CHAPTER-1
1. INTRODUCTION

The invention of machinery in the European continent let to industrial revolution. Right from the time the enhancement was inseparable one. We people with burgeon thinking in the field of automation had taken a real time task. The match stick manufacturing industry has human intervention in the filling of stick to matchbox which results in decrease in productivity and health problem to labours. The situation demands an automation aid in the filling of wax sticks to matchbox. The GAYATHRI MATCH INDUSTRIES screened the above mentioned clearly.

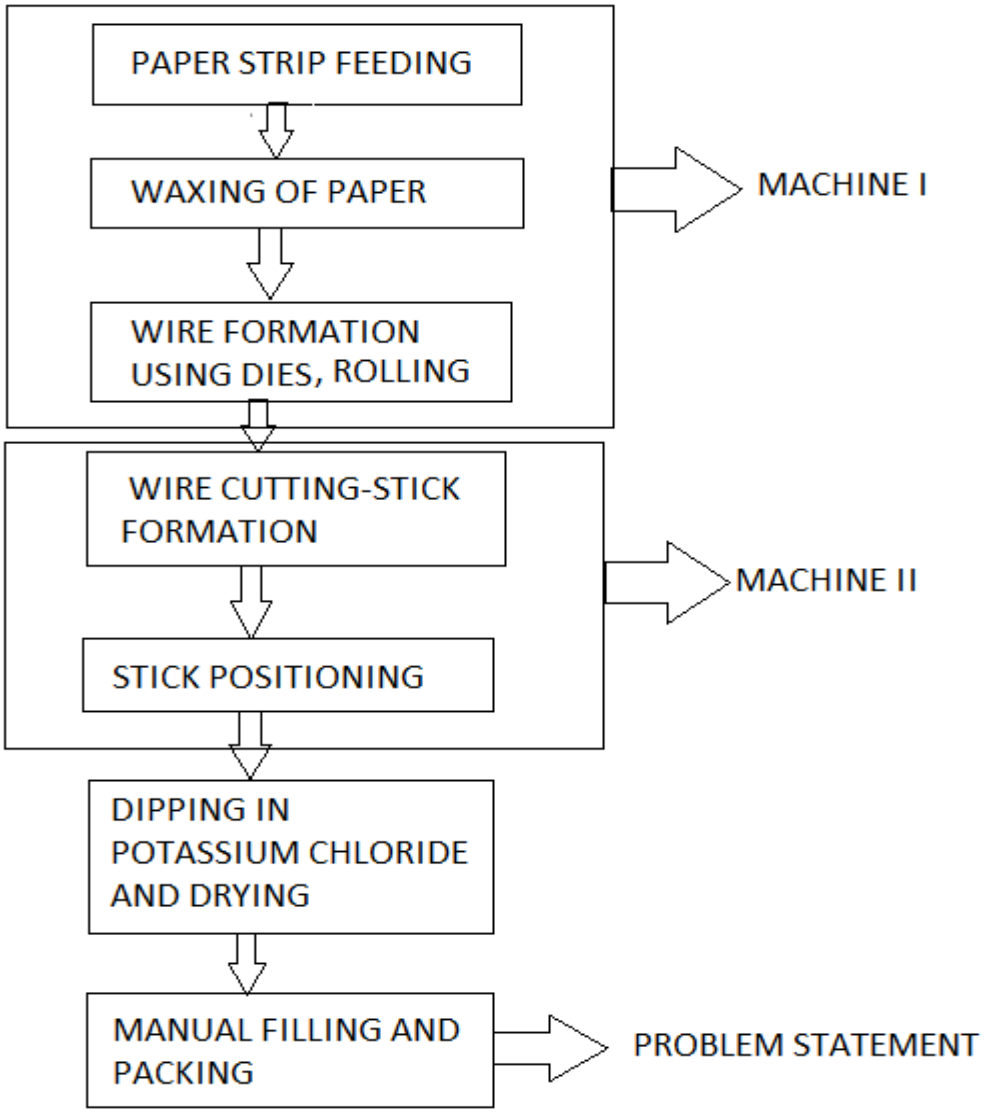
1.2 BRIEF HISTROY ABOUT THE COMPANY:

An anonymous SWEDAN company started their semi-automated match stick manufacturing machine in the year 1975 in Coimbatore.
Due to union problem the company was closed after one and half years.
The Sweden engineering gave the set of machine drawing to the loyal worker Mr NADARAJAN.
He worked with machine drawing for three years (1978-1981) and produced the first machine in the year 1982. He started the company GAYATHRI MATCH INDUSTRIES in pattinamputhur, Coimbatore.
They supplied their first machine to STANDARD fireworks.
In the year 1988 his son MrP.N.SenthilKumar took in charge of the company.
In the year 1991 the company started exporting their machines to Korea, Srilanka and African countries.
Right from the time the company underwent multidimensional development.

CHAPTER 2

2. LITERATURE REVIEW

2.1 THE WORKING PROCESS IN THE COMPANY:



2.1.1 EXISTING TECHNOLOGY IN THE COMPANY:

The special type of paper is purchased and then cut into long strips of width 15mm and then rolled to the wheel. The wax is melted using a heater. The paper

is fed over the working bed.

Figure I-PAPER STRIP FEEDING

The molten wax is pumped and sprayed over the moving strip. The waxed strips are passed into a series of dies of decreasing diameter.

Figure II- WAXING OF PAPER AND WIRE FORMATION

Finally it is converted into wire of 1.5mm and rolled.

Figure III-ROLLING AND WIRE FEEDING

Then using Machine II the wired strips are fed into cutter for the required length of stick (30mm). The cut pieces are arranged in between the sticks. Then it is moved down using chain drive. This position is occupied by the new stick and the process goes on. Once the maximum sticks of frame are made it is replaced by empty frame.

Figure IV-STICK CUTTING AND POSITIONING

The filled frame is dipped into potassium chloride.

Figure V-DIPPING IN POTTASIUM CHLORIDE

The dipped frames are kept aside to cool.

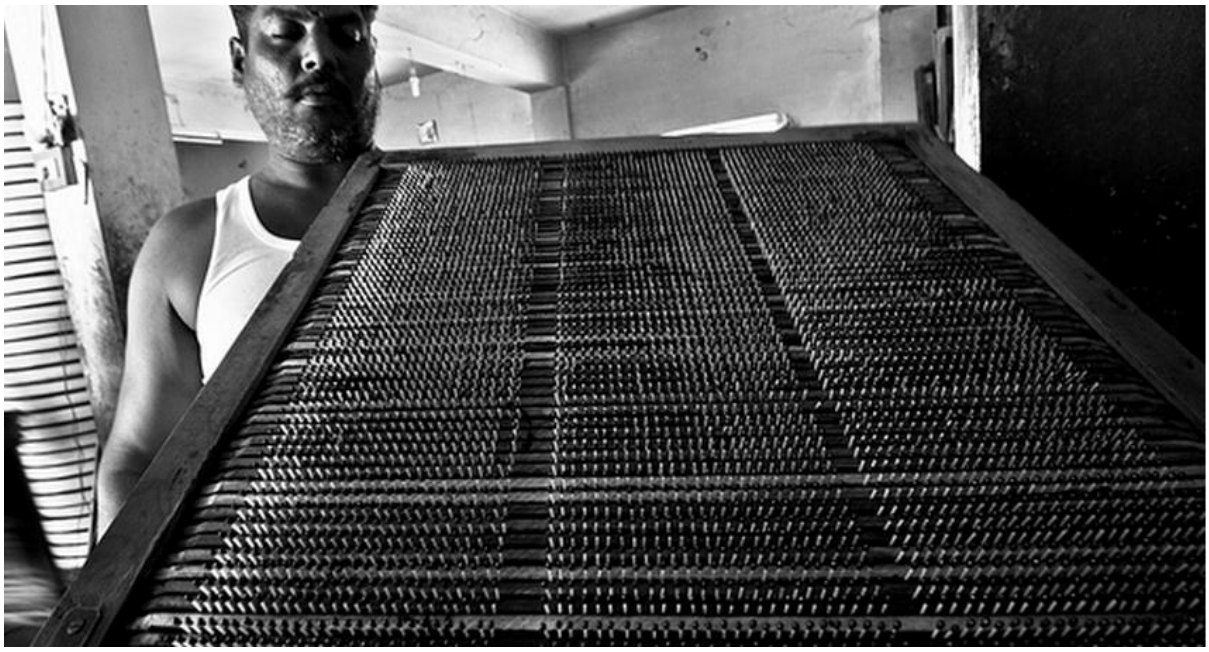


Figure VI-DRYING OF STICKS

CHAPTER-3

3 METHODOLOGY

3.1 PROBLEM STATEMENT

Once the sticks are dried it is filled in the match box manually. This job takes more time and it is hectic. So we have decided to automate the process.

Figure VII-MANUAL FILLING AND PACKING

3.2 OBJECTIVE

We have planned to solve the problem in two simple steps as follows:

Part-I: Falling of match sticks

We have planned to release sticks row by row. In order to implement this, a suitable method to be selected such that only one strip is released and others to be hold. The forward strips slide down and due to gravitational force the matchsticks falls down vertically and process to be continued to last strip.

Part-II: Feeding system

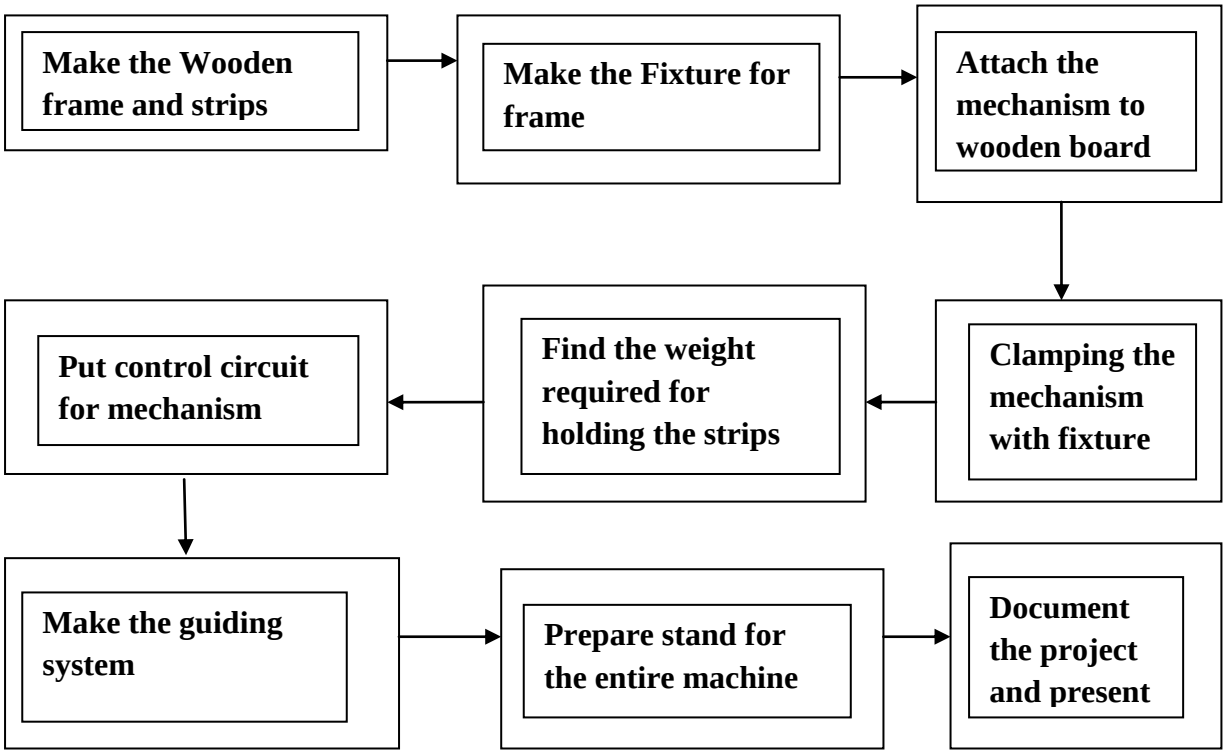
These falling matchsticks are guided to the match box using a **tram and a funnel system**. The box motion is controlled using **conveyor** and we get 40 sticks to be filled in a box.

3.3 SCOPE

- Design and fabricate the mechanism for falling of sticks.
- Design and fabricate the setup for filling of sticks.
- On the successful completion this project, one can implement it in the industry.

3.4 PROJECT PLANNING

After screening the problem statement, we started with literature review of mechanism basics. The primary data for starting the research was obtained directly from the company "**THE GAYATHRI MATCH INDUSTRIES", Coimbatore.** During phase one the team underwent integrated study of various feeding mechanism for selecting an optimum required one. The preliminary design was obtained using rope and pulley system. On the testing end it showed poor performance and then we tried with sprocket and chain mechanism. It required more space for working. Then we selected cross arm mechanism even after thinking in terms of pneumatic and Programmable logic circuits. After several iteration we got the required mechanism. Then we framed a bottom to top approach in the fabrication process.


Make the Wooden frame and strips
Make the Fixture for frame
Attach the mechanism to wooden board
Clamping the mechanism with fixture
Find the weight required for holding the strips
Put control circuit for mechanism
Make the guiding system
Prepare stand for the entire machine
Document the project and present

3.5 ABOUT THE WOODEN FRAME:

It is and rectangular size block which holds the wooden strips in the Groove cut along both sides. The groove surfaces are smoothened for sliding action. The nylon cloth is attached on both sides of strips so that matchsticks can be hold tightly.

3.6 SPECIFIC OBJECTIVE FOR THE SELECTION OF MECHANISM:

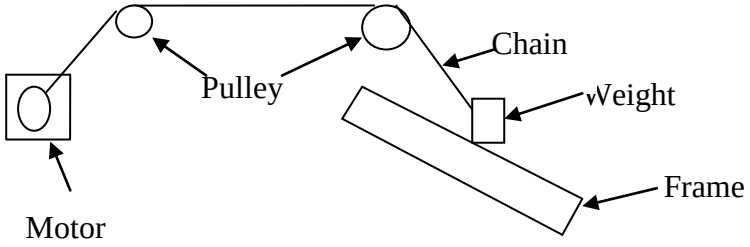
- The mechanism must hold strips tightly.
- Its working stroke should be equal to width of the wooden frame.
- It should release a single strip at a time and hold the other strips.
- It should hold the strips until matchsticks gets filled in the box.
- The process should be continuous and it should return back quickly for next frame work
- It should not damage the strips.

3.7 Selection of mechanism through trial and error method

Trail I:

Using rope and pulley system

The system has a weight on one end and the other end of the rope is coupled to the motor through series of pulley.



Disadvantages

- The slag side of rope hinder the movement of weight.
- The winding of rope requires proper guiding elements.
- The system requires larger space.

Trail-II

Using sprocket and chain

In this system the toothed profile is made on each sticks and sprocket is made to rotate in it. The sprocket is controlled by motor through chain. When it moves

form one strip to another strip, the match stick from the current strip is released and falls down.

Disadvantages

- The sticks wearing rate is high due to metal contact.
- Difficult in assembly and replacement of parts.

Trail-III

Using pneumatics and PLC circuits

The straight line motion can be achieved by using pneumatic cylinder and weight at end of the piston rod. The speed and directions of motion is controlled using directional valve and programmable logic control kit.

Disadvantages

- The setup is costlier.
- Need of air compressor input.
- The system is complex and leakage is series problem.

Trial – IV

Using straight-line mechanisms-cross arm mechanism

There are varies straight line generator mechanisms rotational motion of one link is transformed to straight line motion.

Commonly used straight line mechanisms are Watt's straight-line linkage, Robert's straight-line linkage, Chebyschev straight-line linkage, Hoeken straight line linkage, Evans straight-line linkage, Peaucellier straight-line linkage. They are six or five links mechanism which is difficult to design and it takes large spaces.

Scissor or cross arm mechanism is four bar mechanism in which two are sliding links.

3.8 DESIGN FAILURE MODE EFFECTIVE ANALYSIS FOR SELECTION OF MECHANISM (DFMEA).

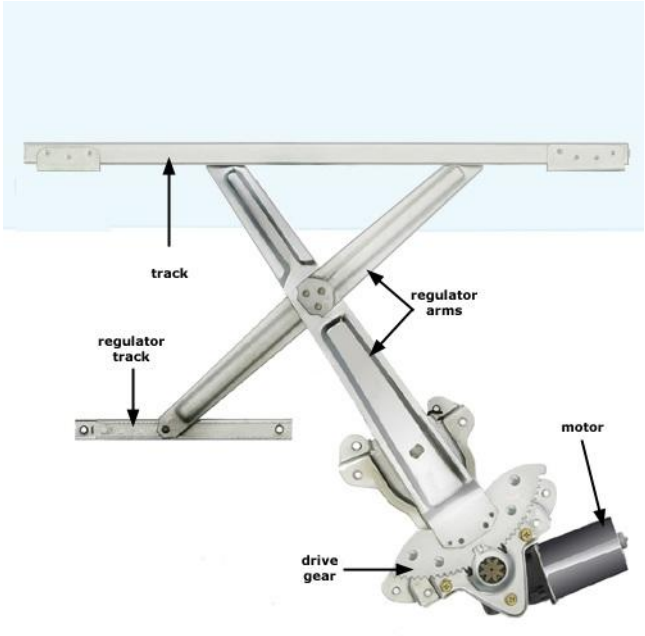
Item	Potential failure	Potential effect of failure	SEV	Class	Potential Cause of Failure	OCC	Current Design Control	DET	RPN	Recommended action	Action taken	RPN
Pulley	In Holding of strips	Can't control the sticks falling	8	c	Tension in the rope	9	Reduced the distance of pulley	7	504	Add support and guide	Position of pulley changed	284
sprocket	Difficulty in movement	Can't hold the strips properly	7	kl	Tooth profile Missing on strips	7	Change sprocket Size	6	294	More rigid support for holding	Rail system	144
Scissor	Fast working	Rapid falling of sticks	8	kl	High voltage and current	8	Timing circuit	4	256	Step down transformer	Linked the timer and Power system	18

After analysing various choices **scissor mechanism is chosen** due to following reasons

- Mechanism is simple four bar linkage and easy to design
- It is low cost and no need of compressed air source.
- It is easy to control and it is safe to operate.
- It has good reproducibility and flexibility.

3.9 SCISSOR OR CROSS ARM MECHANISM AND DRIVE SYSTEM

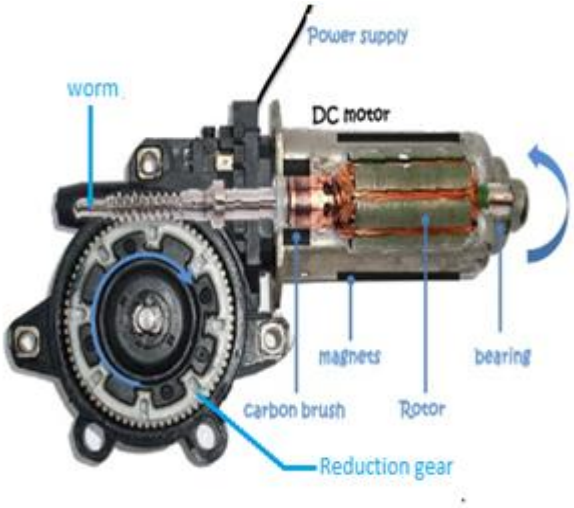
The scissor mechanism is used to convert rotational motion of motor into vertical motion by using gears and links.



The basic parts are

- Motor
- Drive gear
- Regulator arms or links with bushes
- Regulator track (fixed and movable)

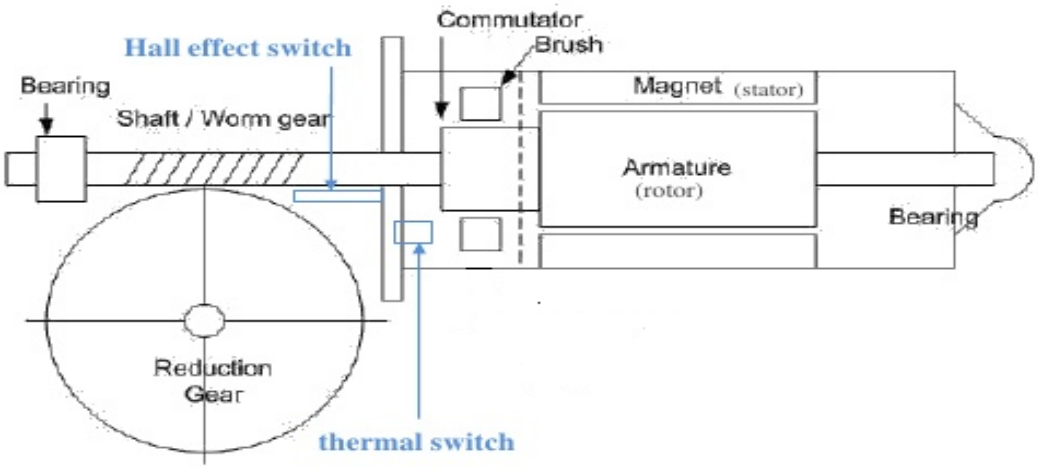
DRIVE SYSTEM



A **DC motor** is a mechanically commutated electric motor powered from direct current (DC). DC motors have a rotating armature winding (rotor) and a static field winding or permanent magnet.

If an Electric current flows through armature coils that are between the poles of a permanent magnet, it experiences a mechanical force whose direction is given by **Fleming's Left-hand rule**.

The loop can be made to spin by fixing a half circle of copper which is known as **commutator**, to each end of the loop. Current is passed into and out of the loop by **brushes** that press onto the strips. The brushes do not go round so the wire does not get twisted. This arrangement also makes sure that the current always passes down on the right and back on the left so that the rotation continues.

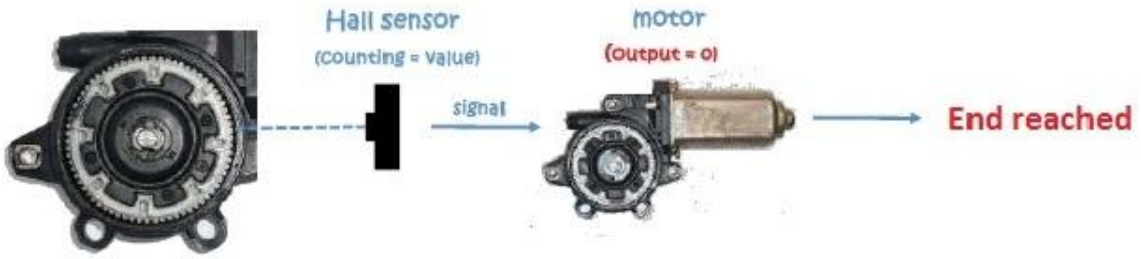


The end of the motor is connected to **Worm** which reduces the speed of motor which connected to **reduction gear.** Worm also prevents rotation of gears freely.

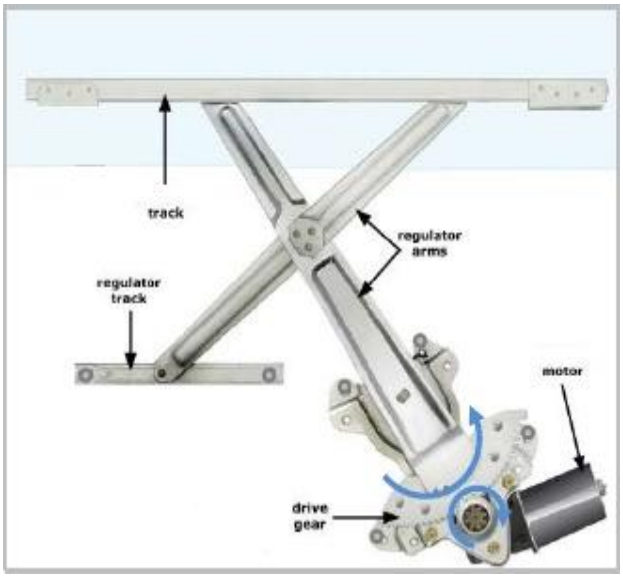
It has two safety switches: - Hall Effect switch and thermal switch**.**

Thermal switch is a safety switch which has thermal sensor in it, it stop the motor when it gets heated much preventing motor failure

Hall Effect switch is to control the rotation of gears. It has a counter which counts the number of gears rotated. When link reaches the end the Hall Effect switch will stop the motor in the same direction.



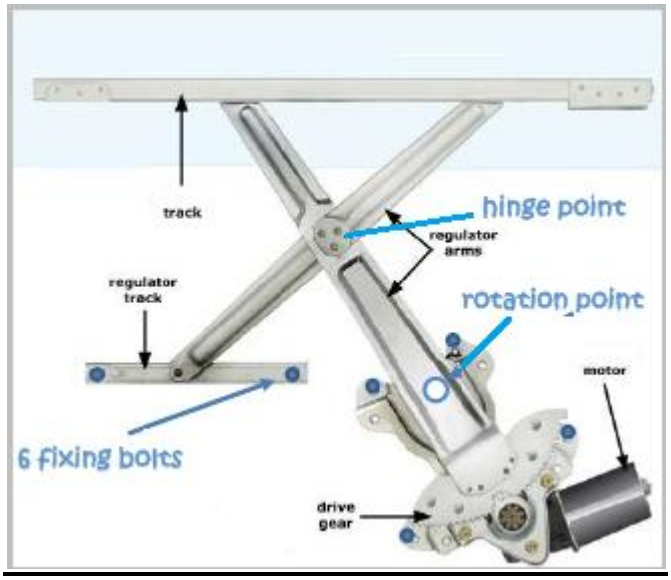
The gear at end of the motor is connected with a small gear through driving axis which is geared with a sectioned gear as shown in figure.



When motor rotates the small gear rotates which rotate the sectional drive gear.

Regulator arms and tracks

It consists of **two regulator arms and two regulator tracks**. The two arms are connected by a hinge at the middle. One end of a regulator is connected with drive gear through rotation point and one end of other regulator is made to move along a regulator track which is fixed by bolts. The other end of the regulators is connected by track which is movable.



3.10 MATERIAL USED AND PRODUCTION TECHNIQUES

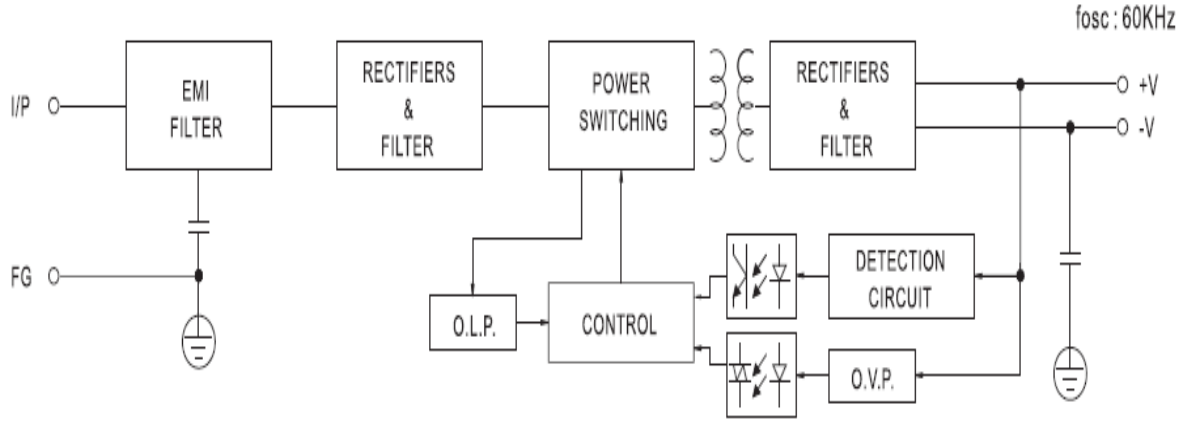
SI NO	Product	Material use	Production technique	Function
1	Worm	Stainless steel	Thread rolling	Reducing the speed
2	Worm gear	Polycarbonate (PC)	Injection moulding	Change of rotation axis
3	Driving axis	Stainless steel	CNC turning	Connecting small and reduction gear
4	Sectional spur gear	Stainless steel	Gear cutting	Transmission of torque from motor
5	Arm linkage	Galvanized steel	Deep drawing	To provide motion
6	Bolts	Galvanized steel	Heading-thread rolling-blackening	To hold parts tightly
7	Track regulator	Galvanized steel	Roll forming	To guide the arm linkage

3.11 POWER SUPPLY

A 12V DC motor is connected to mechanism. To reduce the speed of mechanism step-down transformer with rectifier circuit need to be used.
For this purpose **Mean well NES 35-5 model** is selected.

Output
DC voltage - 5V
Rated current - 7A
Rated power - 35W

Circuit diagram



The features are

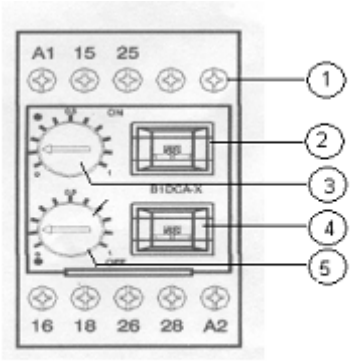
- universal AC input/full load
- protections: short circuit/overload/over voltage
- 100% full load burn-in tested

3.12 TIMING CONTROL - CYCLIC TIMER

The necessary time gap should be given in between release of strips so that the match sticks fall, slides down to box and next box comes to the position.
For this purpose **B Series B1DCA-X Timer** is selected. Its specifications are given below:-

Model	Function	Source Voltage	Time Range
B1DCA-X	Cyclic adjustable on-off	24V to 240V AC & 24V to 220V DC	0.6 secs to60 mins

It has two connections in one can be connected to motor and other can be connected to conveyor that holds the matchboxes. The ON timer is set based on the motion of mechanism and OFF is set based on time for filling the sticks in boxes.



1 TERMINAL SCREW WITH SELF LIFTING CLAMPS

2, 4 THUMB WHEEL SWITCH
This switch is used for the time range selection.

3, 5 KNOB
This knob is used to select the desired time range.

Terminal Details

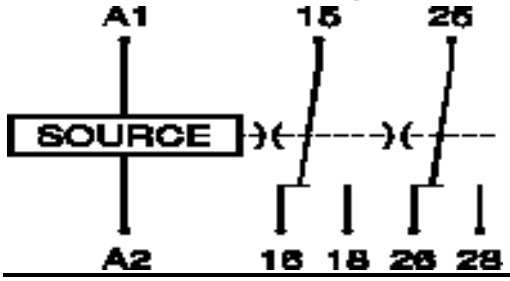
A1, A2 : Source

15-16, 25-26: Normally Closed (NC)

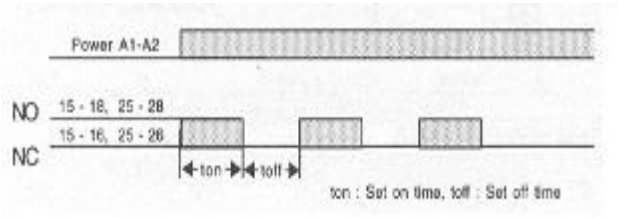
15-18, 25-28: Normally Opened (NO)

* The timer resets on power interruption.

Connection diagram



Timing diagram

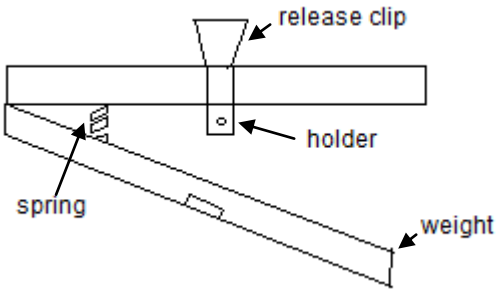


Connection of timer

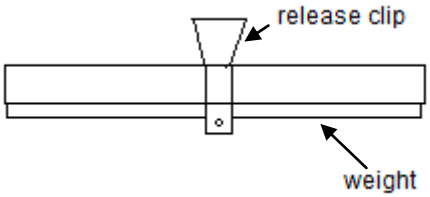
- Set the ON delay using the upper thumb wheel switch and knob.
- Set the OFF delay using lower thumb wheel switch and knob.
- Apply rated voltage across A1 & A2 ON delay starts (ON LED GLOWS) with the closure of the NO contacts.
- At the end of the set ON delay the 2 c/o contacts revert back to normal position and set OFF delay starts(OFF LED glows)
- The cycle repeats till the power is interrupted.

3.13 WEIGHT HOLDER

During forward stroke weight remain in contact with the strips due to free falling of weight and expansion of spring. During return stroke weight get entangled in the holding pin due to compression force acting on the weight, It get loosen when the release pin is pressed after reaching initial position.



During forward stroke



during return stroke

3.14 FEEDING SYSTEM

These falling matchsticks are guided to the match box using a **tram**. The box motion is controlled using conveyor. The is made of aluminium sheet of 0.2 mm thickness.

The aluminium is chosen since it has

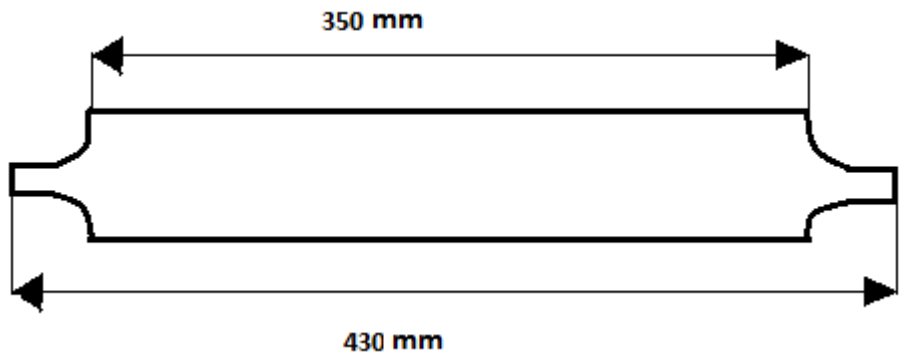
- Good corrosive resistance.
- Less coefficient of friction and surface resistance.
- Less weight.

3.15 DESIGN CALCULATIONS:

Design of weight and inclination

The basic parameters for design calculations are

- Wood frame width.
- Wooden strips thickness.



Density of wood ρ= 238kg/m^3

Coefficient of friction between wood surface μ= 0.4

Volume of one stick = length × width × thickness

= 430 × 430 × 15 × 10^{-9}

= **2.7735 × 10^{-3} m^3**

Weight of 1 stick = density × volume

= 238 × 2.7735 × 10^{-3}

=0.66 kg

Weight of 25 sticks = 0.66 × 25

= **16.5 kg**

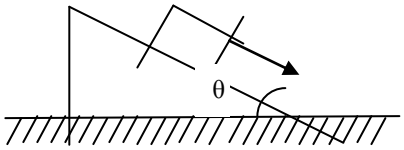
Inclination of wooden frame

Angle of plane in which body slides itself due to its body weight is called **angle of repose.**

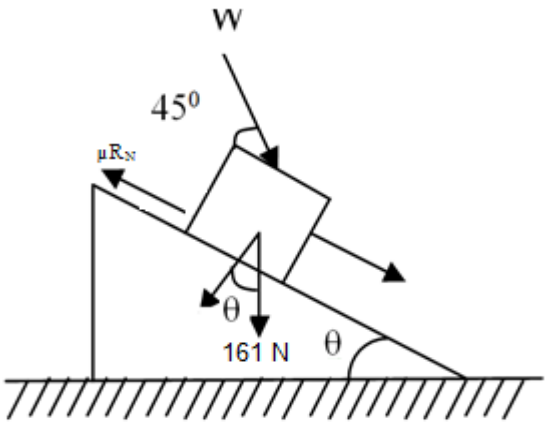
Angle of repose **θ = $\tan^{-1}$ μ**

θ = $\tan^{-1}$(0.4)

= **20^0**



Finding of Weight

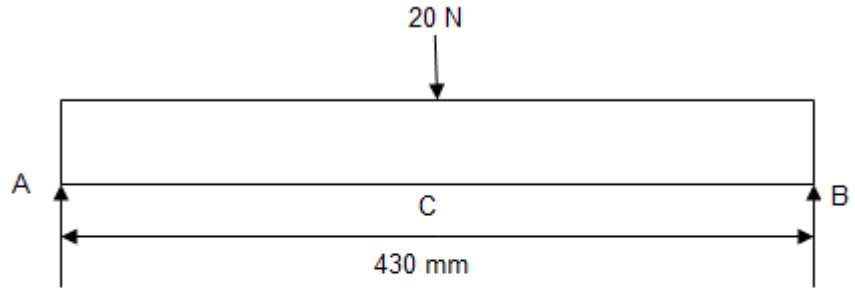


Equating vertical component, we get
$W\sin 45 + 161\cos 20 = R_N$
$R_N = 171 + 0.707W$ ------ I
Equating horizontal component, we get
$171\sin 20 + 0.707W = \mu R_N$
Substitute equation I
$58.6 + 0.707W = 0.4*(171 + 0.707W)$
W =21.1 N
W =2.1 kg

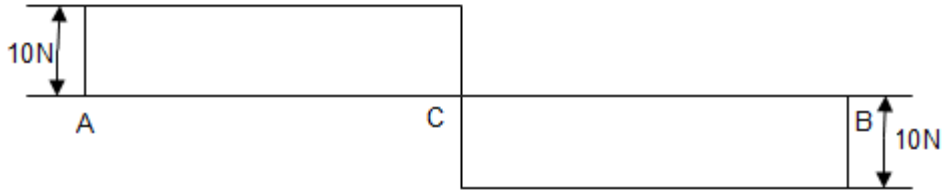
Checking the strength of wooden strip
Consider wooden frame as simply supported and load at centre

Upward and downward forces are equal. So,
$R_A + R_B = 20$ ----II
Taking moment about B, we get
$R_A*430 = 20*210$
R_A = 10 N
Substitute in equation II
R_B = 10 N
Bending moment will be maximum at centre c
$M_C = (R_A * L)/4$ **= 2.15 Nm**

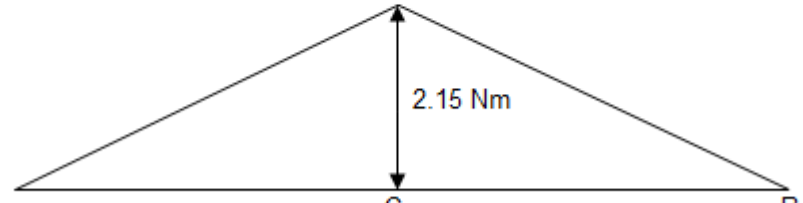
Shear force and bending moment diagram is given as



FREE BODY DIAGRAM



SHEAR FORCE DIAGRAM



BEANDING MOMENT DIAGRAM

Moment of inertia is

$I = b*d^3/12$

$= 14*(22)^3 *10^{-12}/ 12 =$ **$12.42 * 10^{-9} m^4$**

Section modulus is

$Z = I / (d/2)$ = **$1.129*10^{-6} m^3$**

Bending stress is given by

$\sigma = M / Z$ = 1.9 MPa

Ultimate compressive strength s_u is 225 MPa

Deflection at the centre is

$y_c = WL^3 / 48EI$

young modulus is given by E = 550 MPa

$y_c = 20*(.43)^3 / (48*550*10^6*12.42*10^{-9})$

= **2.411 mm**

Take fos =10

For **maximum principle stress theory**

s_u / fos > σ

225/10 > 1.9

Satisfies failure theory, selection is safe.

Design of pinion and drive gear

step 1:- estimation of module diameter of pinion and gear

power of motor P=V * I

= 7*5 = 35 Watts

assume radius of drive gear r_g is 95mm, radius of pinion r_p as 10.75 mm, speed reduction is 8.8: 1, number of teeth in pinion is 8 and velocity should be 0.025m/s.

angular velocity of drive gear $\omega_g = v/ r_g$ = 0.265 rad/s

angular velocity of pinion $\omega_p = v/ r_p$ = 1.17 rad/s

speed of drive gear $N_g = \omega_g * 60/ (2*\pi)$ = 2.53 rpm

speed of pinion $N_p = \omega_p * 60/ (2*\pi)$ = 11.18 rpm

pinion gear is made of 40C8 carbon steel. So s_{ut} = 600 N/mm^2

z_p = 8 teeth

$z_g = iz_p$ = 8.8*8 = 70 teeth

Estimation of module on beam strength

Lewis form factor for 8 teeth from PSG design data book (PSGDDB) is

Y = 0.16

for v = 0.025 m/s, velocity factor

c_v = 3/ (3+v) = 0.99

assume b/m is 20 service factor c_s are 1 and fos as 3. Then module is obtained from equation:-

$$m = \left(\frac{60*10^6}{\pi} \left(\frac{P*c_s*fos}{z_p*N_p*c_v*\left(\frac{b}{m}\right)\left(\frac{s_{ut}}{3}\right)*Y} \right) \right) \wedge \left(\frac{1}{3}\right)$$

substituting values we get

m = 2.6875 mm

diameter of pinion gear $d_p = mz_p$ = 21.5 mm

diameter of drive gear $d_g = mz_g$ = 190 mm

face width of pinion b = 20*m = 53.75 mm

step 2:- check for design

Beam strength $s_b = m*b*\sigma_b*Y$
ultimate tensile strength σ_b is 300n/mm^2
s_b = 7391.7 N
$M_t = p_t * 60/(2*\pi*N_p)$ = 30 Nm
p_t = $\frac{2*M_t}{d_p}$ = 2781N
p_{eff} = $\frac{c_s}{c_v}$**$*P_t$** = 2783.78 N
fos = s_b / p_{eff} = 3
The design is satisfactory.

Step 3:- for dynamic load based on Buckingham's equation

$\varphi = m+0.25(d_p)^{0.5}$ = 3.8467
e_p = 8 + 0.63φ = 10.42 µm
from PSGDDB ,steel deformation factor C = 11400N/mm^2

$$p_d = \frac{21*v*(c*e*b+p_t)}{21*v+\sqrt{(c*e*b+p_t)}}$$

substituting values we get
p_d = 48.5 N
$p_{eff} = (c_s*p_t + p_d)$
= 2785.08 N
fos = $\left(\frac{s_b}{p_{eff}}\right)$ **= 3**
The design is satisfactory

Step 4:- dimensions and specifications of gears

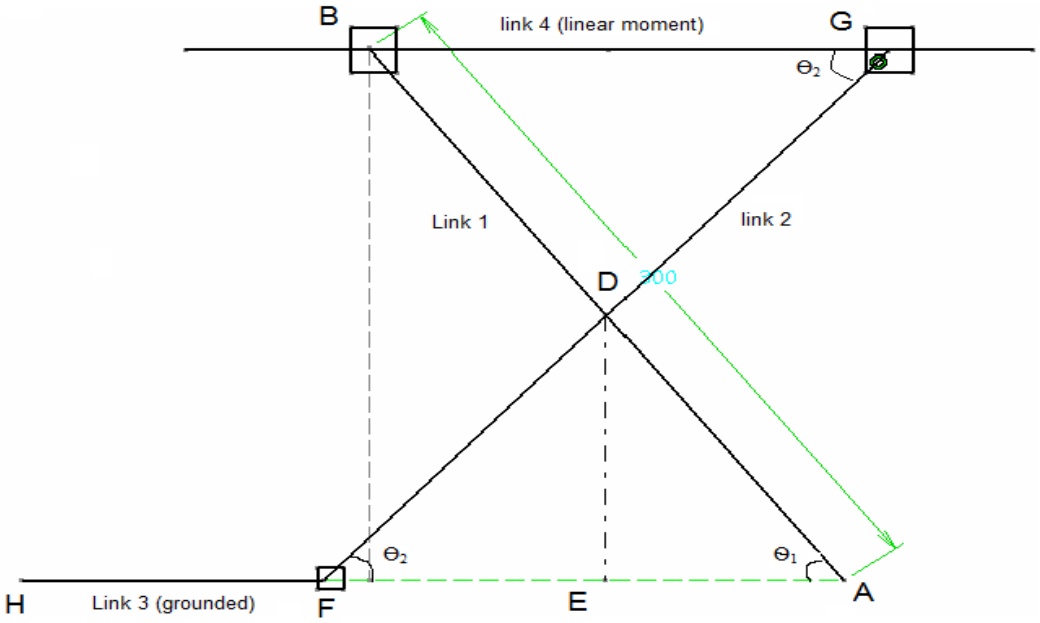
- pitch circle diameter of pinion d_p = 21.5 mm
- pitch circle diameter of drive gear d_g = 190mm
- number of teeth in pinion = 8
- number of teeth in drive gear = 70
- angular velocity of pinion ω_p = 1.17 rad/s
- angular velocity of drive gear ω_g = 0.265 rad/s
- speed of pinion N_p = 11.18 rpm
- speed of drive gear N_g = 2.53 rpm
- module = 2.6875 mm
- addendum (m) = 2.6875 mm
- dedendum (1.25m) = 3.36 mm
- clearance (0.23m) = 0.67 mm
- tooth thickness (1.5708m) = 4.22 mm
- fillet radius (0.4m) = 1.075 mm

Design of mechanism

number of links **L = 4**
number of joints **J = 4**(three sliding and one hinge joint)
number of grounded link **G = 1**
substitute in **grueblers equation**, we get
degree of freedom or mobility M is

M = 3L -2J - 3G
= 3*4 - 2*4 - 3*1
M=1

The mechanism has one degree of freedom.
To design the links of mechanism the main parameter is that the stroke length should be equal to width of wooden frame.
First assume length of any one link. Take link length as 300 mm so that it moves for entire width of wooden frame.
The drive gear radius is designed to be 95 mm.



consider ◺ABC
AB = 300 mm, BC = 240 mm
$\theta = \sin^{-1}(240/300) = 53.13^0$

consider ◺ADF
AE = 150*cos53.13 = 90 mm
For drive gear total arc angle is 53.13*2 = **106.26^0**
total arc length is
= **radius * π* θ/180**
= 95*106.26*π/180 = **176.18 mm**
circular pitch of gear is found to be 0.6 mm
number of teeth is arc length / number of teeth
= 176.18/0.6 = **29 teeth**
assume link to values and select the optimum value

Trial 1 :-
For link 2 length as 400 mm
consider ◺BDG
BD = 150 mm , DB = 200 mm
BG = 200 / sin 53.13^0 = 250 mm
$\theta_2 = \sin^{-1}(150/250) = 36.87^0$

consider ◺DEF

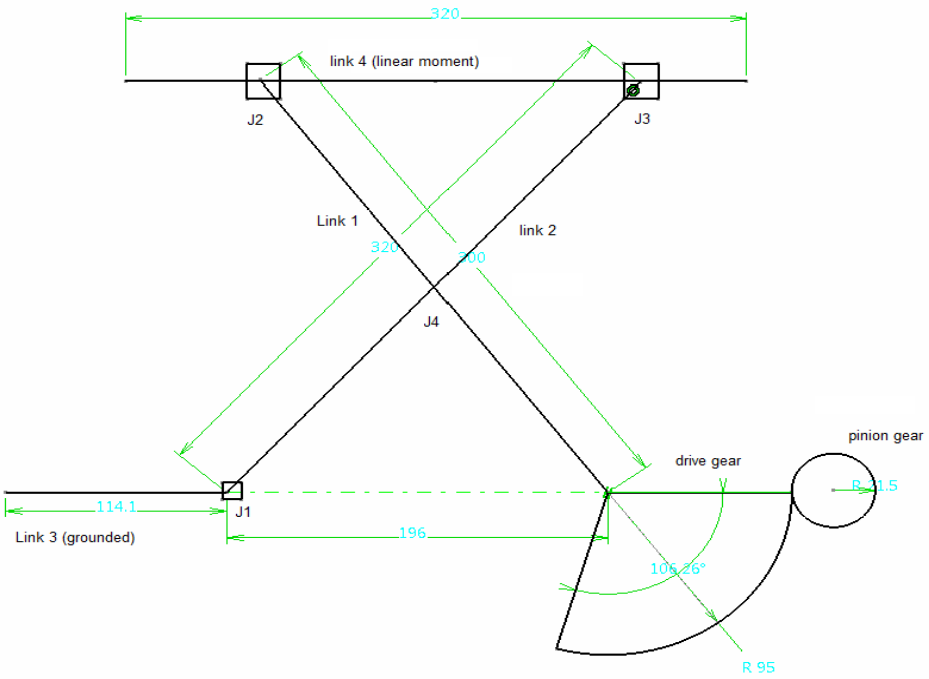
EF = 200*cos36.87^0 = 160 mm
AF = AE + EF = 266 mm
length AH = AD + DF
= 160 + 200 = 360 mm
length HF = AH - AF
= **94 mm**
so length of link 3 is 94 mm
length of link 4 is maximum at centre
= FG -(AH-AB)
= 340 mm
so length of link 4 is 340 mm

Trial 2 :-
For link 2 length as 320 mm
consider $\triangle$BDG
BD = 150 mm , DB = 160 mm
BG = 160 / sin 53.13^0 = 200 mm
$\theta_2 = \sin^{-1}(150/200) = 48.59^0$

consider $\triangle$DEF
EF = 160*cos48.59^0 = 106 mm
AF = AE + EF
= 196 mm
length AH = AD + DF
= 160 + 150 = 310 mm
length HF = AH - AF
= **114 mm**
so length of link 3 is 114 mm
length of link 4 is maximum at centre
= FG -(AH-AB)
= 310 mm
so length of link 4 is 310 mm
length of link 4 and position of link 3 of trial 2 is less compared to values of trial 1
so after trying different link value. Trial 2 values are taken.

The final specification is

- length of link 1 = 300mm
- length of link 2 = 320mm
- length of link 3 (fixed track) = 114mm
- length of link 4 (moving track) = 310mm



Time for releasing each stick

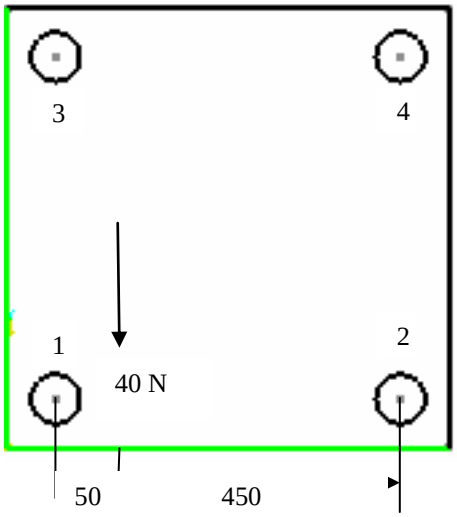
velocity in which link is moved = 0.025 m/s

time taken to move from one stick to another = width of one stick/ velocity

= $(15*10^{-3})/ 0.025$

= **0.6 seconds**

Design of bolt



ALL DIMENSION ARE IN MM

Total load is 40 N. the maximum load acting at bolt number 2 since moment is maximum.

primary shear stress

$p_i = \frac{P}{no\ of\ bolts}$ = 40 / 4 = 10N

secondary shear stress

$p_{ii} = \frac{(P*(l_1))}{(l_1{}^2+l_2{}^2)}$

$= \frac{(40*450)}{(50^2+450^2)}$ = 39.51 N

total load at bolt 2 is

$p = p_{ii} + p_i$

= 49.51 N

strength of the bolt σ = 75 N/mm^2

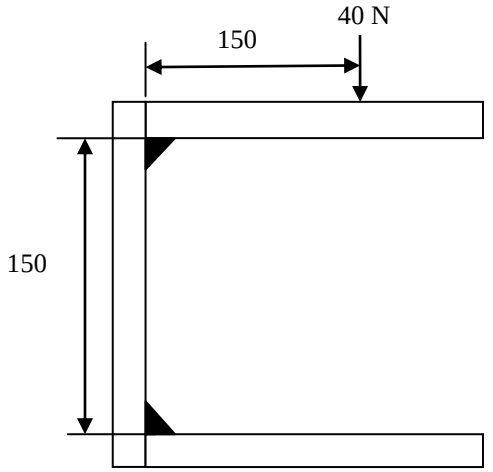
bolt area A = P/ σ

= 49.51/ 75 = 0.133 mm^2

from PSGDDB maximum allowable stress area for M5 bolt is 14.2 mm^2

so design is safe.

Design of welded joint



ALL DIMENSION ARE IN MM

Primary shear stress

$\tau_1 = P/A$

$= 40/(2*50*3)$

$= .133\ N/mm^2$

Bending stress

$\sigma = M/Z$

$M = P*e = 40*150 = 6000 Nmm.$

section modulus from PSGDDB

$Z = b*e*t = 50*150*3 = 22500\ mm^3.$

$\sigma_b = 6000/22500$

$= .266\ N/mm^2.$

Thus the resultant shear stress $\tau = \sqrt{\left(\left(\frac{\sigma_b}{2}\right)^2 + (\tau_1)^2\right)}$

$\tau = .188\ N/mm^2$

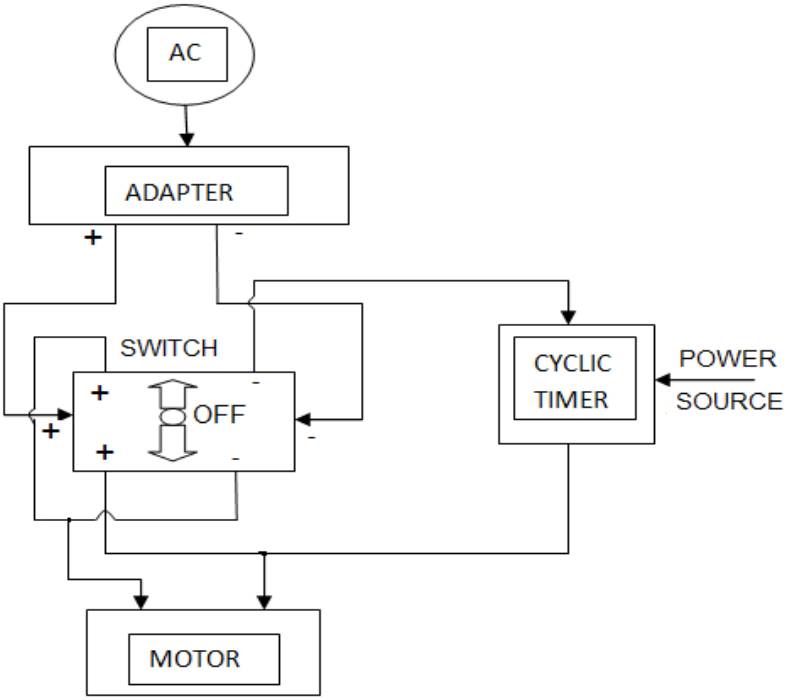
Form PSG design data book , For weld size of 3mm maximum permisable shear stress = $75N/mm^2$.

Hence the design is safe.

Electrical circuit diagram

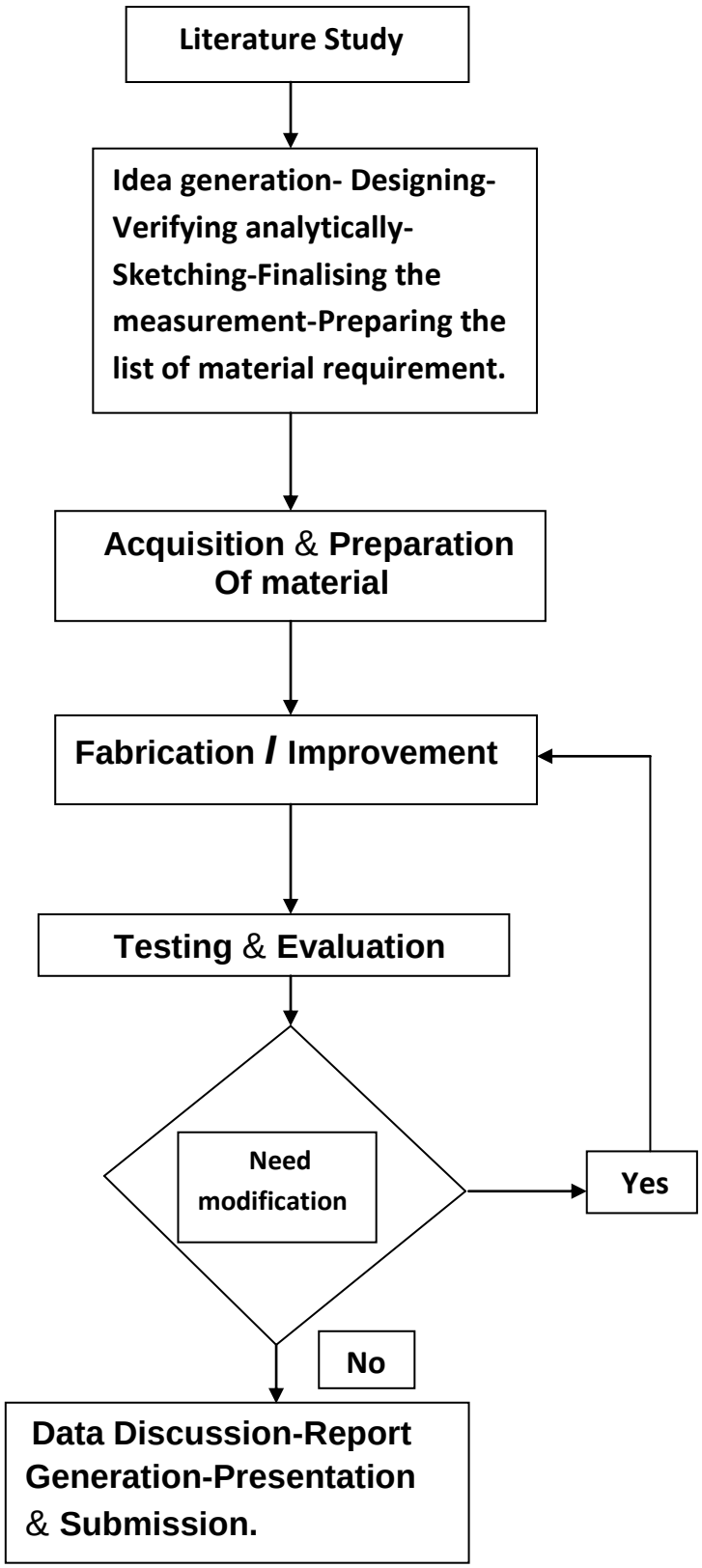
The connections are given such that cyclic timer works only for during working stroke. Thus weight returns back to starting position for next frame.

For this purpose 2 way switches is used. The timer controls the circuits through negative connection.



3.16 PROJECT FLOW CHART

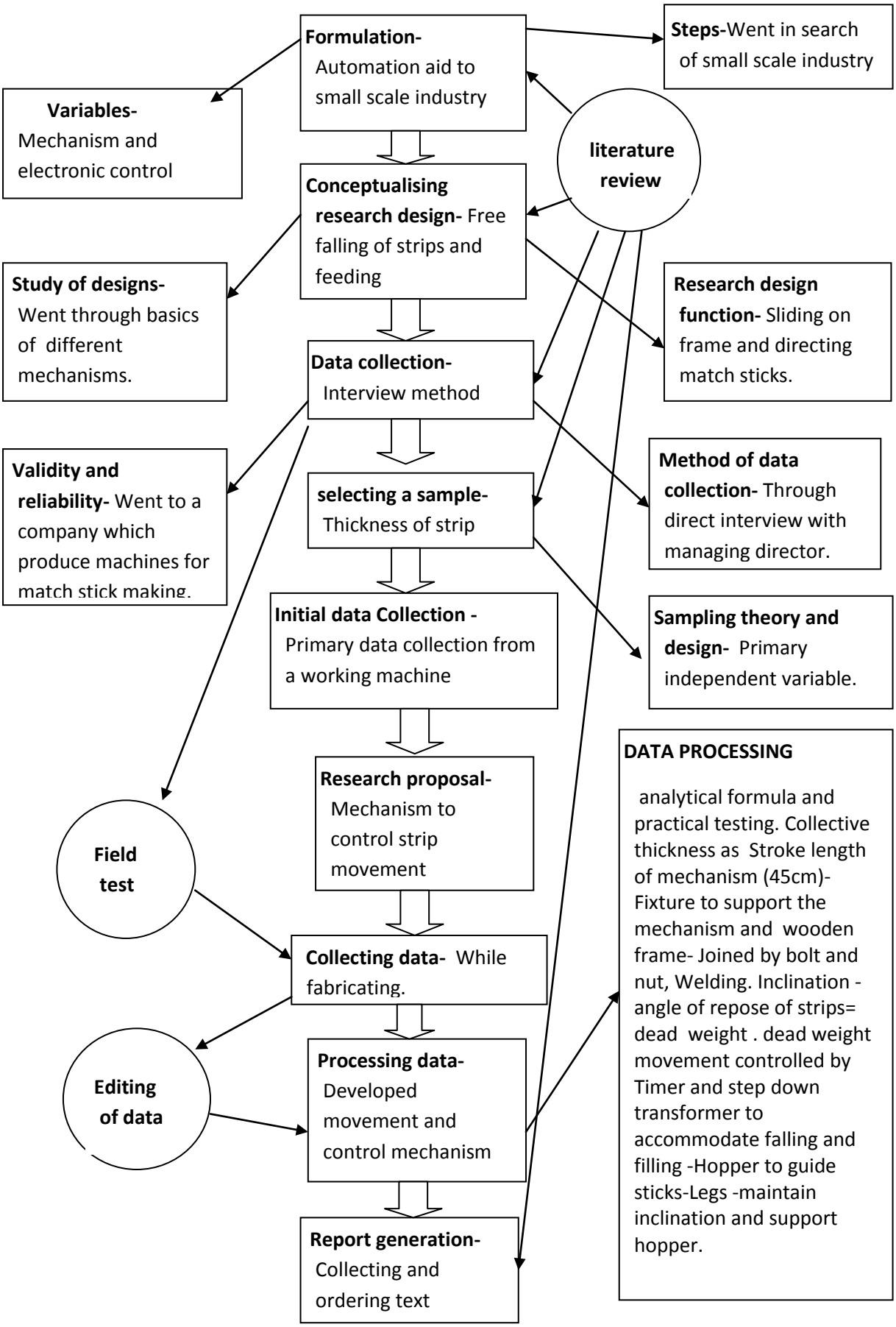
The study was about a small scale producer of wax match stick making machine- The Gayathri match industries, Pattinamputhur, Coimbatore. The purpose of the study was to make a contribution to small scale industry and increase productivity. The data collected was primary type, where we were able to get the dimension of the wooden frame from the working machine directly. The period of study and gestation period of the project was six months. The solution provided in filling of sticks to matchbox would cover all the industry where they fill the match box manually. The company was selected on the basis of industrial visit; the raw data of the wooden frame was processed by the following flow chart.


Literature Study
Idea generation- Designing-Verifying analytically-Sketching-Finalising the measurement-Preparing the list of material requirement.
Acquisition & Preparation Of material
Fabrication / Improvement
Testing & Evaluation
Need modification
Yes
No
Data Discussion-Report Generation-Presentation & Submission.

3.16 RESEARCH METHODOLOGY

We have framed the research methodology based on the eight steps of research process. We were in the idea of doing final year project in automation field. Then we thought that the project must be useful to a small scale industry. When we went in search of small scale industry, we found the gayathri match industries, Coimbatore. They produce wax match stick making machines. The problem of skilled labour in filling of sticks, Hazardous working was a constrain for human. We took the constrain in filling of sticks like miss orientation and number of sticks filled per box. Taking the thickness of wooded strip as a sample of our design we proceeded further. The reason for choosing this as sample is that it was a independent variable which controlled all other parameters. We took the collective thickness of strip as working stroke length of mechanism to feed the strip one by one. We designed a cross arm mechanism to solve the purpose. To support this mechanism and wooden frame we made a fixture in steel bar. We clamped the mechanism to the fixture using "c-clamps". The c-clamps were welded in the fixture ends and bolt jointed with another support frame to the mechanism. Then we found the angle of repose for the strip and found exact weight that must be added to the mechanism to control strip movement. The normal 12V, 5 amps working of adaptor was not solving the purpose due to rapid movement. To solve this we used a step down transformer which used 5V, 7 amps. Now the working time of mechanism was slowed down. In order to feed the sticks to box, one need interrupted working of mechanism. To aid this we went in search of cyclic timer. We got the B1DCA-X cyclic timer. The working time during forward stroke is .6 seconds working and 6 seconds idle time. It takes .6 seconds to move over a single strip & 3seconds for filling of sticks. To aid the directing of sticks we used aluminium sheet of .5mm thickness, optimised the angle of hopper by trial and error method. Then finally the stands were designed to the required angle of repose of the strips. The fixture frame to support the aluminium sheet was taken from wooden fixture base. The timer and the step down transformer come rectifier are clamped to the side of motor using wooden boards.

3.2 THE EIGHT STEPS OF RESERCH METHODOLOGY



3.17 The Gantt chart

Scope	Weeks																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Literature review	■	■						■										
Design and measurement consideration			■	■														
Acquisition & Material preparation				■	■	■	■											
Methodology study							■	■	■									
Fabrication									■	■	■	■	■	■	■	■		
Evaluation & Improvement				■								■	■	■	■			
Report writing				■												■	■	
Presentation					■			■			■			■				■

Week 1-2:

We went in search of a small scale industry where automation could improve the productivity. We found the Gayathri match industries, Patinamputhur, Coimbatore. Found the constrain in filling of match sticks to the boxes.

Week 3-4:

We proposed a conceptual design to Mr.P.N. Senthil Kumar. We were able to collect the primary data from the working machine there. We fixed the thickness of the strip as a constrain for initiating the preliminary design. We proposed a need of mechanism for falling and filling.

Week 5-7:

We ordered the same set of frame with adequate number of strips. We initiated the process with pulley and weighted system, which resulted in poor control over strip thickness. Then again we iterated with sprocket and chain mechanism. The resultant mechanism was bigger in size and wear between the

surfaces of contact was more. Even we tried with pneumatic and programmable logic control which was costly solution and so we dropped it. We again looked into literature review constrains.

Week 8-9:

We again went for deeper study about mechanism and found that cross slider would solve the purpose. After three iteration we were able to find a mechanism with optimum length. When we went in search of mechanism in the market we got similar one with minimum variation.

Week 10-12:

We started the main fabrication process with the fixture designed to hold the wooden frame. We used the same weighted system to solve the purpose. We found the weight by keeping the apparatus in the inclined position. We found the angle of repose to be 20 degree. We found the dead weight to be 2 kilograms.

Week 13-15:

We found that the normal 12volts, 5 amps working of motor drive to be very sensitive and fast. So we changed the rating of motor to be 5 volts and 7 amps using step down transformer. To aid the falling and filling of sticks the working must be interrupted. We added a cyclic timer B1DCA-X which solved the purpose exactly. We clamped the timer and power set up in the side of the motor. We clamped the mechanism with fixture using a wooden frame joined by bolts and nuts.

Week 16:

Now we were in the position of making guiding system which carries the sticks to the box. We used aluminium sheet of .5mm thickness to solve the purpose. We found the exact angle of the inclination of aluminium sheet by trial and error method. Then we made stand to support the fixture with angle of repose(20 degree) and the guiding system with proper guiding angle of about 25 degree inclination.

Week 17-18:

Report generation and final presentation generation with fine tune adjustment in the working model.

CHAPTER-4
4 RESULTS AND DISCUSSION

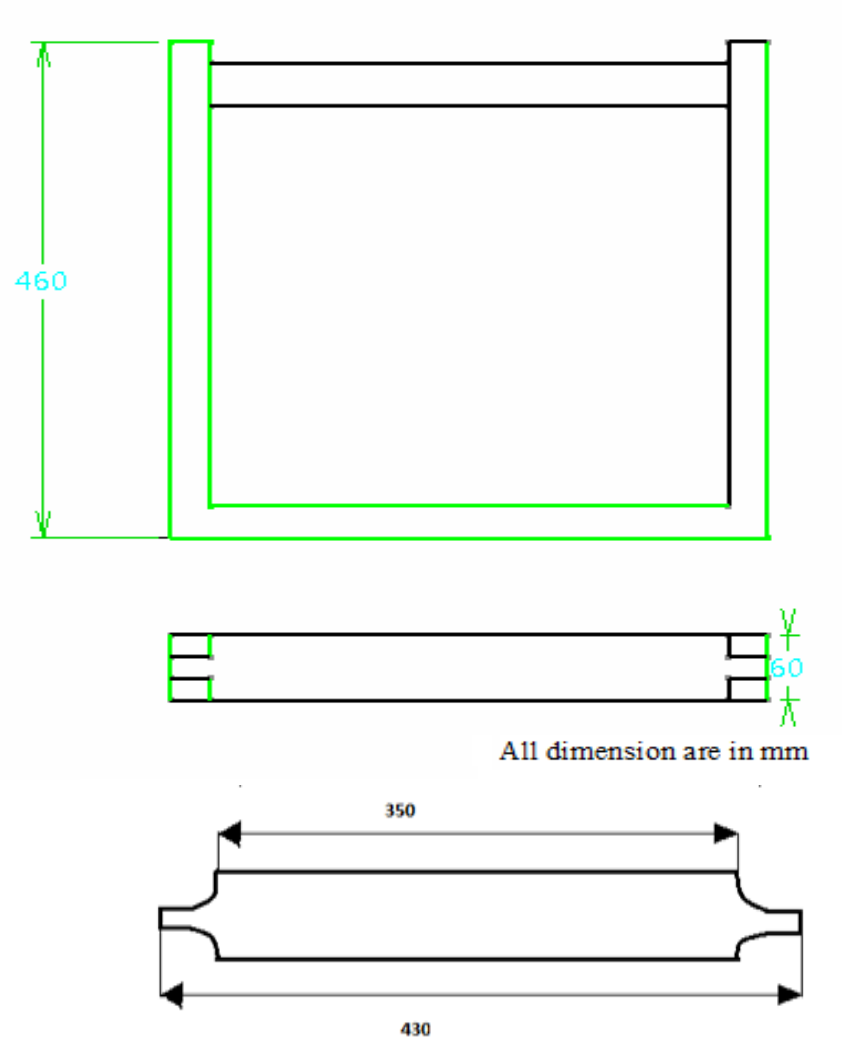
4.1 FABRICATION PROCESS

4.1.1 PRELIMINARY DESIGN

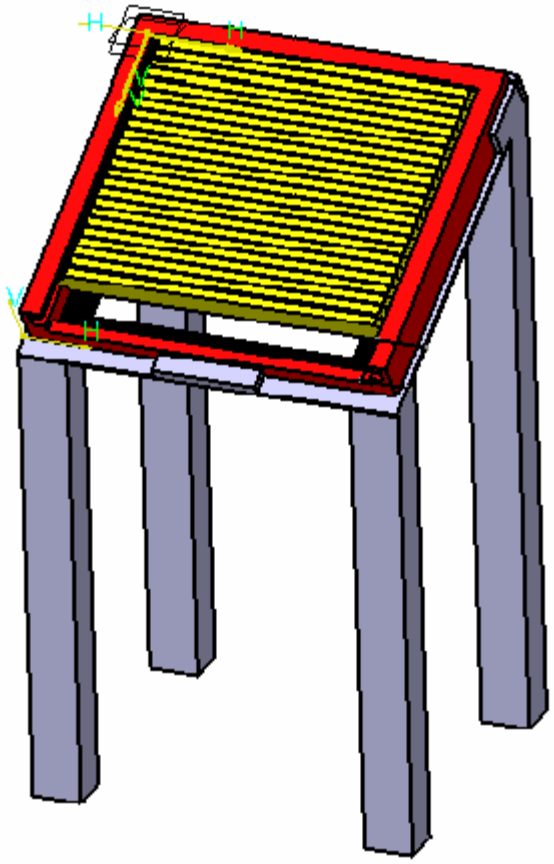
The initial designing was done in CATIA V5R19 designing software and the proposed model was verified analytically using formula and design was confirmed. Even the slight change during fabrication was updated later into the main design.

The wooden frame design in 2D: The frame is made of ordinary carpentry wood with grooves to provide sliding motion of strips.

2D diagram of strip and wooden frame

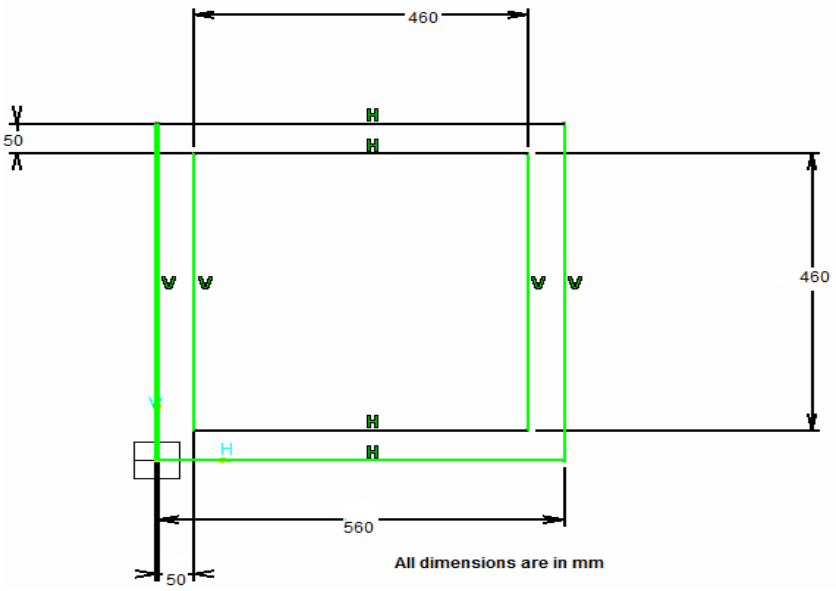


The 3D model of wooden frame with fixture and stand:

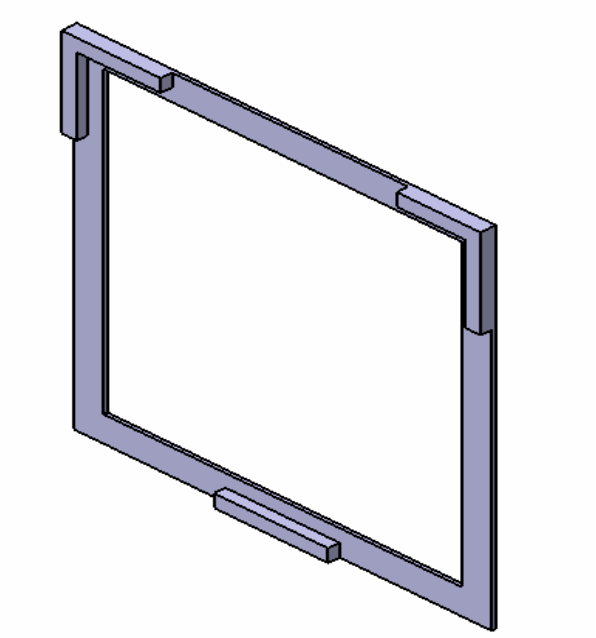


The wooden frame is then mounted on the steel fixture frame with accurate dimension to hold the frame rigidly during the working process.

The Fixture 2D diagram:



The fixture 3D diagram model:

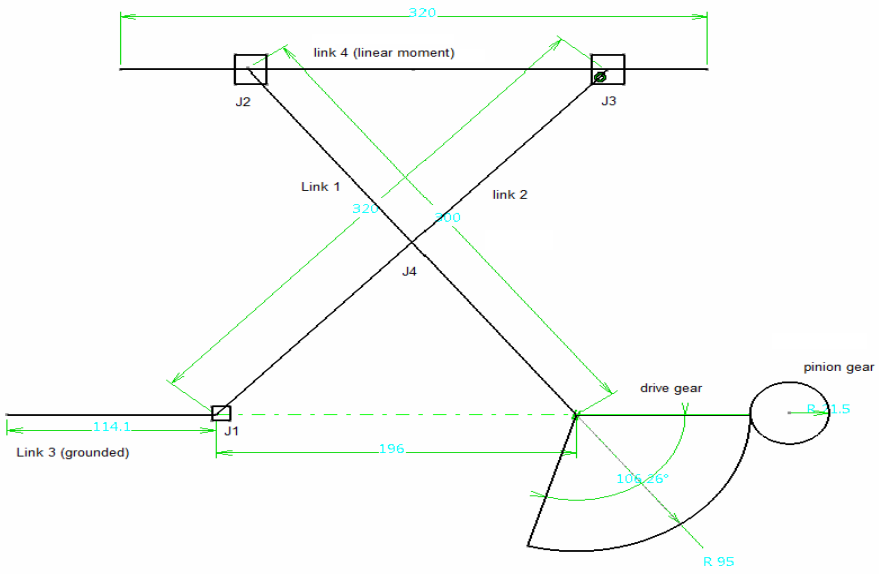


The fixture is welded using arc welding machine. The metal strips outer dimension are 50mm*560mm*3mm.

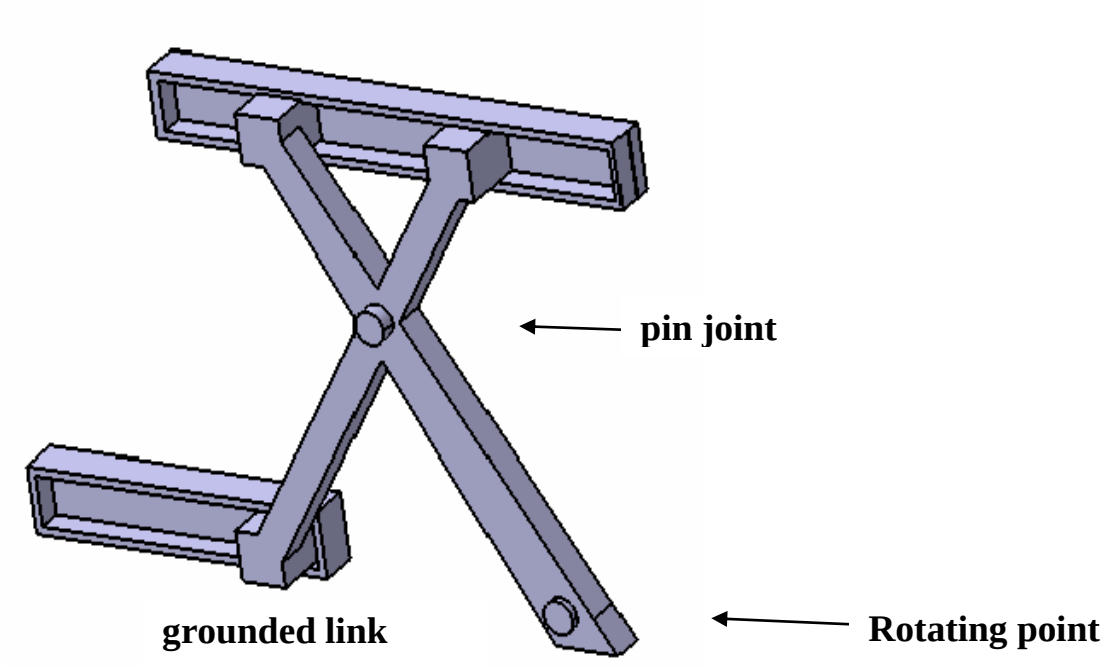
The fixture steel bars were cut using power hacksaw cutting machine.

The mechanism is mounted parallel to the fixture using C-clamps and bolts:

The 2D diagram of mechanism:



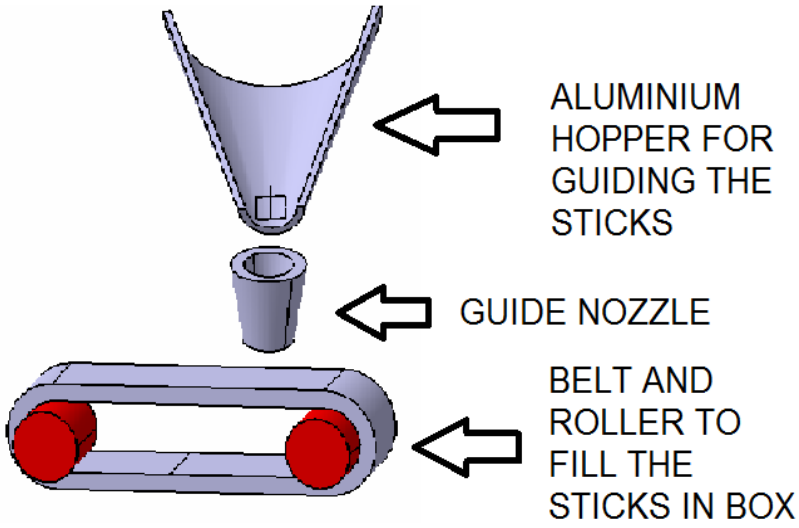
The 3D model of mechanism:



The mechanism is mounted on the C-clamps using bolts and nut. The bottom of C-clamp is mounted to fixture by arc welding process.

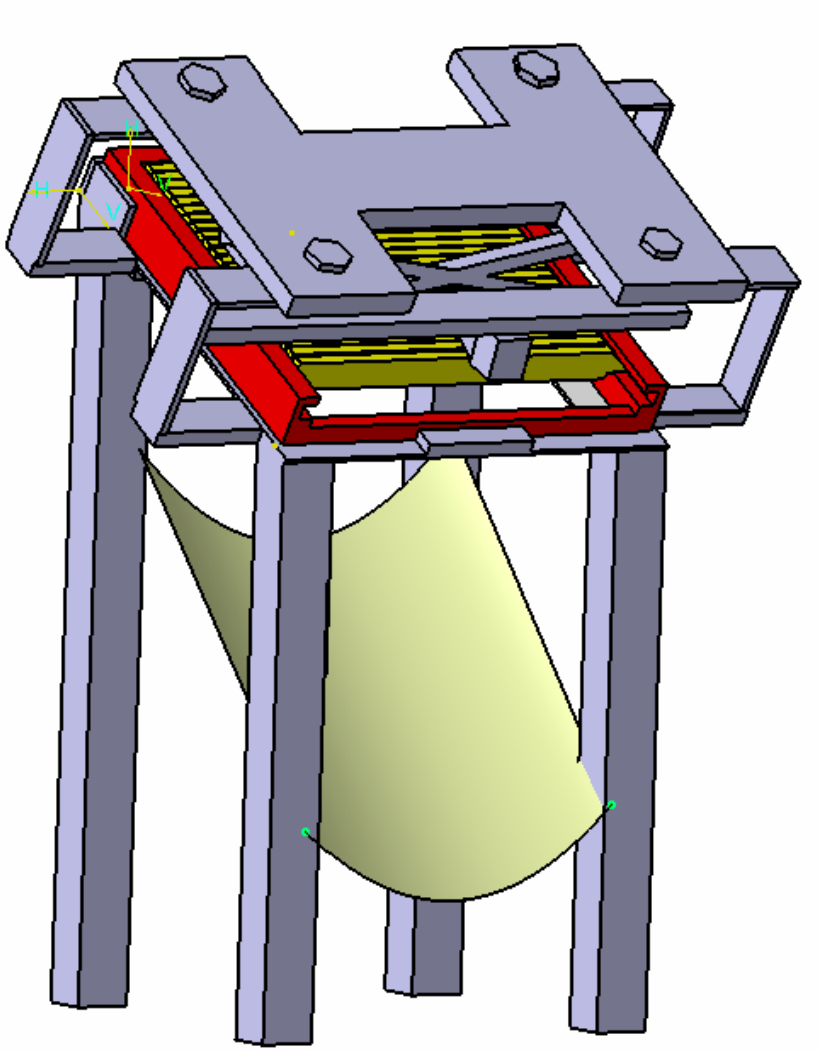
The inclination is found out using angle of repose (20 degree) of strips and the weight is increased accordingly. The timer and step down transformer are used to control this drive motor of mechanism. The feeding system aluminium sheet inclination is found out by trial and error method. It is found to be 25 degree.

The 3D model of feeding system:



The support for aluminium sheet was taken from the base of the fixture and it is connected by bolted joints.

3D model of complete machine after assembling



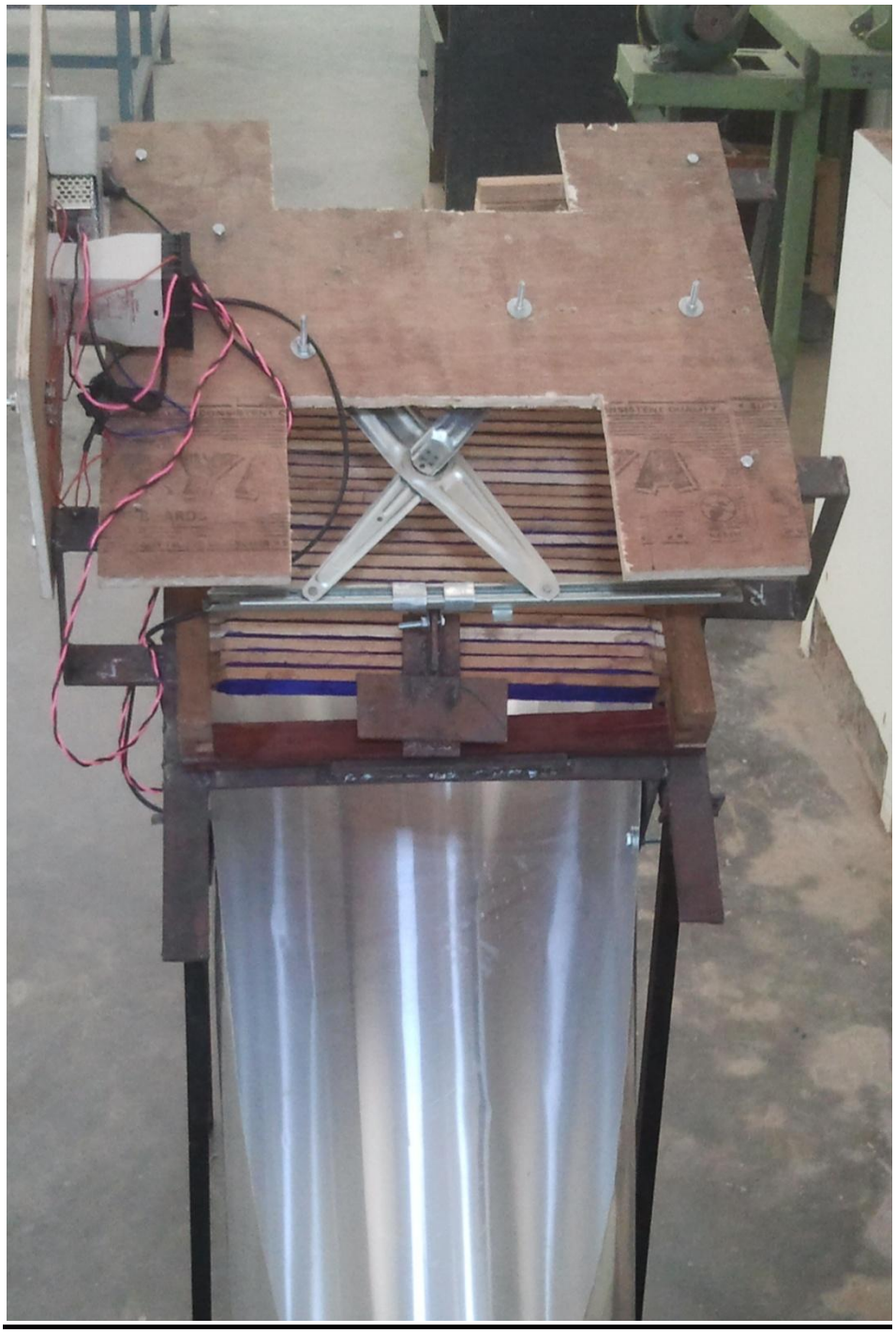
Stand

The stand is used to provide support to the apparatus inclination angle and feeding system inclination angle.

Special note

The mechanism and timing control setup can be fixed using six bolts and nuts.

4.2 Final fabricated model



4.3 THE COST ANALYSIS

SI NO	MATERIAL	AMOUNT (Rupees)
1	WOODEN FRAME & STICKS	500
2	CROSS ARM MECHANISM	1800
3	WOODEN BOARD	150
4	CYLIC TIMER	1350
5	ADAPTER 35 W	1500
6	2 WAY SWITCH, WIRE ,CUTTER, BOLT AND NUT	300
7	ALUMINIUM 80*60 mm^2	250
8	METAL STRIP	400
9	WELDING COST	175
TOTAL COST		6425

CHAPTER-5
5. CONCLUSION

We were in the motive to find a small scale industry and enhance production using automation techniques. We went in search of small scale industry in and around Coimbatore. We found that the contribution from the gayathri match industry to the society in the field of match sticks inevitable.
The reason behind choosing this industry is that they produce machine that make match stick. The primary data can be easily obtained and the implementation scope is more.
We found that the existing machines in the gayathri match industries were performing to the greater level of satisfaction till match stick chemical dipping.
They had a constrain in manual filling of match sticks after chemical dipping. The company was in the motive to make a machine that would solve the problem of manual filling. We took this as a problem statement and underwent much deeper study about the mechanisms. We proposed preliminary idea to the company and they told us to make a working model of the idea we proposed.

5.3 RECOMMENDATION

We design the model and verified it by analytical methods and proceeded further. We made three iteration in the mechanism for accurate movement over the strips. In order to achieve this we got technical support in terms of electronic aid (Timer, Step down transformer).

After undergoing a complete bottom to top approach in the machine development, we found several iteration in the subsystems. We have successfully implemented those updated in terms of fabrication and designing.
Now we are in the position to strongly implement in the industry on its successful project validation by the external examiner.

5.4 FURTHER SCOPE OF STUDY

We have worked to the fullest extent and completed the fabrication till match stick filling into the boxes.
The timing control off mode terminal can be used to control the conveyor system in the box feeding. If the project reviewer finds to implement the project in terms of programmable logic control, He can work on it.

5.5 PROJECT CONCLUSION

It is inevitable in this world to live without enhancement in the working system. When it comes to advancement of mechanical system electronics play a vital role. The automation provides solution too many industrial constrains.
By implementing the automation in the match stick filling machine, the automation basics and present industrial scenario were also exposed to a greater level. On the successful completion of this project human effort could be reduced and productivity is improved.

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