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BACHELOR OF TECHNOLOGY
IN

MECHANICAL ENGINEERING

BY

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C E R T I F I C A T E

This is to certify that the work in this thesis entitled: “DESIGN AND FABRICATION OF AUTOMATIC CUTTING MACHINE” by **Patnala Ankit and Manas Ranjan Patra** has been strictly carried out under my supervision in partial fulfilment of the requirement for the degree of **Bachelor of Technology** in *Mechanical Engineering* from session 2011- 2015 in the Department of Mechanical Engineering, National Institute of Technology, Rourkela.

To the best of my knowledge, this work has not been submitted to any other University/Institute for the award of any degree or diploma.

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We are extremely thankful to **Prof. S.S. Mohapatra**, Head of Department of Mechanical Engineering. We are also greatly thankful to all the staff members of the department and all our class mates and friends for their inspiration and help. DATE: 10-05-2015

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ABSTRACT

The project undertaken is about the design and fabrication of a machine known as the motor driven cutting machine for food items. This machine was made with the intention of helping the fish sellers or also making the household task easier. This machine mainly comprises of two mechanism, i.e., Crank-Rocker mechanism and the Scott-Rusell mechanism clubbed together. A motor input was provided to drive the crank. The Scott Rusell then came into the picture with the desired blade movement that led to the subsequent cutting of the food items. This project was actually designed to benefit the fish sellers by increasing their productivity. There, it takes a long time to cut fishes so this mechanism would prove to be both handy as well as affordable for the fish sellers to cut the fish quickly and appropriately. Since the machine as fabricated in wood, it was light weight and portable.

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LIST OF FIGURES:

FIGURE 22	**CATIA MODEL OF THE CUTTER LINK**
FIGURE 23	**DIMENSIONS OF THE CUTTER LINK**

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(1) INTRODUCTION:

The new generation wants no manual labour and optimized work. Hence looking at the present scenario from the fish sellers to the chefs in high star rated hotels, including the household tasks of women in India, we came up with an idea to make a portable and economically viable machine that can be used in all fields with remarkable efficiency and fully automatic.

All the food items generally being eaten like potato, onion, cucumber, fruits like banana, papaya to meat and fish items are desired to be served in slices for making the food more delectable.

Generally, the commercially available machines have a complex design, are heavy and are manual. Along with this, their high marketed price refrain people from buying them.

(2) AIM OF OUR PROJECT

Looking at the prior desires for household task and industrial requirements, we came up with a plan to build a cutting machine that would be fast, cheap, portable, and handy and has the ability to cut the food items with desired thickness. In order to make it light we made it in wood as an alternative to mild steel that is costlier and requires a high torque motor. As our machine is built up with wood, hence we need a low torque motor which indeed means we can achieve higher R.P.M and thus we can obtain fast cutting motion. We tried to get the desired blade action with less number of possible links in order to make it portable. Thus, we clubbed the crank-rocker mechanism and the Scott-Rusell mechanism that helped us in building a machine with just six links. Taking due advantage of wood, we required less torque hence high R.P.M. Hence just by changing the potential difference across motor will help us in reducing the R.P.M with the same torque thus we can achieve different sizes of the slices of food items.

(3) LITERATURE REVIEW

The prior knowledge of “Theory of Machines " is quite essential for a mechanical engineer in order to build this type of handy commercial stuff. With the book written by Khurmi and Gupta [3] buoyed us in making link calculation for the equipment.

Looking into the needs of fishermen of Gariahat, a place in Kolkata we came up with an idea of building a cutting equipment that would work automatically, thereby reducing their time as well as labour that will undoubtedly increase productivity.

Looking up to the models which are commercially available and being sold in Asian sky shop ,we found that the type of slices that we are getting from it are not uniform and add to that those are hand driven .

Secondly many mechanical engineers have given their concept on these like “Design and Development of Automated Vegetable Cutting Machine ” by Tony Thomas, MuthuKrishnan.A, Sri Nandha Guhan.K.S [2] where they program the motion that would indeed require costly types of equipment like Arduino and servo motor. Hence, we aimed to produce economically feasible machine doing exactly the same thing. Another concept by Johnny Damian Anak Tawi in his paper titled “Industrial Design and Manufacturing of a Manual Driven Low-Cost Banana Slicing Machine" [2] where the design seems to be less compact and more complex. Along with this, it was manually driven.

After going through a lot of models in the commercial market, we inferred that the one meeting our requirements are quite heavy and thus not portable. Some even had very intricate design making the parts difficult to assemble.

Most of the models cut the vegetables and fruits gradually, so the cutting impact is less. Thus we thought of providing more impact load on food items and hence letting it fall from a height for proper cutting.

(4) METHODOLOGY

1) DESIGN OF MODEL IN SOFTWARE:

After making the link calculations as per our requirements, we tried to imitate the real product in CATIA V5 R17.

2) MOTION VERIFICATION:

Using kinematics and stimulation section in CATIA we were able to verify whether the path traced by the blade is meeting our requirement or not.

3) FABRICATION:

After getting the desired output in step 2, we started manufacturing each part of desired shape in wood with the help of carpentry tools.

4) ASSEMBLY:

Proper assembly of the wooden parts produced in step 3 with the help of bolts, nuts, washers and more.

5) MODIFICATION:

Some fallacies were observed after the assembly while in motion due to dynamic instability. In order to make it stable we had to modify our design either by changing equipment or by adding a new part.

(5) PRE-REQUISITES FOR FABRICATING THE MODEL

5.1 -FOUR BAR LINKAGE:

Four bar linkage is a simple closed chain. It has four links that are joined to each other in the form of a loop through four joints. However, this assembly is also called the planar four-bar linkage because all the links move in planes those are parallel to each other.

The links are formed by four joints having one degree of freedom. The link connected to the ground by a hinge is called the crank of the linkage. The link attached to the ground by the prismatic joint is also known as the slider.

The four very basic types of planar four-bar linkage are as follows:

1) Also known as the RRRR linkage, we have this linkage called planar quadrilateral linkage which consists of 2 cranks connected by a coupler. It has four revolute joints.
2) The second one is called the slider crank mechanism also known as the RRRP mechanism.
3) The third type is also called the RPRP mechanism having two revolute joints and two prismatic joints.

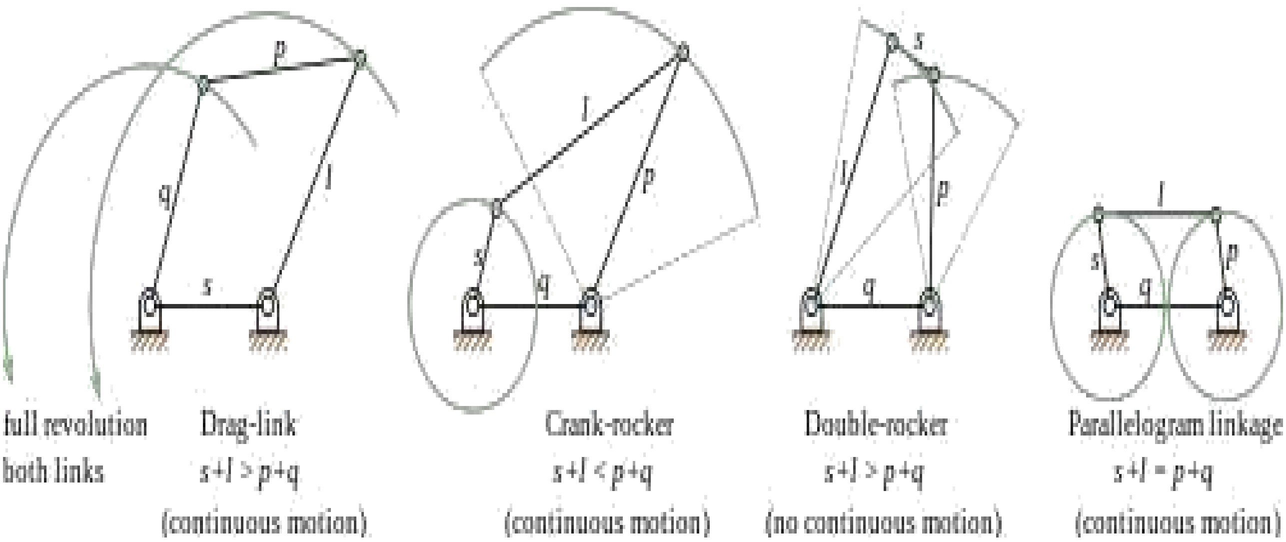

FIGURE 1

5.2- DESCRIPTION OF PARTS

i) CRANK:

The crank is a link that is attached to the rotating shaft at an angle of 90 degrees. The primary function of the crank is actually to convert the rotatory motion to reciprocating motion or to convert vice versa.

The displacement at the end of the connecting rod is directly proportional to the angle of rotation of the crank. The expression can be written as follows:

$$x = r\cos\alpha + l$$

r: radius of the crank

L: length of the connecting rod

X: distance of the crank axle from the end of connecting rod

But due to the changing angle of the crank continuously, we have that the actual equation would be given by:

$$x = r\cos\alpha + \sqrt{l^2 - r^2\sin^2\alpha}$$

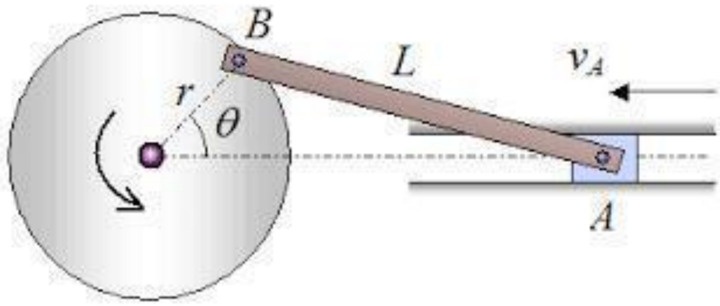

FIGURE 2

ii) **REVOLUATE JOINT:**

A Revolute joint also called as a pin or hinge joint is a joint having only one degree of freedom. This joint provide for only one axis of rotation. They can be used as either active joints or can be used as passive joints.

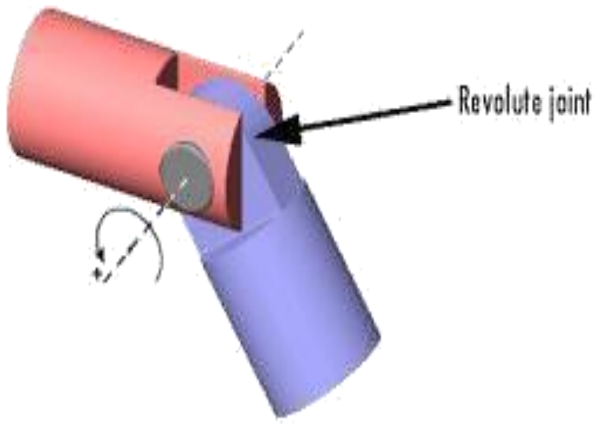

FIGURE 3

iii) <u>DC MOTOR:</u>

The motor used in our project to drive our crank is a DC motor. It is a 12 V and a 500 rpm motor. A DC motor is a very commonly used device in everyday life. It uses the principle of energy conversion (electrical energy to mechanical energy) to give us the desired output. It can also be called as an actuator, a rotatory actuator.

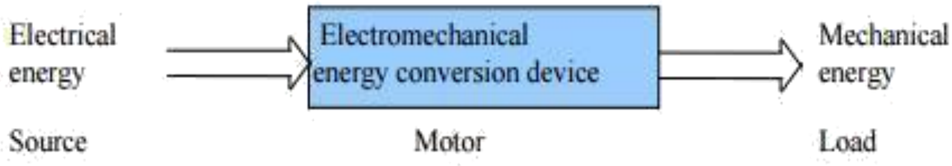

FIGURE 4

5.3 - CONSTRUCTION OF A DC MOTOR

The DC motor consists of two set of coils one set is called the armature winding, and the other set is called stator. The stator can well be a set of a permanent magnet as well. The following are the parts of a Dc motor.

i) STATOR:

1) The stator is the stationary part of the motor system or also can be called as the outside part.

FIGURE 5

ii) ROTOR:

1) The rotor is the rotating part of the system.

2) The rotor is made up of armature windings, and the rotor is connected to the external circuit through the commutator.

3) Both the Rotor as well as the stator are made up of ferromagnetic materials.

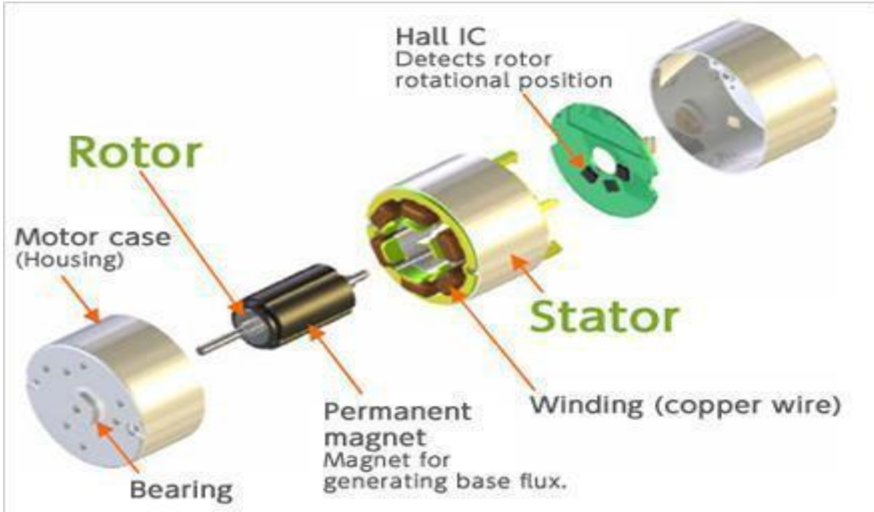

FIGURE 6

5.4 - FERROMAGNETIC MATERIALS:

Ferromagnetism the strongest type of magnetism out of paramagnetic, diamagnetic and antiferromagnetic. Ferro-magnets are permanent magnets that can be magnetised by external influence and remain magnetic even after the external effects are removed. Some of the common ferromagnetic materials are Cobalt, Iron, Nickel and rare earth materials.

MECHANISM:

When an external magnetic field is applied to a Ferro-magnet, then the atomic dipoles of that ferromagnetic material align themselves with the magnetic field that is applied. Even after the external field is removed, then the dipoles remain aligned. This means that the given material has actually become permanently magnetised. It will remain magnetised indefinitely. This

Relation between the magnetization M and magnetic field strength M is not linear and is precisely shown in the form of a hysteresis loop.

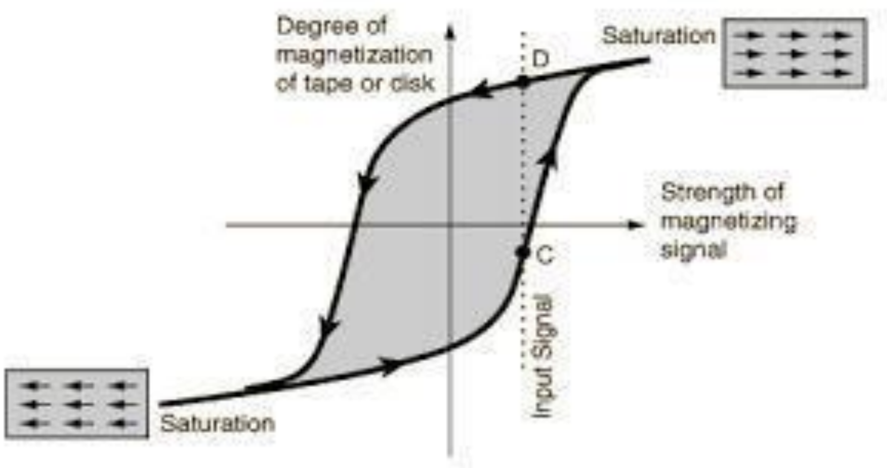

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FIGURE 7

WINDING:

1) Winding through which voltage is applied is called the armature winding.
2) Field winding through which current is applied or flux is applied.
3) Windings are usually made up of copper.

5.5 - THE BASIC PRINCIPLE:

The basic principle can be given by the fact that when any current carrying conductor placed inside the magnetic field it experiences a force depending on the Flemings left-hand rule that can be shown as follows:

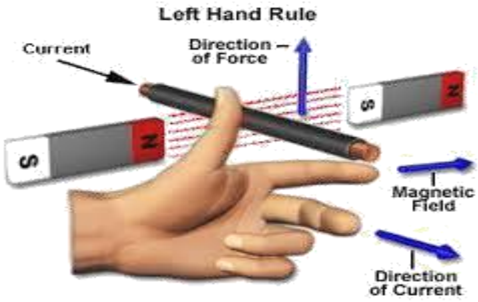


FIGURE 8

The force acting on the conductor can be given by the equation as shown.

F= (B)*(I)*(L)

F is the force acting on the conductor.

B is the magnetic field intensity.

L is the length of the conductor.

Further the torqued developed by the motor can be given by:

$$T = (K)*(\phi)*(I_a)$$

ϕ is the flux per pole.

I_a is the current flowing through the conductor.

K is the constant depending on the coil geometry.

WORKING:

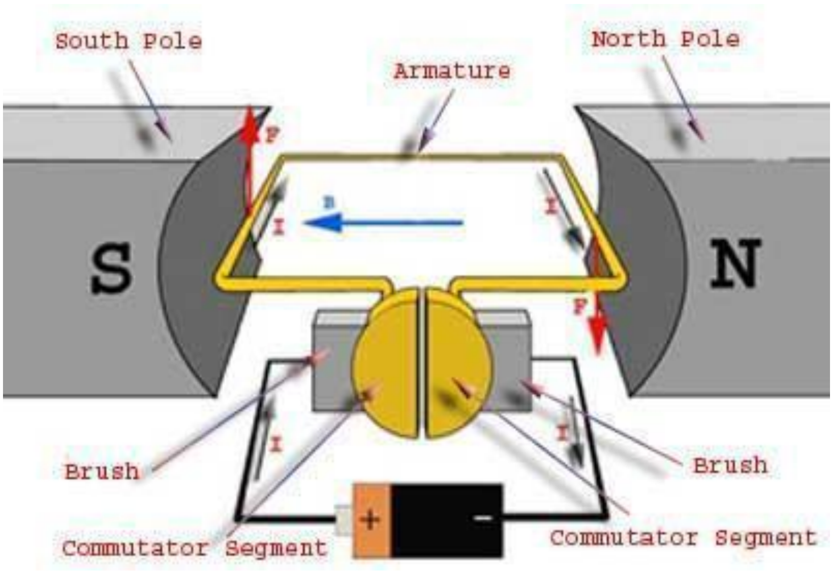


FIGURE 9

This is the setup of a DC motor. This is powered by a battery. The battery provides current to the conductor. Looking at the left face the current is moving in an upward direction. Given the orientation of the magnet, we have the magnetic field is directed from the right to left direction. And the applying the Fleming Left Hand Rule we have the force is being applied towards the top direction. On the other hand, the right side of the conductor is having current flowing in the downward direction. Again applying the rule we have the force is downward direction. Thus, these apply torques (couple) to the conductor, and it rotates.

5.6- BLADES:

The blade is made up of stainless steel. This steel is the most commonly used steel of all. Widely used in a large variety of industries, it is also called the Inox steel. It is an alloy containing around 10.5% of the metal chromium in it. This steel has excellent corrosion resistance and is not easily affected by the oxygen or the water content in the atmosphere. Further, it is also stain proof in low concentrations of oxygen as well as in high salinity conditions. Carbon steel is not so much corrosion resistant. Greater iron-oxide layer formation leads to the flakes development in the material and the subsequent falling off of the material. Chromium present in the stainless steel actually protects the steel by forming a layer of chromium oxide on the top which prevents further rusting of iron by cutting off the contact of oxygen with the iron. This prevents the iron from rusting and gives the blade a long life.

The amount of chromium present in the stainless steel depend on the environment. The harsher environment has generally higher amount of chromium (around 27 %) whereas the normal environment needs around 13 % chromium.

Another very important property of the stainless steel is passivation. This property refers to the fact that whenever the surface of the stainless steel is scratched, then the layer of chromium oxide redevelops on the surface. This property also is true in the case of aluminium.

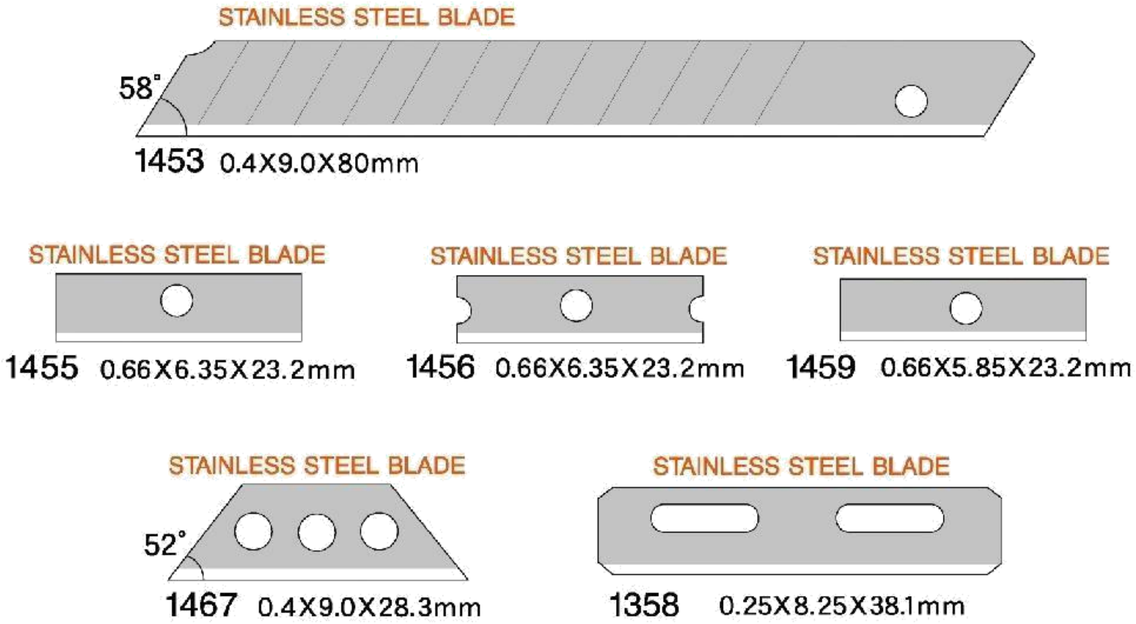

STAINLESS STEEL BLADE
58˚
1453 0.4X9.0X80mm
STAINLESS STEEL BLADE
1455 0.66X6.35X23.2mm
STAINLESS STEEL BLADE
1456 0.66X6.35X23.2mm
STAINLESS STEEL BLADE
1459 0.66X5.85X23.2mm
STAINLESS STEEL BLADE
52˚
1467 0.4X9.0X28.3mm
STAINLESS STEEL BLADE
1358 0.25X8.25X38.1mm

FIGURE 10

5.7- THE GRASHOFS CONDITION:

The Grashofs condition for a planar quadrilateral 4 bar linkage states that the condition which the crank should so as to rotate fully with respect to a neighbouring link is given as:

$$(S + L) <= (P + Q):$$

WHERE S: The smallest link in the mechanism.

L: The largest link of the mechanism.

P AND Q: Remaining links.

5.8- CLASSIFICATION OF LINKAGES:

Depending on the length of the various links and their lengths the various different models can be shown as follows:

Three values need to be calculated T1, T2 and T3

Let a, b, g and h denote the input link length, the output link length, the ground link length and the floating link length respectively.

T1= g + h – a – b

T2= b + g- a- h

T3= b + h – a - g

T_1	T_2	T_3	Grashof condition	Input link	Output link
−	−	+	Grashof	Crank	Crank
+	+	+	Grashof	Crank	Rocker
+	−	−	Grashof	Rocker	Crank
−	+	−	Grashof	Rocker	Rocker
−	−	−	Non-Grashof	0-Rocker	0-Rocker
−	+	+	Non-Grashof	π-Rocker	π-Rocker
+	−	+	Non-Grashof	π-Rocker	0-Rocker
+	+	−	Non-Grashof	0-Rocker	π-Rocker

TABLE 1

5.9- ADVANTAGES OF USING WOOD OVER STEEL:

There are several advantages of using wood over steel in for our project fabrication process. Some of them are listed below:

1) Wood is cheap compared to metal. In order to make it commercially viable on a large scale, it is a necessity.

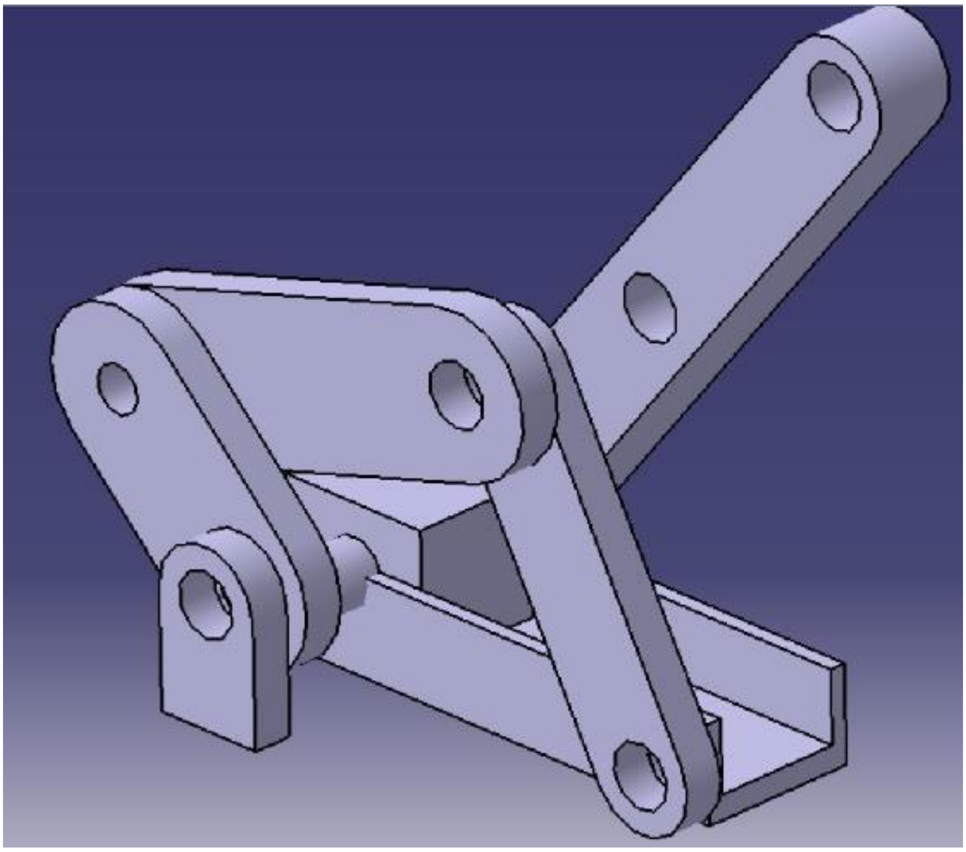
2) Wood being light has no high power requirements. Therefore, a less torque motor can easily do the job. It becomes extremely portable and easy to handle if the machine is made out of wood.

3) Wood is a very good insulator. It is at least 400 times better than steel and about 1770 times better than aluminium in this context.

5.10- TOOLS REQUIRED FOR FABRICATION

1) Chisels
2) Back saw
3) Coping saw
4) Twist bits
5) Screwdrivers
6) Rasps
7) Try-square
8) Tape measure
9) Metal smoothing plane
10) Claw hammer
11) Hand saw

(6) OBSERVATION AND CALCULATION



ASSEMBLY OF MOTOR DRIVEN VEGETABLE CUTTING MACHINE

FIGURE 11

The above-shown figure is the vegetable cutting machine. The motor input rotates the crank. The motor used is a 12V DC 500 R.P.M motor. The rotation of the crank leads to the actuation of the Scott-Rusell mechanism .This mechanism leads to the vertical motion of the blade which further results in the cutting action of the vegetables.

The number of links is 6

Using the formulae, **j= (3/2)*(l) -2**

We have number of joints is 7. So putting in the formulae we have

7= (3/2)*(6) -2

7=7, thus L.H.S = R.H.S

SO THE MOTION IS CONSTRAINED

Now calculating the degree of freedom we have the formulae, from the Kutzbach criterion:

F= 3(n-1)-2*(l)-h

n = number of links

l = number of lower pairs

h = number of higher pairs.

So putting the above values in the formulae we have

F= 3*(6 – 1) – 2*(7) – 0

⇨ **F = 15 – 14 =1**

So we get the degree of freedom is 1.

6.1- LINK CALCULATION

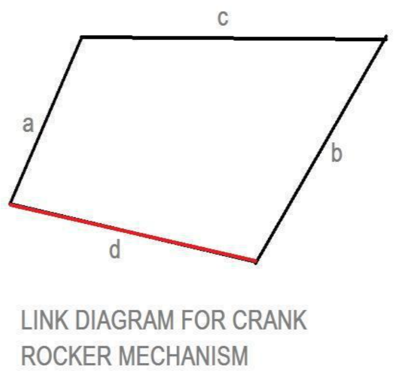


FIGURE 12

CRANK= "a"

DRIVEN = "b"

COUPLER ="c"

FIXED LINK = "d"

PARAMETERS TO BE FIXED

Crank length = 6.35 cm.

Rotation angle of driven link (θ) = 67 degree

Fixed link length = 13.20 cm.

LENGTH CALCULATION FOR DRIVEN LENGTH LINK (b link)

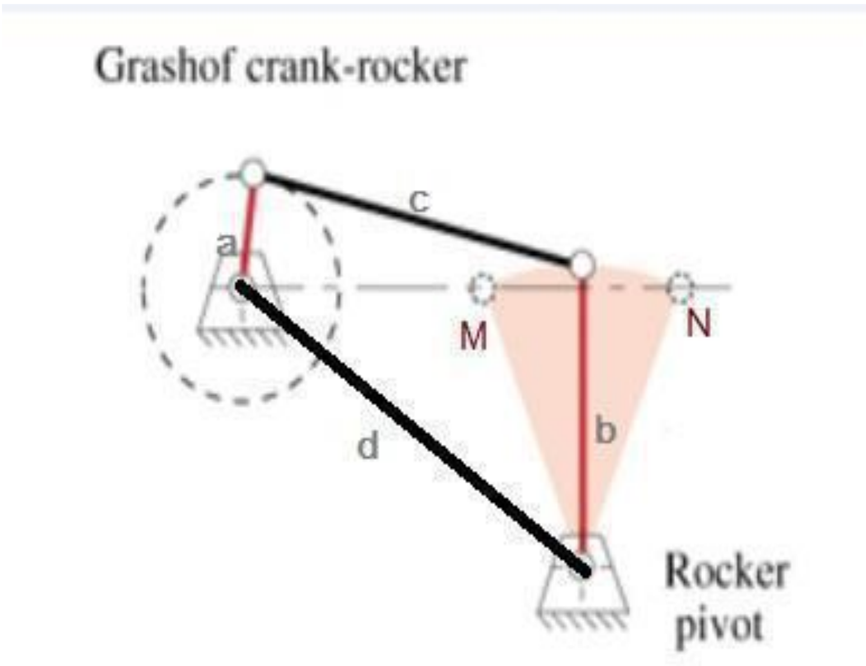


FIGURE 13

$2b \sin(\theta/2) = 2*a$

$b = a/\sin(\theta/2)$

b = 6.35 /sin (67/2)

b = 11.45 cm

LENGTH CALCULATION FOR COUPLER LINK (c link)

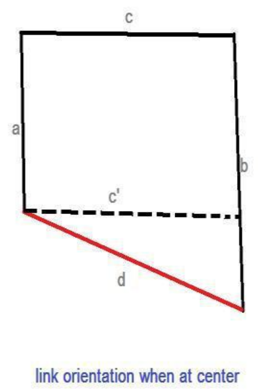


FIGURE 14

By looking at the above figure, it can be easily inferred that triangle containing sides c’,d and (b-a) forms a right-angled triangle. Hence, we can apply Pythagoras theorem to it.

$$d^2 = c'^2 + (b-a)^2$$

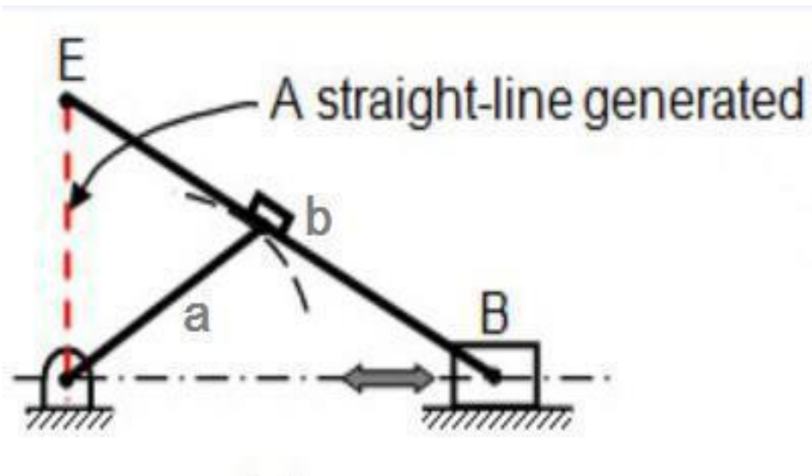
$$c'^2 = 13.20^2 - (11.45 - 6.35)^2$$

$$c'^2 = 148.23 \text{ cm}^2$$

c’ = 12.19 cm

As both c’ and c are parallel to each other. Hence **c = c’ = 12.19 cm.**

LINK CALCULATION FOR SCOTT RUSSEL MECHANISM



Link diagram of Scott-Russel mechanism

FIGURE 15

Length of crank (a) =11.45 cm = driven link of crank rocker mechanism

Length of cutter-driving link (b) = 2*11.45 cm = 22.9cm

Cutter driving link will be pivoted with crank at its centre in order to generate a straight line as marked with red broken line in the above figure.

6.2- DIMENSIONS:

i)CRANK

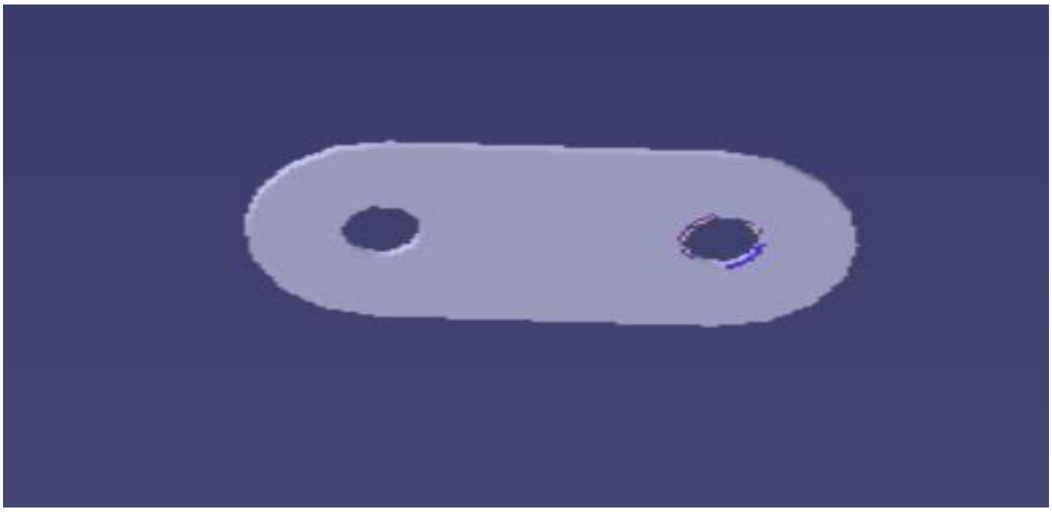


FIGURE 16

Crank is the rotating part of our mechanism. The motor input is provided in the crank. One part is fixed to the base or the ground link whereas the other part is attached to the floating link or the coupler.

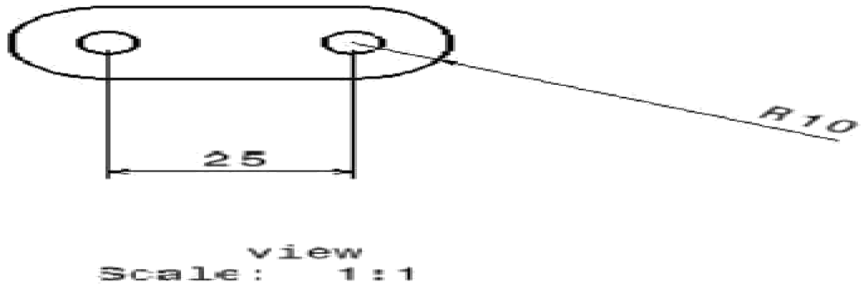


FIGURE 17

ii) <u>COUPLER</u>

FIGURE 18

The coupler also called the floating link connects the crank of our mechanism to the rocker link. This link is responsible for transferring the rotating motion of the crank to the reciprocating motion of the rocker.

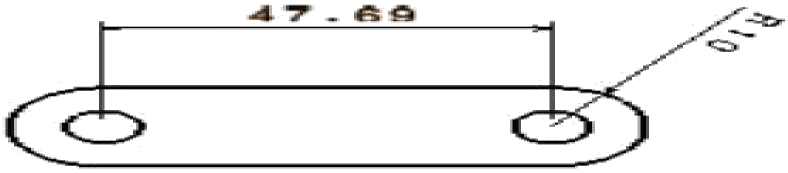


FIGURE 19

iii) DRIVEN LINK:

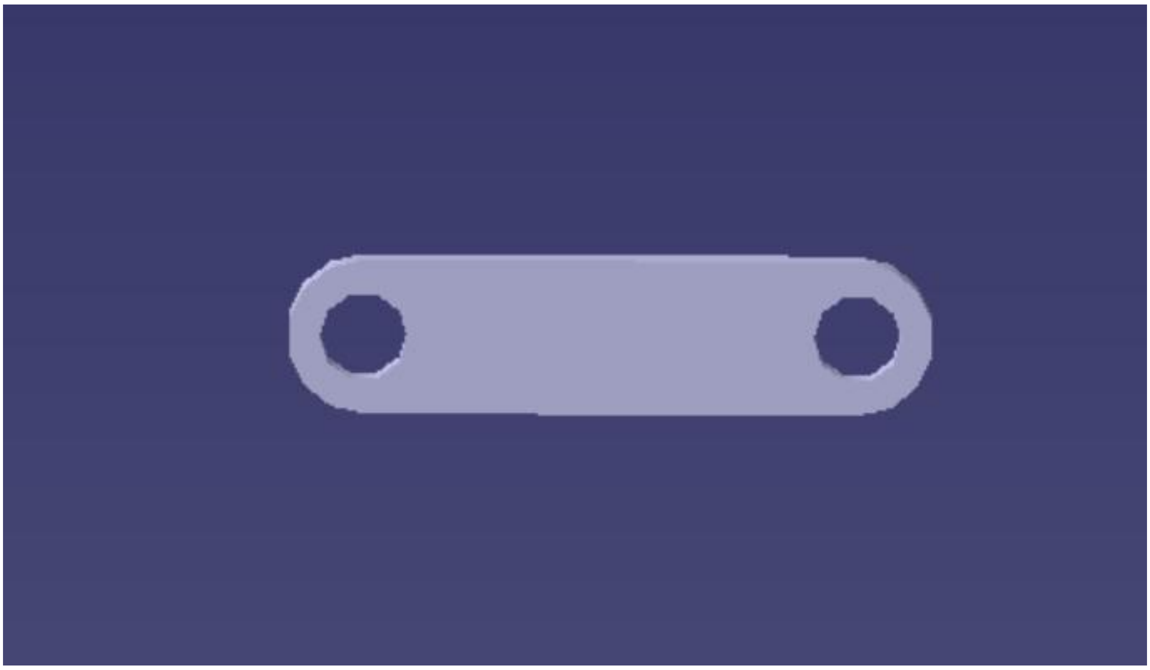


FIGURE 20

The driven link is actually the rocker of the crank rocker mechanism. This link is also attached to the Scott-Rusell mechanism. The reciprocating movement of this link actuates the cutter link and enables the cutting action.

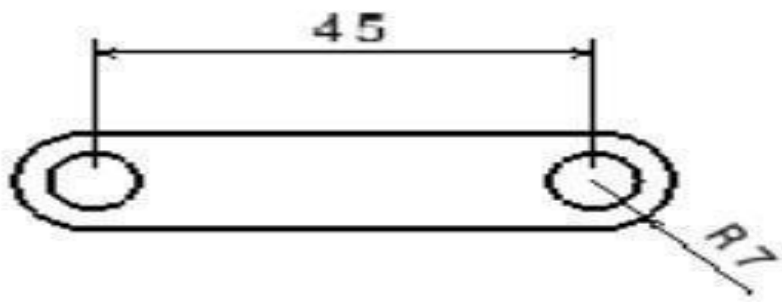


FIGURE 21

iv) CUTTER LINK:

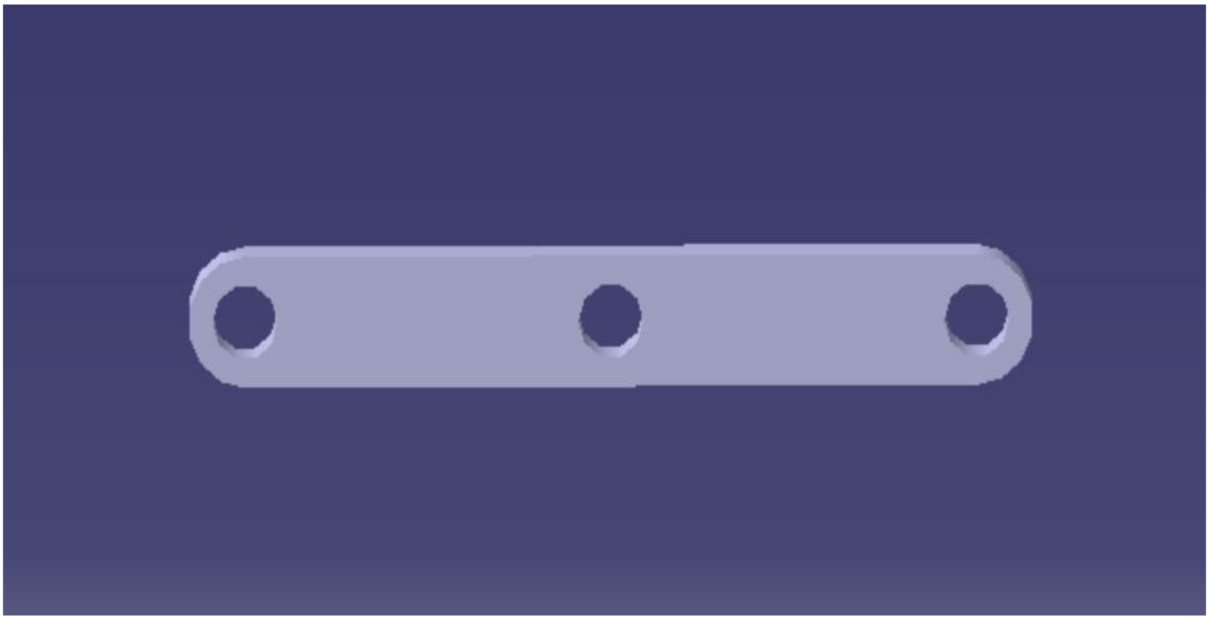


FIGURE 22

The cutter link is an intricate part of Scott-Rusell mechanism whose one end is linked to the slider (roller) and the other end is connected to the driven link of crank- rocker mechanism.

Thus, its motion is dependent on driven link of the crank-rocker mechanism.

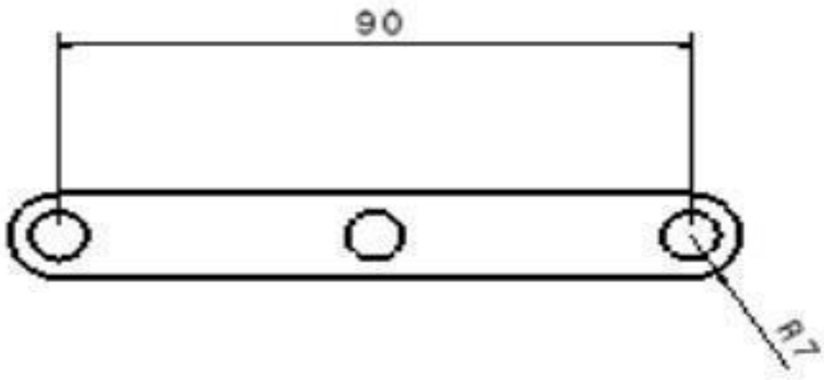


FIGURE 23

RESULTS AND DISCUSSIONS:

1) There were a lot of lacunae found in our model while replicating as per the design made in CATIA. Hence, we added a new rocker at the end parallel to the position of the previous rocker which indeed helped us in achieving dynamic stability.

2) One of the major cons in the stimulation provided in CATIA is the difficulty in analysing the mesh between two parts while in motion. Hence when we ran our machine, there was a lot of commotion that did not provide the smooth motion. Hence, we adjusted the shape of links keeping in mind, the commotion.

3) While running the model with sliding box (cubical in shape), there was a lot of friction because of which motor was unable to drive the machine. Hence, we replaced the box with rolling wheel as found in the base of sliding doors.

SERIAL NUMBER	**R.P.M**	**OBSERVATION**
1)	20	SMOOTH RUNNING BUT LESS SPEED
	40	SMOOTH RUNNING BUT STILL LESS SPEED
	100	RUNNING PROPERLY
	200	PROPER RUNNING
	500	RUNNING BUT NOT SO SMOOTH
	1000	UNABLE TO RUN

TABLE 2

The threshold of the model designed by us was 500 R.P.M. hence we chose 500 R.P.M D.C gear motor.

(8) CONCLUSION AND FUTURE SCOPE

1) By varying the potential difference across the motor, we could vary the speed. Hence by, we can achieve desired thickness of the sliced food item so we could use a regulator while varying the R.P.M of the motor keeping the torque constant.

2) In order to achieve a feed motion, we could use a simple slider-crank mechanism with less R.P.M. motor.

3) Some food items like apple need to be cut across an axis. Hence, we require a circular feed for that. So by making the cutting mechanism and the feed mechanism separately, we can expand the scope of this equipment to all types of food items.

REFERENCES:

1) “Design and Development of Automated Vegetable Cutting Machine” by Tony Thomas. A, MuthuKrishnan.A, Sri Nandha Guhan.K.S

2) Industrial Design and Manufacturing of a Manual Driven Low-Cost Banana Slicing Machine" By Johny Damian. Anak Tawi.

3) ‘‘Theory of Machines” By Khurmi and Gupta.

4) www.youtube.com/watch?v=PIkgo6nmW7A

5) Online shopping sites like Alibaba, Amazon, Rediff and online Teleshop companies like Asian Sky shop.

6) Romeo et al. (Pub no: US2009/0193953 A1)

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