AUTOMATED BOX FOLDING MACHINE

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***Abstract* -** This paper introduces the design of an automatic box folding machine, using both the drafting methods for element synthesis and with the aid of computer aided design determined the details of the elements. This process has a series of repeated motions, so it should be automated. If machine is made more efficient, this could minimize the human interference during the packaging process and reduce the operation time as much as possible.

Keywords :- Box folding process, Design description, CAD models

1. INTRODUCTION

There are different departments in the company like production, Packaging and dispatch. In the packaging department the boxes are made from plain cardboard sheets. This process includes making cardboards and cutting in required dimensions, printing of company and product name after that stitching process is done, finally the boxes are ready for packaging of product.

The whole process is done manually, that is from printing the cardboard pieces, then carrying and folding of this printed cardboard pieces at last this folded cardboard sheets are stitched.

The aim is to convert this manual process into automatic process which reduces human effort and save time. So, the concept is to make a design of the machine such that it can automatically fold he boxes before stitching and load it to the stitching machine without human interference.

2. OBJECTIVES

1) Knowledge about machines and working
2) Information about process
3) Know problems facing
4) Getting auxiliary solutions

3. LITERATURE SURVEY

MD. Ashraf Ul Alam[1], presents by his observation and study of ABMM gives a total documentation on how ABMM operates. It made possibility to detect the errors of the machine and the errors done by operators and the errors which happens by the supplies to the machine. The dimensions of the cardboard are very important factor to take concern of. Because of the dimension issues the whole process of box making is affected seriously. If the wastage amount is getting lower and the production rate is growing higher, then the production time also comes down. If the recommendations as per standards are accepted then this increment on production rate will seriously have an outstanding effect for company profit. The analysis is done not only as a researcher but also as a operator of ABMM. It helped a lot to find out not only different figure of production numbers but also to find out the mechanical improvement for the automation process.

4. PRODUCT DETAILS

The box is manufactured from corrugated board which consists of 3 or more layers of kraft paper. The middle fluted layer is pasted with two flat parallel sheets of paper. The boxes find their number of applications in the packaging of canned & bottled goods, food products etc.

Box Size	**Minimum**	**Maximum**
Length (mm)	270	540
Width (mm)	255	410
Height (mm)	225	265
Wight (gm)	75	847.6
No. of Ply	3	3
No. of Stitches	3	4

Table 1 Product Details

5. AUTOMATED BOX FOLDING PROCESS

In order to clearly define the structure of our machine's process, we decided to break the entire process into two "stages."

Stage I :- Initial Stage

The initial folding operation is defined as stage 1. The initial folding operation is the transformation of the cardboard from the flat, 2-D state in which the machine receives it to an open position. This initial 90-degree fold must be made before the subsequent stages can take place. This 90-degree fold of the box is done for the first 10 meters and the further folding operation is done in another 10 meter distance. The stage 1 mechanism has four necessary functions.

Stage II :- Final Stage

Final stage defined as stage 2 as the folding of the box from 90-degree fold to the required angle for stitching. In this stage the further box folding process from 90-degree inclination to the required angle of the flaps of the box is spread over 10 meters length. The stage 2 mechanism is situated directly linear to the stage 1 mechanism and is attached to the same frame. The folding of the box flap will be done as shown in the figure below.

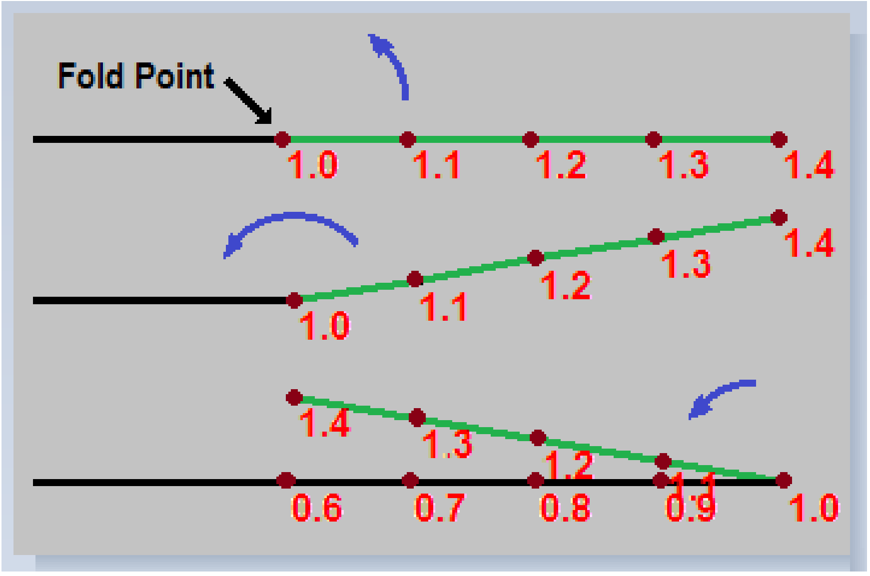

Fig.1 Box Folding Operation

6. DESIGN DESCRIPTION

The design of the automatic box folding machine includes the following elements :-

1. Motor
2. Bearing
3. Conveyor
4. Rubber rolls
5. Conveyor Pulley / Idlers

5.1 Motor

Induction machines are by far the most common type of motor used in industrial, commercial or residential settings.

Motor Specifications :-

Type :-	3 Phase Induction Motor
HP :-	0.5
KW :-	0.25
RPM :-	1440
Hz :-	50

TABLE 2 Motor Specifications

5.2 Bearing

Deep groove ball bearings are particularly versatile. They are suitable for high and very high speeds, accommodate radial and axial loads in both directions and require little maintenance.

5.3 Conveyor

Due to the boxes low weight and the precise positioning needed for folding operations to be completed, it would be necessary to find a belt that would either have a high grip and coefficient of friction or a belt that would limit the vibrations transmitted to the box. Based on these characteristics a belt constructed of Polyvinyl Chloride, or PVC, with a conveyor side surface featuring a quad/inverted diamond woven pattern. The side offers a bare surface with low grip coefficient of friction <0.15.

I. Width And Velocity Of Belt

Width of a belt can be assumed by taking in account the dimensions of the maximum box size.

Let assume,

Width of a belt = B = 1100mm = 1.10m

Actual velocity of a belt can be found by,

$$B = 1.11\left[\left(\frac{Q}{\rho C_r V}\right)^{\frac{1}{2}} + 0.05\right]$$

ρ = Density of material = 1.5 tonne/m^3 [PSG 9.22]

C_r = Factor for type of idler = 240 from [PSG 9.18]

Q = Conveyor capacity = 847.6 gms × 1800

$$1.1 = 1.11\left[\left(\frac{847.6\times10^{-6}\times1800}{1.5\times240\times V}\right)^{\frac{1}{2}} + 0.05\right]$$

Velocity = V = 4.78 m/s

II. Power Calculation

B = 1100 mm

Axle diameter = 20 mm

Rolling resistance to run can be determined by

From PSG 9.18

$$W_o = C_r f L\left[(G_g + G_b)\cos\delta + G_{ro}\right] \pm H\,(G_g + G_b)$$

Assuming material is conveying in forward direction therefore,

Consider +ve sign where,

L = Conveyor length = 10 m

C_r = Secondary resistance factor = 2.3

f = friction between idler and belt = 0.02 …[PSG 9.18]

G_g = Weight of conveyed material per meter length

$G_g = \frac{Q}{3600 \times \text{Vact}} = \frac{847.6 \times 10^{-6} \times 1800}{3600 \times 4.78}$

= 0.0885 kgf/m

G_b = Weight of belt per meter length

= 18 kgf/m [PSG 9.19]

δ = Inclination of conveyor = 0^0

G_{ro} = weight of troughing idler on the forward run per meter length = 29.9 kgf/idler assembly [PSG 9.19]

Spacing for idler in meters = 0.4 m [PSG 9.19]

$G_{ro} = \frac{29.9}{0.4}$ = 74.75 kgf/m

W_o = 2.3 × 0.02 × 10 [(0.0885 + 18) cos0^O + 74.75] + 0 [0.0885 + 18]

W_o = 42.705 kgf = Total resistance

Power = P = 42.705 kgf

III. Number Of Plies And Thickness Of Belt

$$\frac{T_2}{T_2} = e^{\mu\theta}$$

$\mu = 0.25$

$\theta = 230^o$ => Assume due to snub pulley

$$\frac{T_1}{T_2} = e^{0.25 \times \frac{\pi}{180} \times 230^o}$$

$T_1 = 2.7279\ T_2$

$P = (T_1 - T_2)$

$42.705 = (T_1 - T_2)$

T_2 = 24.71 N

T_1 = 67.41 N

Let us select 360Z grade belt for which working tension f_t = 0.71 kgf/m [PSG 9.21]

Ply rating

$$i = \frac{T_{max}}{B \times f_t} = \frac{67.41}{1100 \times 0.71}$$

i = 0.0863

i = 5 [PSG9.21]

Thickness of the belt = (Ply thickness × No. of ply) + (Upper cover thickness × Back cover thickness)
Assuming ply thickness = 0.5 mm

Thickness of belt = (0.5 × 5) + (1 × 1)

t = 3.5 mm

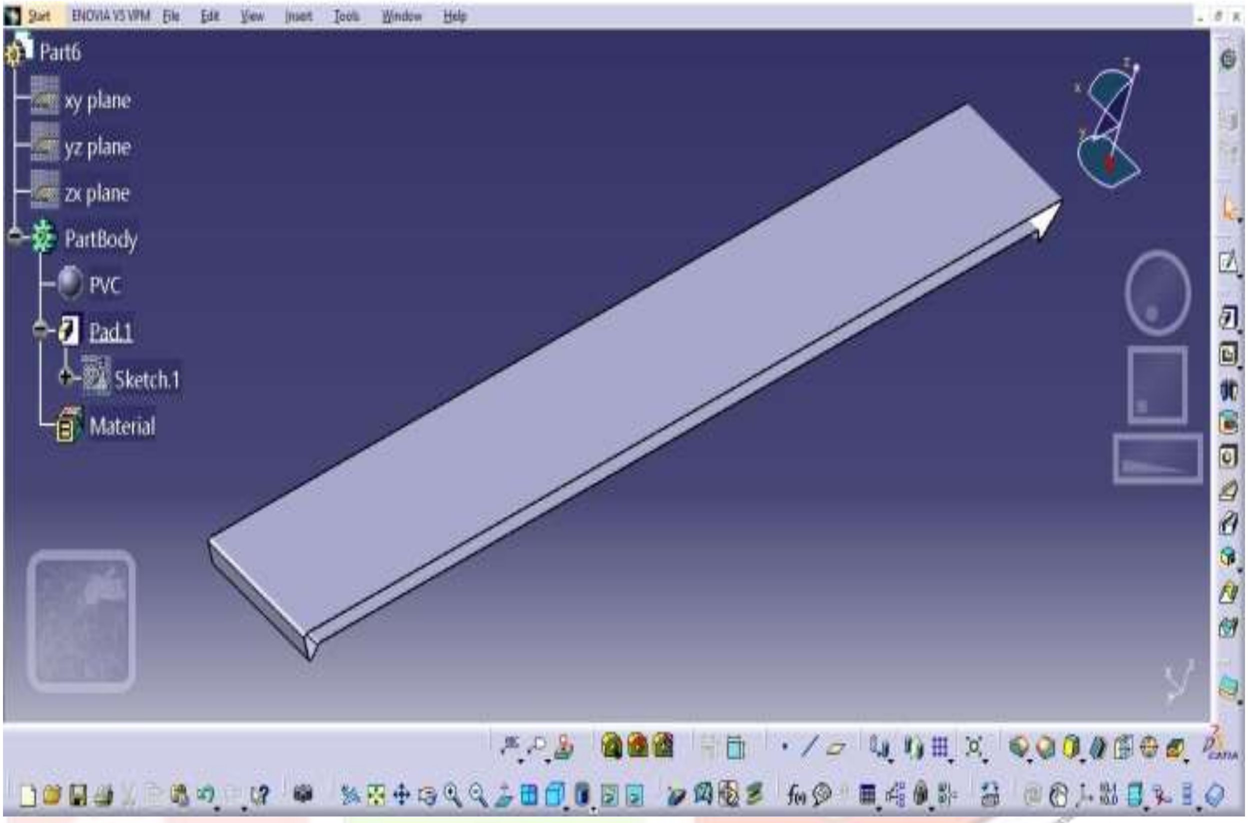

Fig. 2 CAD Model of Conveyor Belt

5.4 Conveyor Pulley/Idlers

A conveyor pulley is a mechanical device used to change the direction of the belt in a conveyor system, to drive the belt, and to tension the belt. Pulleys are made up of several components including the shell, end disk, hub, shaft and locking assembly. The end disk and hub may be on piece. The locking assembly may also be replaced with a hub and bushing on lower tension pulleys.

Assuming C-45 as a tube material and axle diameter is 20mm.

Belt width = L + 2(L-50)

1100 = L + 2(L-50)

L = 400 mm

Length of belt = 2L + πD

Length of belt = 2 × 10 + π × 0.040

Length of belt = 20.143 m = 22 m [Appr]

No. of troughing idler = $\dfrac{\text{Centre Length}}{\text{Spacing}}$

No. of troughing idler = $\frac{10}{0.4}$

Total troughing idlers for forward run = 25

No. of straight idler for return run= $\frac{\text{Centre Length}}{\text{Spacing}}$

No. of troughing idler = $\frac{10}{3}$

No. of troughing idler = 4

Spindle or idler axle diameter is calculated by BM.

$$BM = \frac{\omega L}{4}$$

$$BM = \frac{25.99 \times 10 \times 400}{4}$$

BM = 25990 N-mm

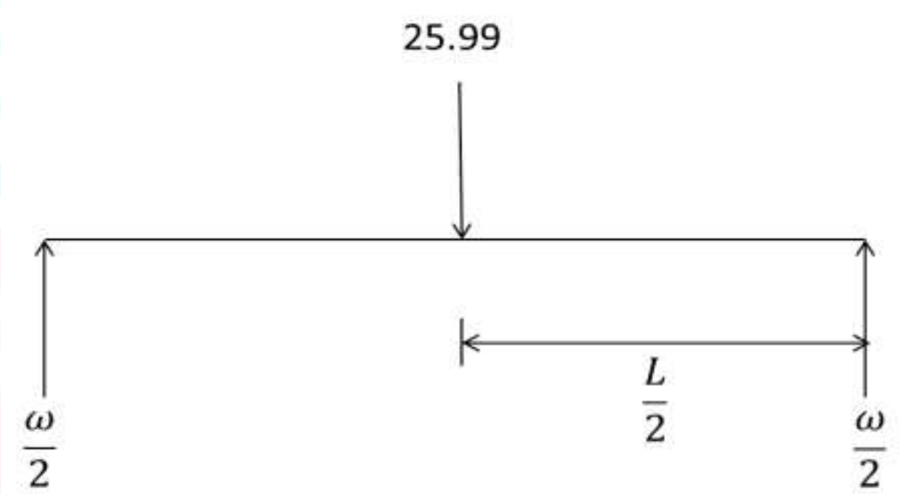

Fig. 3 Free Body Diagram Of Idler

For steel tube,

σ_b = 110 N/mm^2

$$\sigma_b = \frac{M}{Z}$$

$$BM = \frac{\pi}{32} \times {d_{axle}}^3 \times \sigma_b$$

$$25990 = \frac{\pi}{32} \times {d_{axle}}^3 \times 110$$

d_{axle} = 13.40 mm

Selected axle diameter of tube is 20 mm > 13.40 mm

Hence the dimensions selected for the tube are safe.

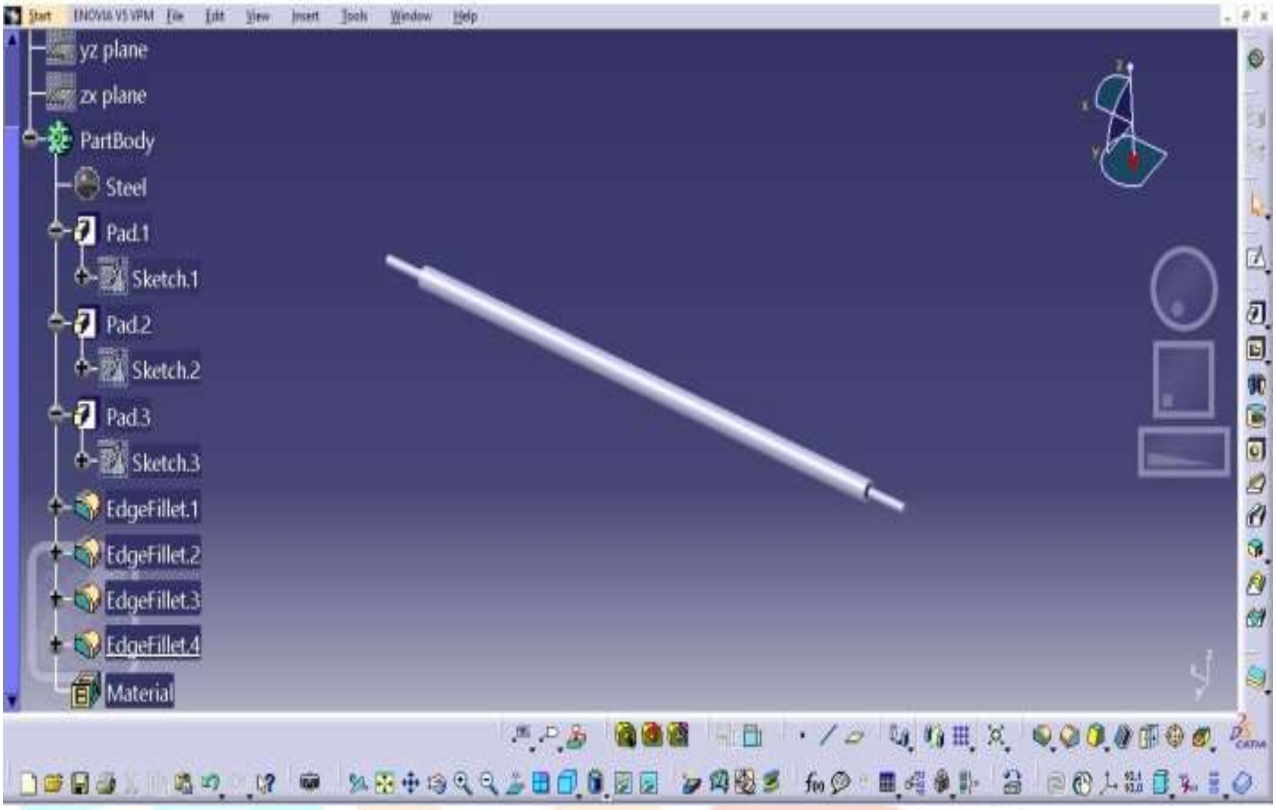

Fig.4 CAD Model of Idler

5.5 Rubber Rolls

The main function of the rubber rolls is to support and push the cardboard in the forward direction. This will help in obtaining only the positive movement of the cardboard in the forward direction.

PARAMETER	DIMENSION (mm)
Width	75
Outer Diameter	150
Inner Diameter	30

TABLE 4 Rubber Roll Dimensions

7. CAD MODELS OF ASSEMBLY

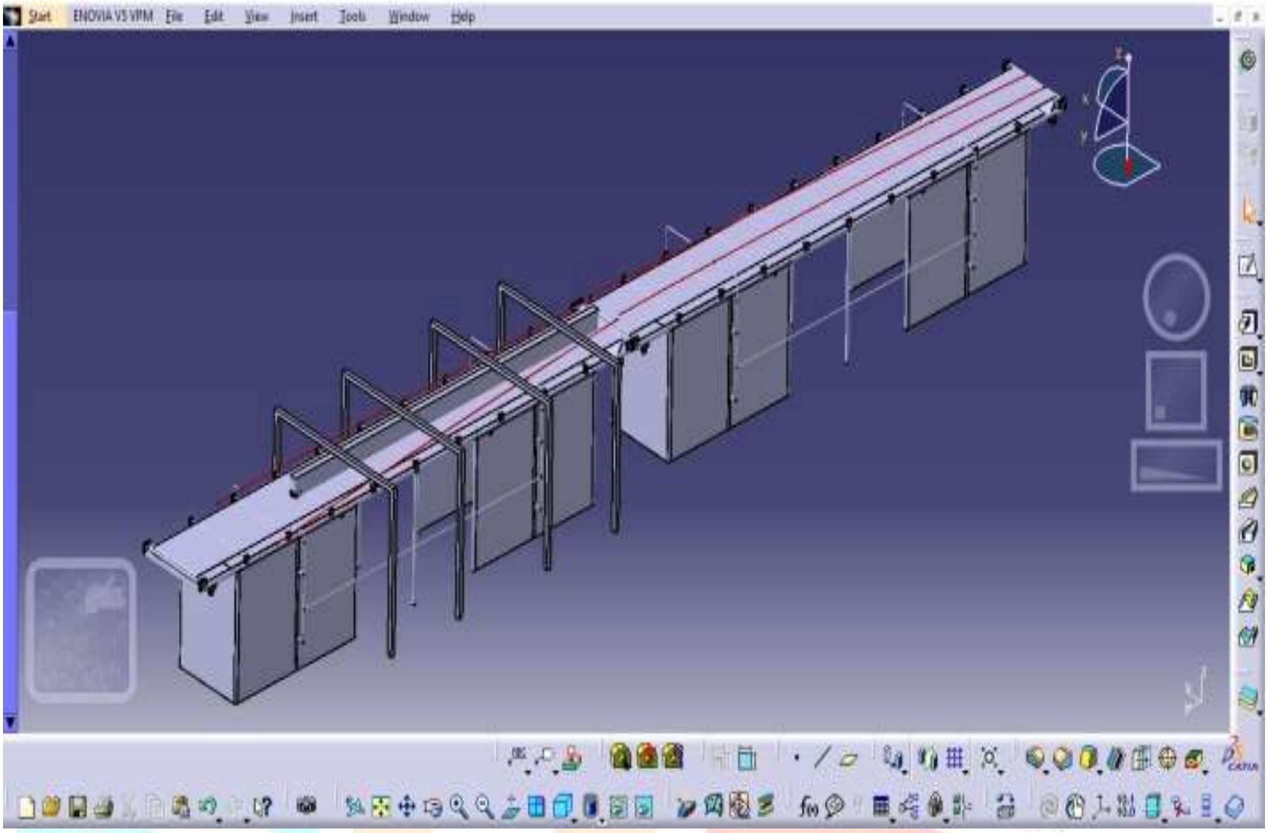

Fig.5 CAD Model of Assembly

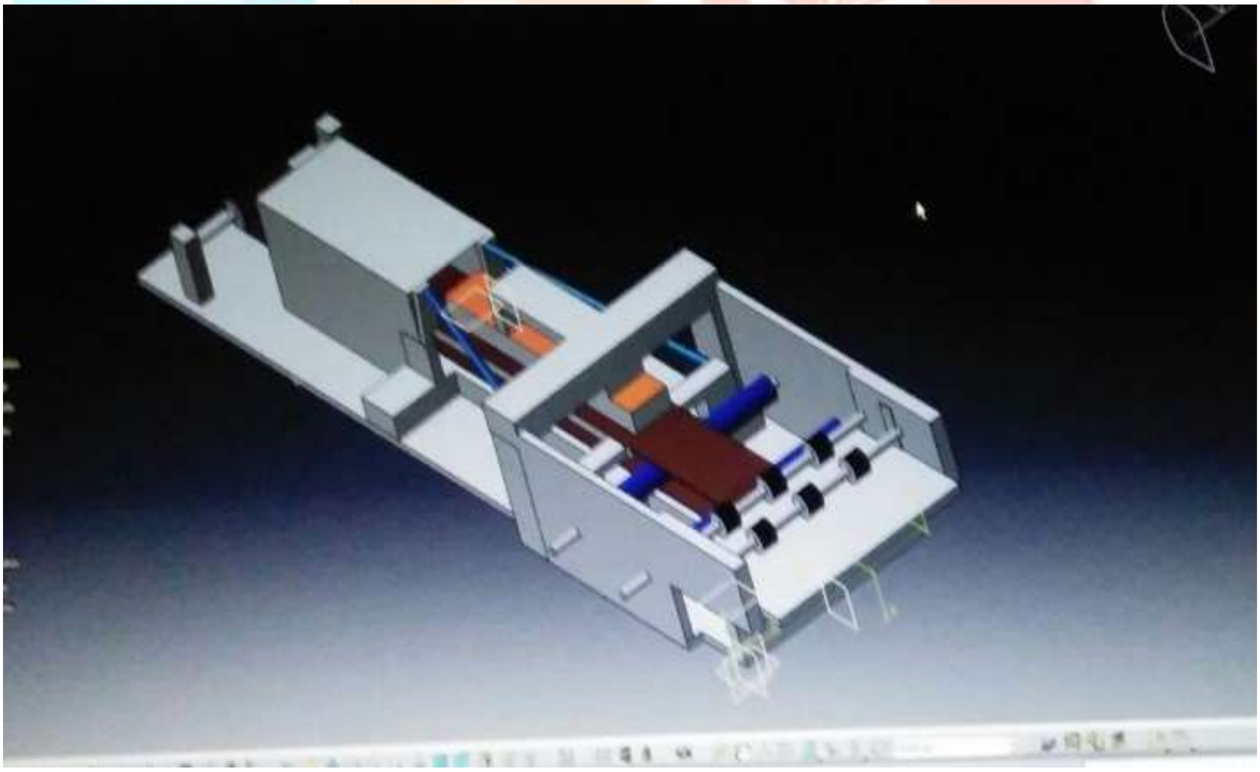

Fig.6 CAD Model of Assembly

8. CONCLUSION

The proposed design has a direct impact on product quality, productivity and cost. This design will not only provides the repeatability and high productivity, but also offers a solution, which reduces the human interference and production time. Hence the automatic process is much better than the manual process.

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