design challenge. The challenge was to design and manufacture a device that would turn a single sheet of paper into a paper airplane and launch it. The project is divided into three portions. The three portions are the frame and paper loading, folding mechanism, and launching. The circumference equation is used, to determine what the proper speed of the paper loading motor is. Notably, a slow rpm motor is needed for the loading mechanism to prevent the paper from being damaged. To avoid any deflection in the frame, the total weight of the machine had to be considered. The shear and moment diagram is used to calculate the reaction forces, and to calculate the proper thickness of the material being used. Four motors are used for the paper loading and folding processes, in which each motor has fifteen RPM. Additionally, two linear actuators are used in the paper folding process. Moreover, the launching process requires two motors, each has fifteen thousand RPM. All of the motors that have been mentioned require a twelve-volt battery. Both the launcher motors and the actuators are connected to a single battery. For the other motors, each two motors are connected to one battery. Each battery is connected to on-off switch. As a result, the machine is able to fold a standard sheet of paper into an airplane shape and launch it within 2 minutes. The launcher is able to shoot the paper airplane 10 meters.

N. Gomesh et al [6] carried out the study on "Photovoltaic Powered T-Shirt Folding Machine". Easy T-Shirt Folding Machine is an automatic motor controlled t-shirt folding machine powered by a photovoltaic system. The aim of this project is to fold t-shirts merely by pressing a button. The folding machine is fully automatic where one has to place the t-shirt on the folding tray and press the button. It will then fold the t-shirt by itself. This system uses four DC motors to control the motion of the folding part. Usually, a person uses conventional method to fold the clothes which by hand folding. Many problems usually faced by working women who is unable to manage time for house hold chores The purpose of this project is to introduce an easy and fully automatic t-shirt folding machine. In this propose system, a DC motor are attached to the folding motion and rotates according to a program which uses microcontroller. The microcontroller controls the overall motion of the folding. The overall system is powered by a photovoltaic system. Result shows that by using this system, the time for folding clothes by human can be cut down in half compared to conventional method.

P. Goyal et al [7] carried out work on "Review on Pneumatic Punching Machine and Modification in Punch Tool to Reduce Punching Force Requirement". This project work deals with the design of pneumatically controlled small scale punching machine to carry out piercing operation on thin sheets (1-2 mm) of different material (aluminium and plastic). Reduction in punching force requirement being the main aim of this project work is obtained by modification in punch tool design i.e. by provision of shear on punch face. Subsequently it results in reduction in amount of punching force requirement. And further a CATIA model of the machine is developed on the basis of calculations with respect to punching force requirement.

Sudeep Kelaginamane et al [8] studied on "PLC Based Pneumatic Punching Machine". The work here describes about the design and fabrication of automatic sheet metal punching machine controlled by Programmable Logic Controller (PLC). It also describes the working principle and the hardware structure of the system. By automating the punching system one can have greater control over the whole process. This system can replace existing manual feed and operated punching machines. By interfacing PLC, it is possible to get good results in the form of increased safety of the worker, reduced manufacturing lead time and reduced angular misalignment.

Anand Kumar Singh et al [9] carried out the study on "Design And Development of Pneumatic Punching Machine". Pneumatic is a branch of engineering that deals which study of air/gas characteristic and also their use in engineering appliances either in atmospheric or above atmospheric pressure. Now a day number of application increases in pneumatics system due to high carrying capacity, low maintenance cost and most important not dangerous. Either compressed air or inert gas are generally used, this paper deals with different components of punching machine (proto type) and their assembly and also their related diagrams.

2.2 Summary:

The automation process has a wide range of use in the present days in which sequential operations take place without the help of a man and the assigned job can be performed in the least possible time and by reducing the labour cost. In our project, we used few ideas from the above-mentioned literature papers and we are further developing it to make sure that the paper boxes are made more efficiently both time wise and production wise as an unmanned easier performing operation being used. We use Autodesk inventory for 3-D Modelling of the components used in the project for the detailed study of working of the mechanisms developed.

In this chapter, our detailed research on various research papers has been described. The inputs we took from these papers help us in designing and fabricating the model according to our requirements. These will be discussed in detail in the subsequent chapters.

CHAPTER – III

CONCEPTUAL DESIGN

CHAPTER – III

CONCEPTUAL DESIGN

In this chapter, the main problem in our design of folding mechanism, the functioning of mechanism, the main components involved and their functions are explained in detail. The calculation of component specifications and force requirements are also done by taking the template size into consideration. Finally, we calculated the mobility or degree of freedom in our mechanism.

3.1 Defining the problem and designing the mechanism

We defined the problem in our design as follows:

Whenever the ram that is attached to one end of the piston rod pushes the work base downwards, the linear motion of the piston will convert into rotary motion of the turning pairs attached to the work base with the help of links.

Based upon this, we designed several mechanical arrangements to convert linear motion into rotary motion. Finally, we chose a mechanism based on the suitability and availability of our components.

The work piece base is attached with four turning pairs at four sides. The links are attached to the frame and turning pairs. A spring is placed at the bottom to store the energy and allows the work base to retract to its original position.

So, whenever the ram pushes the work base downwards, the links get activated and transfer the motion to the turning pairs. As a result, the flaps get folded. With the help of the spring, the work base returns to its original position.

The main components involved in the mechanism are:

a) **Ram:** It supplies the force from the compressed air to the work piece.
b) **Work-piece Base:** It is used to place the work piece on it and attach the turning pairs at the four sides.
c) **Turning pairs:** They are used to fold the flaps.

d) **Links:** They are used to convert the linear motion of ram into rotary motion of the turning pairs.
e) **Iron Rod:** It is used to connect the work piece base to the spring bush.
f) **Spring:** It is used to store the energy during the stroke of ram and restore that energy to retract the position of the work base.

3.2 Calculations

Based on the size of the template to be folded, we have calculated the specifications of the components.

3.2.1 Structure Nomenclature and Dimensions

The width of the wooden block at the end of the piston rod (A) = 150 mm

Length of the wooden block at the end of the piston rod (B) = 237 mm

The thickness of the wooden block at the end of the piston rod (E) = 20 mm

The clearance between the wooden block of the piston rod to the workplace (C) = 60 mm

The width of the wooden block at the workplace (D) = 150 mm

Length of the wooden block at the workplace (F) = 237 mm

The thickness of the wooden block at the workplace (G) = 30 mm

Distance from centre of workplace wooden block to the frame end (H) = 250 mm

Length of link (L) = 143.54 mm

Height of Rod (I) = 300 mm

Free length of Spring (J) = 100 mm

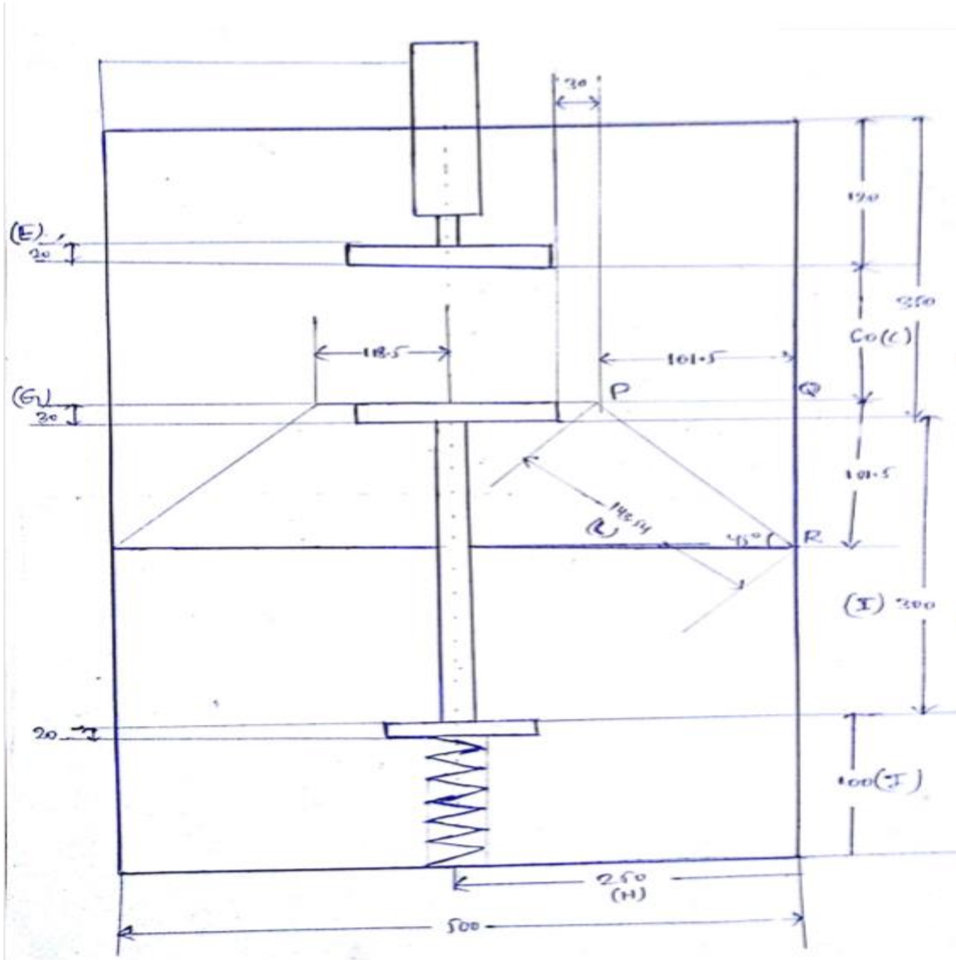


Fig 3.1 2-D representation of the model

3.2.2 Template Specifications

The dimensions of the paper which we assumed to be folded are as follows:

Length = 297 mm

Breadth = 210 mm

Thickness = 1 mm

Based on the specifications of the template, we have designed the wooden block inside the frame. Now, links are to be attached between the frame and flanges of the wooden block. The calculations of link lengths and the position of link attachment to the frame are done based on the figure above.

From triangle PQR,

$$\text{Sin}\theta = \frac{PQ}{PR}$$

$$\text{PR} = \frac{PQ}{Sin\theta}$$

$$\text{PR} = \frac{101.5}{Sin45}$$

Therefore, Link length PR = 143.54 mm.

From triangle PQR,

$$\text{Cos}\theta = \frac{QR}{PR}$$

QR = (PR)*(Cosθ)

QR = 143.54*Cos45

Therefore, the position of the link to be attached to the frame from the flange of the workpiece, QR = 101.5 mm.

Based on the folding of flaps from initial position to final position, the compression rate of the spring is decided and the spring calculations are done as follows:

Outer Diameter (D) = 30 mm

Thickness of each coil (d) = 3 mm

Number of active coils = 12

Free Length = 100 mm

Poisson's ratio = 0.3

Young's Modulus = 200 GPa

Spring index (C) = $\frac{D}{d} = \frac{30}{3}$ = 10 mm

Wahl correction factor (K_w) = $\frac{4C-1}{4C-4} + \frac{0.615}{C}$

= 1.0833 + 0.0615

K_w = 1.1448

General Force exerted by the spring (F) = $\frac{\pi D^3 \tau}{8DK_w}$

$= \frac{\pi(3^3)(207)}{(8)(30)(1.1448)}$

F = 63.90 N

This is the force exerted by the spring on the bottom plate.

Spring Constant (K) = $\frac{Gd^4}{8D^3n}$

$= \frac{(200*10^3)(3^4)}{(8)(30)^3(12)}$

Therefore, the spring constant of spring is K = 6.25 N/mm

Mean Spring Diameter (D) = $\sqrt[3]{\frac{GD^4}{8Kn}}$

D = $\sqrt[3]{\frac{(200*10^3)(3^4)}{(8)(6.25)(12)}}$

Mean Spring Diameter D = 27 mm

Spring Deflection (x):

$$F = (K)(x)$$

$$x = \frac{63.90}{6.25}$$

$$x = 10.224 \text{ mm}$$

This value of x is the deflection of the spring in mm.

Depending on the availability of pneumatic cylinder, the specifications of the cylinder are as follows:

Bore Diameter (d) = 10 mm

Stroke Length (h) = 100 mm

$$\text{Volume (v)} = \frac{\pi}{4}(d^2)(h)$$

$$v = = \frac{\pi}{4}(10^2)(100)$$

$$v = 7.853\ m^3$$

This is the volume of the cylinder in which the piston is contained.

According to the pressure required for the operation, force is calculated as follows:

$$\text{Pressure (P)} = 5\ \text{kg}/cm^2$$

$$= 490500\ \text{N}/m^2$$

$$\text{Pressure} = \text{Force/Area}$$

$$F = (490500)\frac{\pi}{4}(0.01)(0.01)$$

Therefore, Force = 38.52 N

This is the magnitude of force with which the piston strikes the work-place wooden piece.

3.2.3 Degree of Freedom (DOF)

The number of parameters define the state of a physical system and they are important in the analysis of systems of bodies. The Degree of Freedom (DOF) of a mechanical system is the number of independent parameters that define its configuration. The position and orientation of a rigid body in space is defined by three components of translation and three components of rotation, which means that it has six degrees of freedom.

$$DOF = 3(n - 1) - 2f - n$$

Number of Links = 10

Binary joints = 13

Higher pairs = 0

Therefore, DOF = 3(10 – 1) – 2(13)

= 27 – 26

= 1

The mobility or degree of freedom for the mechanism is hence calculated.

Pneumatic circuit exhibits one degree of freedom. Therefore the total mobility of the folding machine is 2.

In this chapter, various calculations that are involved in designing the mechanism have been done based on the specifications of the template. These calculations are used in fabricating the model.

CHAPTER – IV

MODELLING

AND

SIMULATION

CHAPTER - IV

MODELING AND SIMULATION

In this chapter, modeling and simulation of various parts in the model can be done. Modeling can be done in various methods such as wireframe modeling, surface modeling, solid modelling, etc., The easiest way is chosen for modeling of the experimental setup. Here we have chosen solid modeling method of creating a solid. There are many packages for modeling, out of which Autodesk Inventor has been selected for its ease of availability and as it is user-friendly.

4.1 Autodesk Inventor

The main features of Autodesk Inventor software are

i. It is 3D mechanical engineering, design, visualization and simulation software.
ii. Autodesk Inventor is a parametric and feature-based solid modeling tool. It allows us to convert basic 2D sketch into a solid model using very simple modeling options.
iii. It creates digital prototyping as opposed to physical prototyping by integrating 2D AutoCAD drawings and 3D data into a single digital model.
iv. It can quickly and easily create stunning renderings, animations, and presentations that improve communication.
v. It can easily generate and share production-ready drawings for manufacturing teams.
vi. The automatic updating feature allows easy changes in models.
vii. It has a simulation environment that allows motion simulation, static and model finite element analysis (FEA) of parts, assemblies and load-bearing frames.

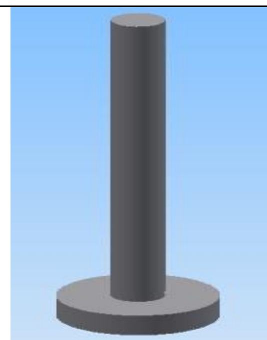
Autodesk Inventor's parametric studies and optimization technology lets users modify design parameters within the assembly stress environment and compare various design options, then update the 3D model with the optimized parameters.

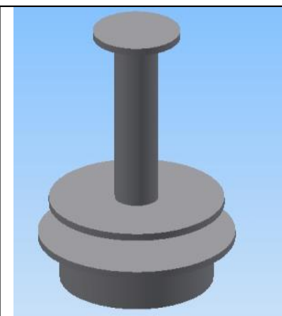
4.2 Part Modelling

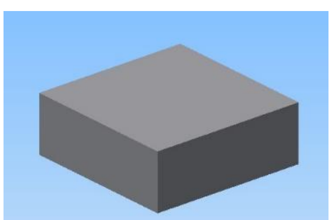
The automated paper-box maker parts are modelled first in the Autodesk Inventor software in order to fabricate the setup. The part modeling is done by the following steps by the top-down approach.

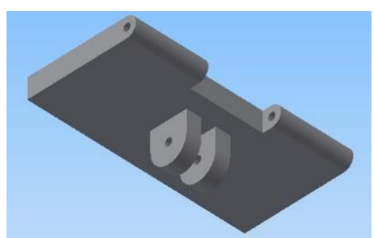
i. Step 1: creating a new part file with the extension". ipt"
ii. Step 2: creating the base part 2D sketch
iii. Step 3: converting 2D sketch to required 3D model by using features like extrude, extrude cut, revolve, sweep, chamfers, fillets, holes, spiral, etc.
iv. Step 4: Saving the file with the desired part name.

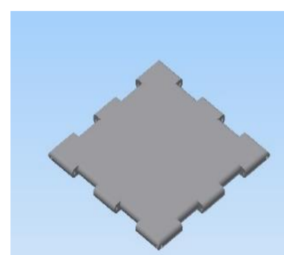

(a) Cylinder

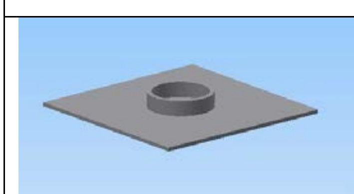

(b) Piston Rod

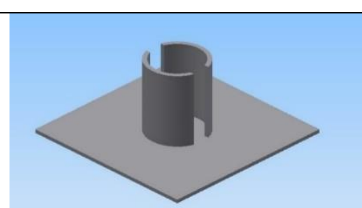

(c) Die support


(d) Ram


(e) Flap


(f) Die base


(g) Base plate


(h) Pneumatic cylinder holder

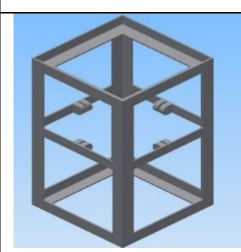

(i) Frame

Fig 4.1 Various parts in the model

4.3 Assembly Modelling

The assembly of the parts is done with proper constraints in the following manner to allow the assembled model to simulate.

i. Step 1: Creating new assembly file with the extension ". iam”.
ii. Step 2: Import the base part first and ground it.
iii. Step 3: Now import all the other parts and assemble them with various constraints to planes and features like mate, align, insert, etc.
iv. Step 4: Give the revolutionary joint at which the linkages revolving fixture assembled.
v. Step 5: Saving the file with the desired file name.

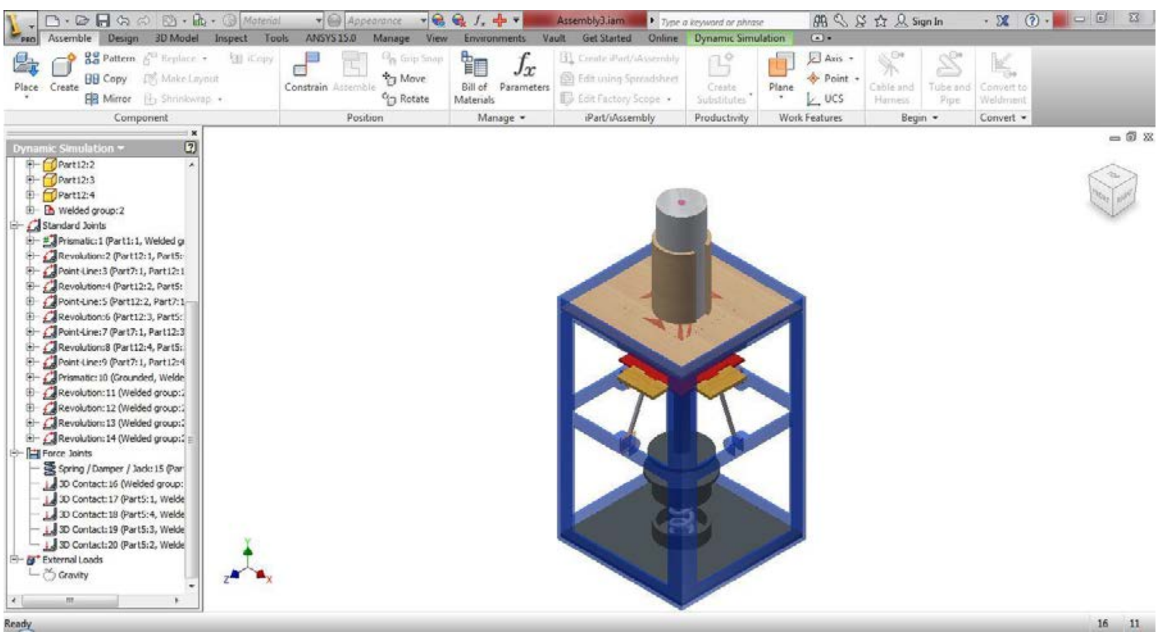


Fig 4.2 Modular Automated folding machine

The complete assembly of the modular automated folding mechanism is shown in figure 4.2.

4.4 Motion Simulation

A more cost-effective alternative is to leverage the digital prototype by using Autodesk Inventor simulation suite software. This software enables designers to automatically convert assembly constraints to mechanical joints to apply external forces including gravity and to measure the effects of contact friction, damping, and inertia. From this information, the software calculates the reaction forces, velocity, acceleration, and much more reaction forces. Build optimized and competitive products.

Use collision detection when we drive constraints to identify incorrectly positioned components. Apply constraints to position the components as intended and then drive constraints to simulate the mechanical motion. If components collide, a message is displayed and the affected components are highlighted in the browser. Use drive constraint on the context menu to simulate the mechanical motion by driving a constraint through a sequence of steps.

Motion check is needed to ensure that the designed, assembled mechanism will able to function properly in real time. For motion, simulation selects the desired revolutionary constraint and drive to check the mechanism. Also, identify the intersecting objects in the path by enabling collision detection. The model is successfully simulated and the model can be fabricated as per CAD design. The simulated assembly is as shown in figure 4.3.

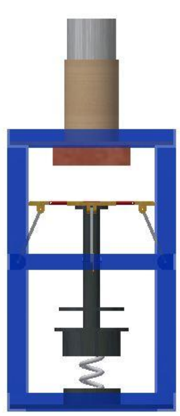
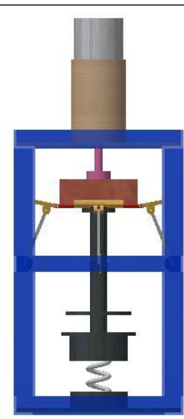
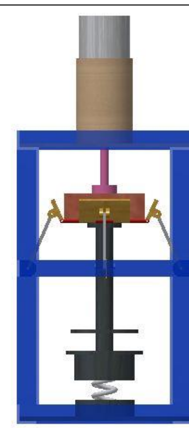
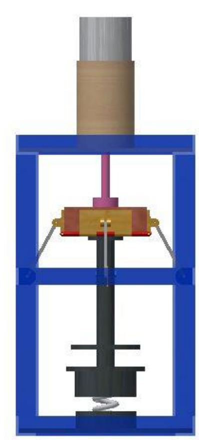
			
Initial position	Contact	Folding	Final position

Fig 4.3 Simulation of the model

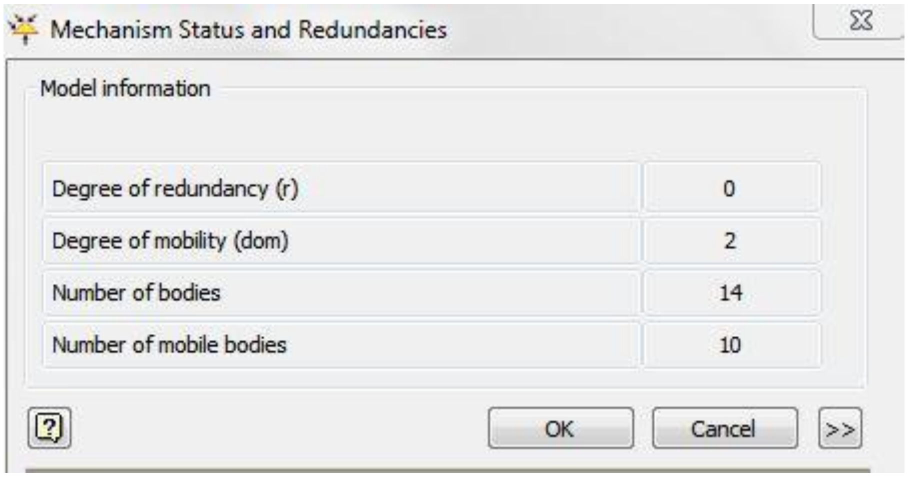
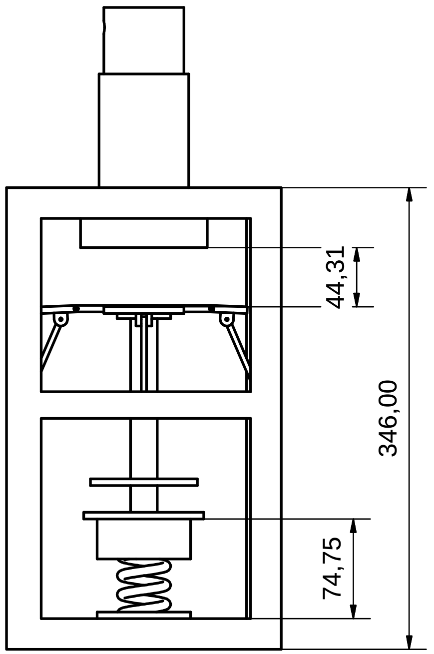
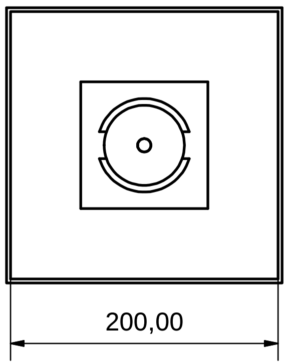


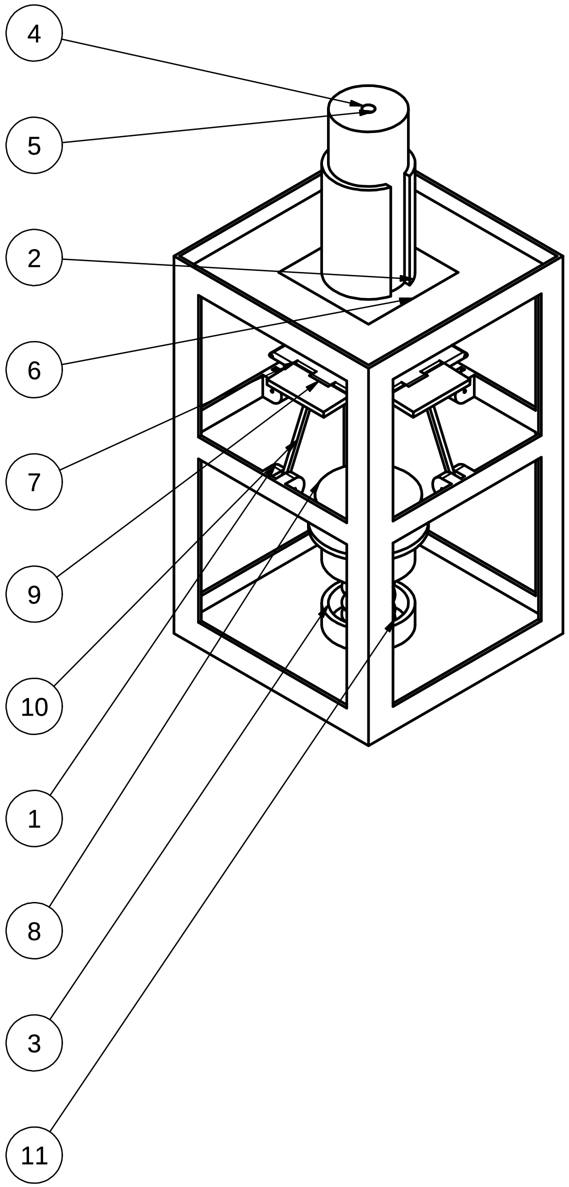
Fig 4.4 Mechanism status

The assembly model is successfully simulated and motion analysis is done on it. The mobility of the system after assembly is 2 as calculated in chapter 3.

Therefore, with the use of Autodesk Inventor, a model with required dimensions has been made and simulated to ensure the appropriate working of the actual fabricated model.







PARTS LIST			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	Part7	FRAME
2	1	Part8	PNEUMATIC CYLINDER HOLDER
3	1	Part6	BASE PLATE
4	1	Part1	PNEUMATIC CYLINDER
5	1	Part2	PISTON
6	1	Part3	RAM
7	1	Part4	DIE BASE
8	1	Part10	DIE SUPPORT
9	4	Part5	FLAP
10	4	Part12	LINK
11	1	Compress Spring1	COMPRESSION SPRING

ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCES(A)

PART NAME: Modular Automated folding machine

PROJECT MEMBERS	PROJECT GUIDE
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	DRAWING NO:
	SCALE:

CHAPTER – V
PNEUMATIC SIMULATION

CHAPTER – V

PNEUMATIC SIMULATION

5.1 Introduction

Fluid power is the technology that the generation, control and transmission of power, using pressurized fluids. Pneumatics is a branch of fluid power technology, which deal with the study and application of use of pressurized gas to affect mechanical motion. The simulation of pneumatic systems gives us an understanding of the complex relationships and interactions within the system.

Fluid power drives and controls can be found across all industries. Irrespective of their usage, minimum pressure losses and vibrations in the overall system along with efficient fluid transport are desired. Due to the non-linear properties of fluid power systems, spreadsheet-based design approaches have their limits. In order to increase performance and efficiency of fluid power systems, the fluid circuit, its controller layout and the connected mechanical as well as electrical components as a whole are studied for the best results. The most effective way to do so is to use software for simulating your fluid power systems.

There are lot of software available for the simulation of pneumatic systems like FluidSIM, Lab-Volt, Automation Studio etc. Of these, we are using Lab-Volt for simulation as it is an open source software and simple to use according to our requirements.

The lab-volt virtual laboratory (LVVL) is a three-dimensional classroom laboratory displayed on a computer screen. Various subject such as hydraulics, pneumatics, electromechanically systems, and digital telecommunication can be studied using this virtual equipment.

The virtual equipment sets form complete training systems which are faithful three-dimensional reproduction of actual lab-volt training systems. They have the same physical appearance and behave in the same way as the actual training systems.

As we are using Pneumatics in our project, we deal with the Pneumatics Equipment in the software.

5.2 Pneumatics Equipment Bar

The Pneumatics Equipment Bar is a set of buttons. Each button corresponds to a piece of pneumatic equipment. The buttons on the Pneumatics Equipment Bar are used to install the Work Surface and the Air Compressor in the Lab-Volt Virtual Laboratory (LVVL), and to install a pneumatic component on the Work Surface. See Installing Pneumatic Equipment to obtain additional information.

The buttons on the Pneumatics Equipment Bar and the name of the component corresponding to each button are displayed below. You can click one of the following topics to obtain a detailed description on the component related to one of the buttons on the Pneumatics Equipment Bar

5.2.1 Work Surface

The Work Surface provides a uniform surface on which to install pneumatic components

Fig 5.1 Work Surface

5.2.2 Air Compressor

The Air Compressor supplies air under pressure to the pneumatic system. It consists of a compressor, a receiver, and two connection ports labelled Outlet Ports.

In order for the Air Compressor to supply air to the circuit, one of its outlet ports has to be connected to the inlet port of the Conditioning Unit.

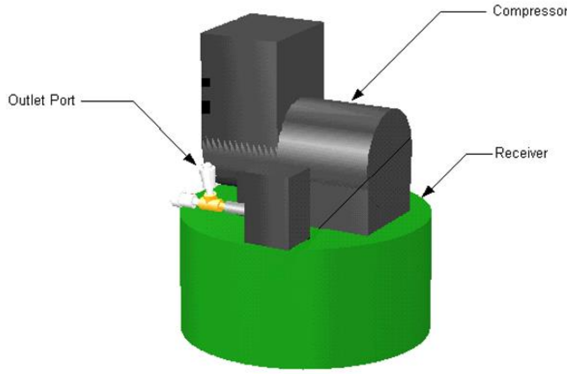


Fig 5.2 Air Compressor

5.2.3 Conditioning Unit

The Conditioning Unit filters, regulates the system pressure, and distributes conditioned air to the pneumatic circuit. The Conditioning Unit consists of an air inlet port, an exhaust port, a main shutoff valve, a filter, a muffler, a pressure regulator, a pressure gauge, a 4-port manifold, 4 branch shutoff valves, and 4 outlet ports. In order for the Conditioning Unit to supply air to the circuit, it must first be connected to the Air Compressor.

The main shutoff valve controls the air supply to the pressure regulator. The main shutoff valve is open when its control knob is in the upper position and is closed when its control knob is in the lower position. The position of the control knob is changed by clicking the mouse left button on the main shutoff valve.

The pressure regulator is used to set the pressure in the circuit. Clicking the control knob of the pressure regulator opens a dialog box that allows you to change the pressure regulator setting.

The pressure gauge allows the monitoring of the regulated pressure. It is possible to obtain a close-up view of the dial by clicking the mouse right button on the Conditioning Unit and selecting Meter View in the context sensitive menu.

The conditioned air is available through the 4 outlet ports individually controlled by branch shutoff valves. The shutoff valves are open when their collar is in the upper position and are closed when their collar is in the lower position. The position of the collars is changed by clicking the mouse left button on the branch shutoff valves.

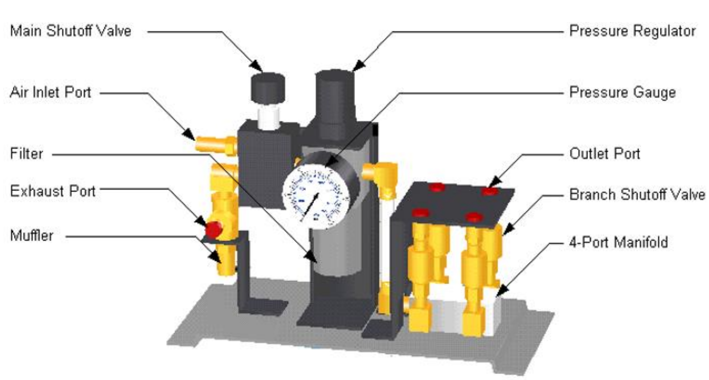


Fig 5.3 Conditioning unit

5.2.4 Accumulator

The Accumulator is used to store pressurized air and to provide a short-term supply of compressed air to a particular device. It has one connection port labelled Accumulator Port.

Fig 5.4 Accumulator

5.2.5 Directional Valve, Pushbutton Operated

A Directional Valve, Pushbutton Operated is used to control the direction of air flow in a pneumatic circuit. The Directional Valve, Pushbutton Operated which is used in the Lab-Volt Virtual Laboratory is a two-way, two-position, pushbutton operated directional valve.

It has three connection ports that allow normally closed and normally open configurations. Flow-path configurations are reversed by depressing the pushbutton. To depress the pushbutton, place the mouse pointer on the pushbutton, click the mouse left button and maintain it down. The pushbutton returns to its released position when the mouse left button is released.

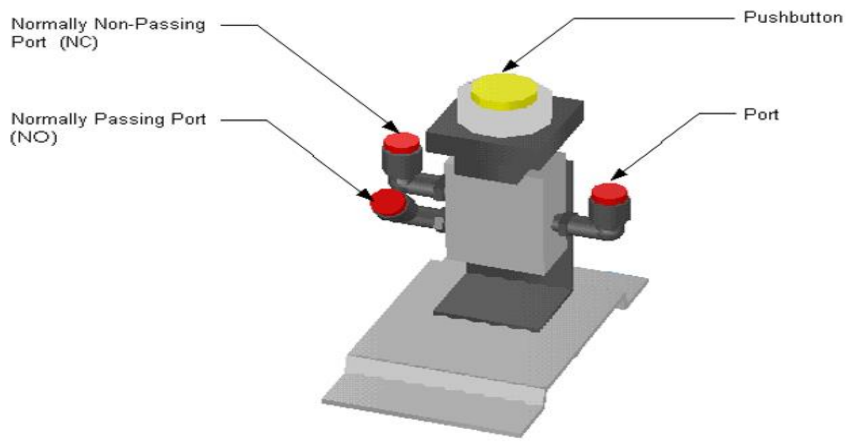


Fig 5.5 Push button operated directional valve

5.2.6 Flow Control Valve

The Flow Control Valve is designed to adjust the resistance to air flow in a pneumatic circuit. It has one Inlet Port, one Outlet Port and a Control Knob.

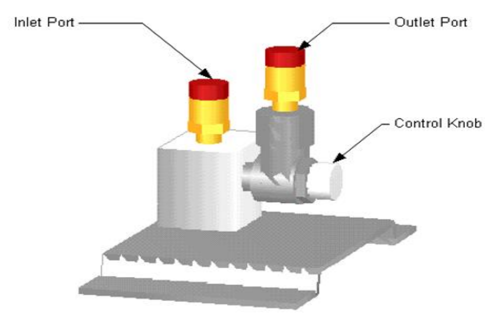


Fig 5.6 Flow control valve

5.2.7 Pressure Regulator

The Pressure Regulator is a valve designed to maintain constant pressure in pneumatic circuits. It has two connection ports, labelled Inlet and Outlet as well as an exhaust port.

The Pressure Regulator is a normally passing valve that regulates pressure by closing partially or completely an opening that allows fluid to flow from the Inlet port to the Outlet port. The pressure at the Outlet port pushes (via a diaphragm) against a spring inside the valve, to automatically adjust the valve opening so as to maintain the desired pressure at the Outlet port.

The regulated pressure, that is the pressure at the Outlet port, is set by turning the adjustment knob on the Pressure Regulator. Turning the adjustment knob clockwise compresses the spring inside the valve more and more, and thereby, increases the regulated pressure setting.

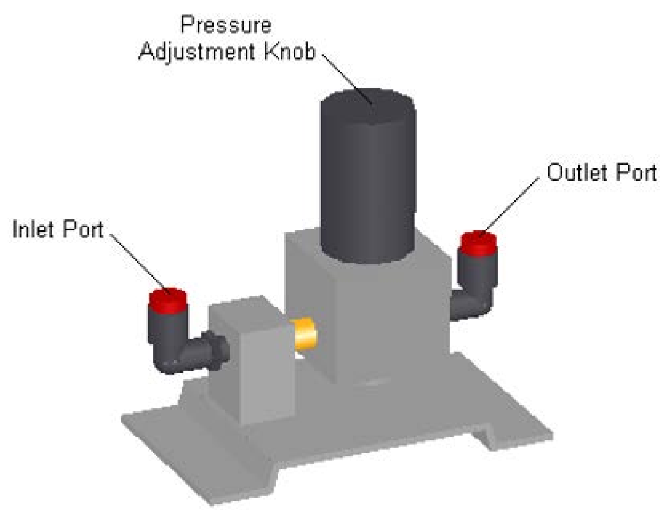


Fig 5.7 Pressure Regulator

5.2.8 Single-Acting Cylinder

The Single-Acting Cylinder is a spring-return cylinder. It converts fluid energy into linear mechanical energy which can be used to perform work in only one direction. It has one connection port labelled Cap End Port.

When air flow is directed toward the Cap End Port of the cylinder, pressure in the cap end rises until enough force is generated to compress the spring, and the cylinder rod extends. When the air pressure is released, the force of the spring makes the cylinder rod retract. The cylinder rod can also be extended and retracted manually. To do so, place the mouse pointer on the cylinder tip. The arrow pointer changes to a hand pointer. Click the mouse left button and drag the rod outside or inside the cylinder. Then release the mouse left button.

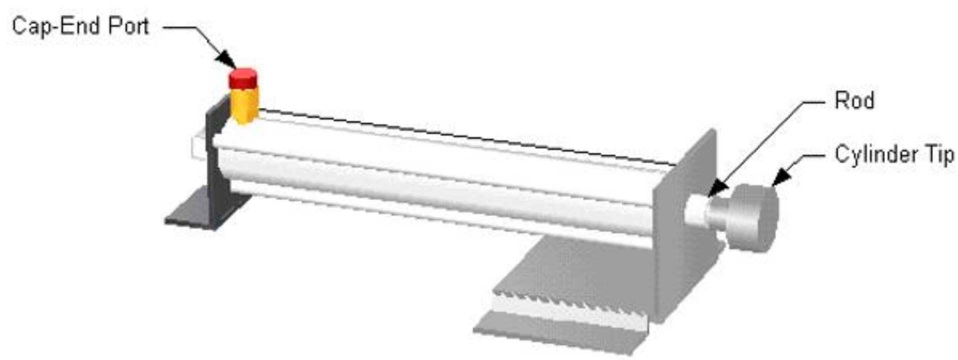


Fig 5.8 Single acting cylinder

5.3 Pneumatic Circuit

The pneumatic circuit is designed using all the controls in the pneumatics equipment bar. A limit switch assembly is also used which senses the movement of the piston and controls its movement.

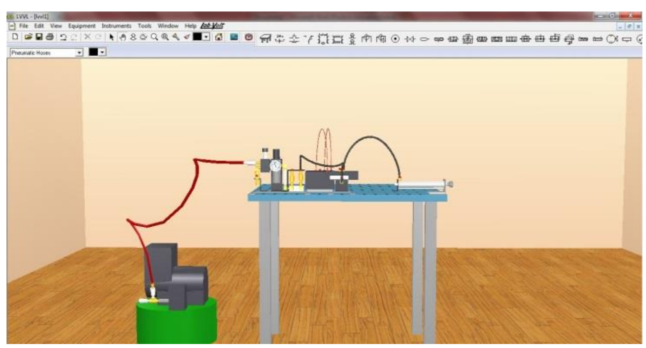


Fig 5.10 Pneumatic circuit

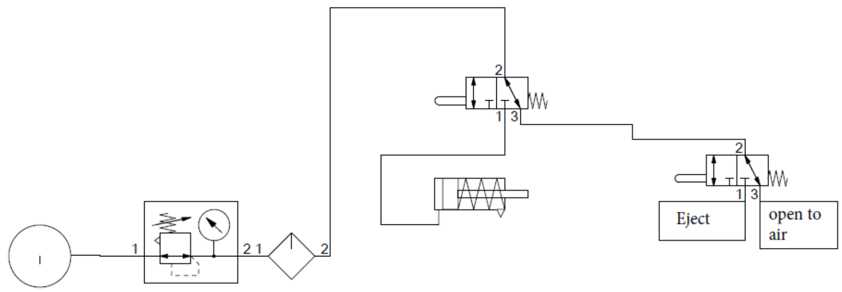


Fig 5.11 Pneumatic circuit manual

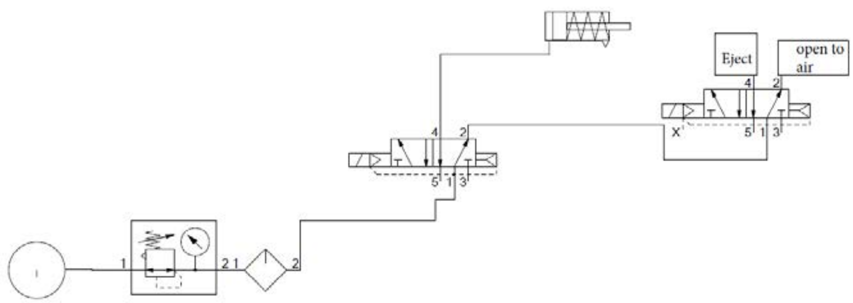


Fig 5.12 Pneumatic circuit automated

In this chapter, the importance of pneumatic simulation and the various tools available in pneumatic simulation software are discussed in detail.

CHAPTER – VI

FABRICATION OF MODEL

CHAPTER – VI

FABRICATION OF MODEL

Based on the design calculations, modelling and simulation, we fabricated a model. The procedure for the fabrication is as follows.

6.1 Fabrication procedure

Utilizing the scrap such as iron bars, we fabricated a frame for the working model. In order to provide support for the frame and for the mobility of the working model, we attached a plywood beneath the frame and fixed rollers at the four corners. By locating the centre of the plywood, a bush is positioned, inside which a spring is attached. The bush prevents the spring from moving. On top of the spring, another bush is attached which in turn supports a wooden piece positioned over it. This is done to prevent any further deflections of the spring due to heavy load. Depending on the specifications of the template, a work-place wooden piece is designed. Four flanges are attached around the four corners of the work-place wooden piece for fixing the links. Now, a rod is assembled between the work-place wooden piece and the top bush of the spring. For attaching links on the frame, iron bars are welded on the respective positions on the frame. The links are attached between the flanges of the work-place wooden piece and the iron bars of frame. Depending upon the clearance between the bottom of the piston rod and the work-place wooden piece, the pneumatic cylinder is arranged to the frame. As per the pneumatic circuit design, the connections are given to the pneumatic cylinder. After switching on the circuit, the compressed air enters into the cylinder. Then the machine works according to the simulation.

The procedure is elaborated below:

i. First, the frame for the model is fabricated using arc welding.
ii. We placed a wooden block at the bottom for support. On it, we arranged a spring suspension system with the help of bushes.

iii. A rod is then attached between the top bush of the spring and the work base.
iv. The turning pairs are attached on four sides of the work base.
v. The links are then attached between the frame and the turning pairs.
vi. On top of the frame, a pneumatic cylinder is placed with some reference for clearance.
vii. The pneumatic connections are given to all the components and are connected according to the circuit designed.
viii. With the help of hoses, connections are made with Arduino boards and relays for automation.

Fig 6.1 Images of Fabricated Model

6.2 Automation Procedure

For the automation of the pneumatic cylinder, for paper detection and ejection mechanism, Arduino has been used along with IR sensors and solenoid valves. This Arduino platform has been chosen as its highly versatile, its components are widely available and Arduino is an open source platform. Coding for the functioning of Arduino is also relatively easy when compared to similar platforms such as a raspberry pi.

The automation for the fabricated mechanism we used an IR sensor to detect the presence of a paper, the mechanism will only operate when a paper is placed on the workplace. Then, piston only engages for a limited time and the ejection system follows.

6.3 Source code for Arduino

```
void setup() {
 int ir;
 pinMode(5,OUTPUT);
  pinMode(6,OUTPUT);
   pinMode(7,OUTPUT);
    pinMode(8,OUTPUT);


}


void loop() {
digitalWrite(5,HIGH);
digitalWrite(6,HIGH);
digitalWrite(7,HIGH);
digitalWrite(8,HIGH);

int ir =analogRead(A0);
if(ir<700)
```

```
{
  delay(3000);
digitalWrite(5,LOW);
digitalWrite(6,HIGH);
digitalWrite(7,HIGH);
digitalWrite(8,HIGH);
delay(3
000);
digitalWrite(5,HIGH);
delay(3000);
digitalWrite(6,LOW);
digitalWrite(7,HIGH);
digitalWrite(8,HIGH);
delay(3000);
digitalWrite(6,HIGH);

}
}
```

CHAPTER – VII
EXPERIMENTATION

CHAPTER – VII

EXPERIMENTATION

After the fabrication of the model, we have conducted experiments and studied the working several times both manual and with automated setup.

7.1 Experimentation with manual setup

First, we have studied the time taken for folding during manual operation. The results are tabulated in table 7.1.

Table 7.1 Manual Folding

S.No	MANUAL FOLDING Time in sec
1	5.20
2	5.05
3	4.98
4	5.12
5	4.99
6	5.05
7	4.17
8	5.21
9	5.02
10	5.00

The time taken for the paper box to eject from the work place manually is measured and the results are tabulated in table 7.2

The total time taken for overall operations of manual experimental setup is tabulated in table 7.3.

Table 7.2 Manual Paper Ejection

S.No	Manual paper ejection Time in sec
1	2.0
2	1.98
3	2.02
4	2.10
5	1.98
6	2.05
7	2.01
8	2.09
9	2.10
10	1.99

Table 7.3 Manual Manufacturing Time

S.No	Total time for Manual manufacturing Time in sec
1	12.2
2	12.03
3	12
4	12.22
5	11.97
6	12.1
7	11.18
8	12.3
9	12.12
10	11.99

7.2 Experimentation with automated setup

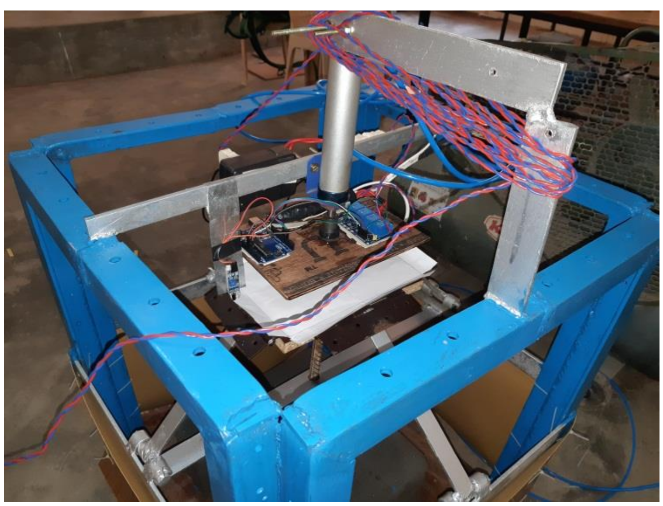
Now, we have studied the time taken for folding during automation. The results are tabulated in table 7.4

Table 7.4 Automated folding

S.No	AUTOMATED FOLDING Time in sec
1	4.1
2	4.08
3	4.00
4	4.03
5	4.01
6	4.00
7	4.10
8	4.07
9	4.03
10	4.08

After the folding operation is done, the paper gets folded and the work base returns to its original position. Then, the paper box gets ejected from the work place.

The time taken for automated paper ejection is also measured and the results are tabulated as follows:



7.1 Automated experimental setup

Table 7.5 Automated Paper Ejection

S.No	Automated Paper Ejection Time in sec
1	0.96
2	0.93
3	0.87
4	0.98
5	0.90
6	0.94
7	0.89
8	0.91
9	0.94
10	0.87

Table 7.6 Automated Manufacturing Time

S.No	Total time for Automated Manufacturing Time in sec
1	8.06
2	8.01
3	7.87
4	8.01
5	7.91
6	7.94
7	7.99
8	7.98
9	7.97
10	7.95

Finally, we have studied the time taken for manual feeding i.e., 5 seconds and automated feeding of paper is assumed as 3 seconds and calculated the total time taken for manual operation and automated operation of making paper boxes.

CHAPTER – VIII
RESULTS AND DISCUSSIONS

CHAPTER – VIII

RESULTS AND DISCUSSIONS

In this chapter, a summary of our experimentation and results are studied and comparison between manual and automated setup operation and cost analysis is discussed.

8.1 COMPARISON OF MANUAL AND AUTOMATED SETUP

A comparison between the total time taken for manual and automated manufacturing has been made in table 8.1 and bar chart is shown in chart 8.1. It is observed that the manual manufacturing time per each box is taken more time. The average time taken for manual setup is 12 seconds and for automated 8 seconds.

Table 8.1 Comparison of Manual and Automated Paper Ejection

S.No	Total time for Manual manufacturing in sec	Total time for automated manufacturing in sec
1	12.2	8.06
2	12.03	8.01
3	12	7.87
4	12.22	8.01
5	11.97	7.91
6	12.1	7.94
7	11.18	7.99
8	12.3	7.98
9	12.12	7.97
10	11.99	7.95
Average	12.011	7.969

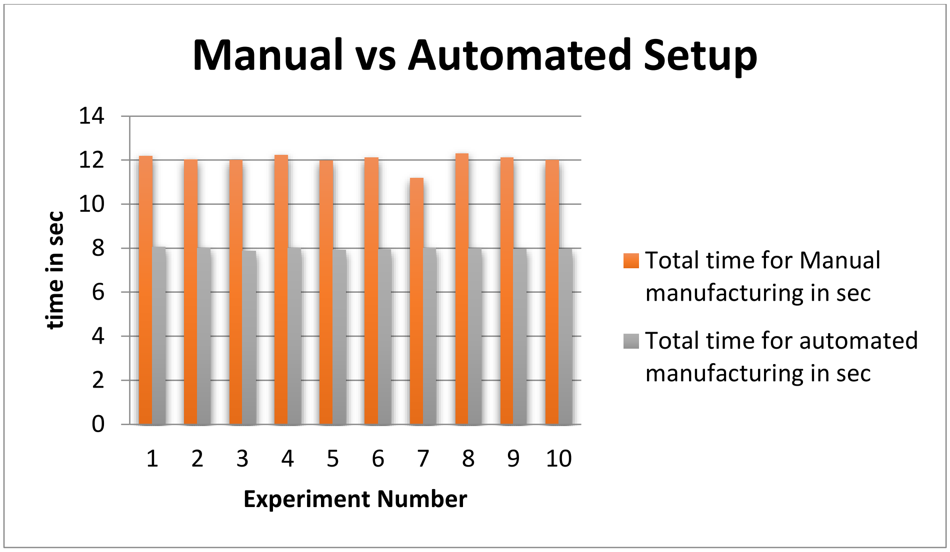


Chart 8.1 Manual vs. Automated Setup Experimental Times

8.2 Cost Analysis

Table 8.2 Cost analysis

S.No	Name of Component	Cost in Rs.
1	Pneumatic Cylinder	1000
2	Spring	100
3	5/2 ACV	1300
4	Pressure regulator	700
5	Frame (Procured from a scrap yard)	1000
6	Wood	200
7	Screws, nuts, bolts	300
8	Labour cost for welding and drilling	1000
9	Transportation	500
10	Hoses	120

Total Cost: Rs.6220/-

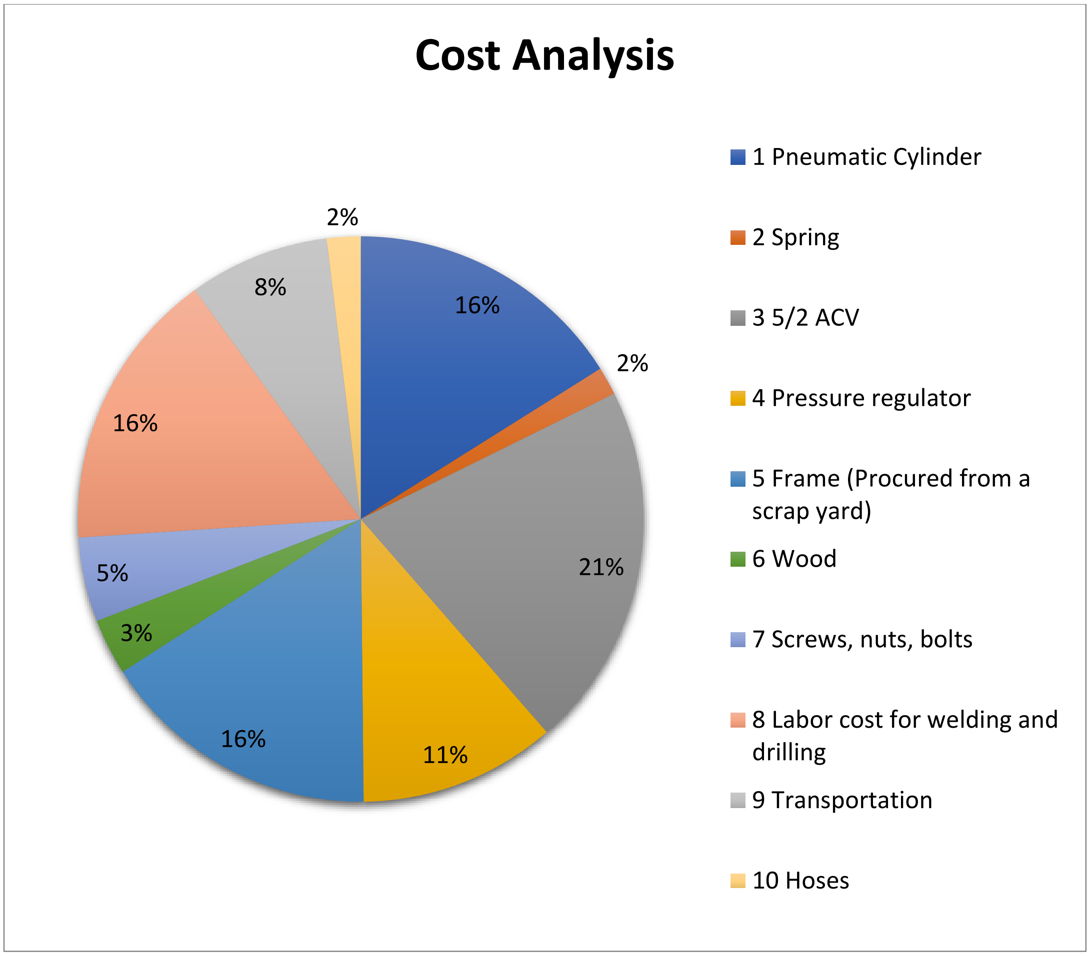


Chart 8.2 Cost analysis

The cost analysis of the total setup is done and tabulated in table 8.2 and pie chart is shown in chart. 8.2. The total cost comes to Rs. 6,220/-. And maximum portion is spent on pneumatic system

CHAPTER – IX
CONCLUSION

CHAPTER – IX
CONCLUSIONS

We have fabricated the machine using pneumatic systems and it is tested successfully in the folding of paper. It can be used in the manufacturing industry for the folding of paper in order to obtain efficient packing of boxes. We have studied the result analysis by conducting experiments like folding and ejecting the paper.

8.1 Conclusions

We conclude that for the manufacturing of one or two boxes, there exists only a small difference between manual and automated operations. But, in order to manufacture large amounts of boxes, a lot of time will be consumed by the manual operation. So, automated operation is the best suited for folding of boxes.

- The 3D model of box folding machine is developed according to conceptual design and its mechanism status is successfully determined by dynamic simulation.
- The box folding machine is fabricated with minor changes due to manufacturing feasibility.
- The total cost spent to fabricate the machine at a cost of Rs. 6,220/-, which affordable for small scale industries.
- The machine is automated, which reduced the manufacturing time by 4 seconds. Although it is very little but when a lot of 1000 boxes manufactured, approximately 1hr time is saved in total production time, in which more 500 boxes can be manufactured.

8.2 Future Scope

The modelling, simulation, fabrication and automation of the model is already done but there is lot of scope for improvement for this machine

- FEA analysis can be done to determine the optimum dimensions of various parts.
- PLC can be used as an alternative to microcontroller, which is widely used in industries.
- Hydraulic systems can be used and the same model can be used for metal sheets.
- The feeders and adhesive mechanisms can also be developed for this machine.

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REFERENCES

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