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.

<table>
<thead>
<tr>
<th>Box Size</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length (mm)</td>
<td>270</td>
<td>540</td>
</tr>
<tr>
<td>Width (mm)</td>
<td>255</td>
<td>410</td>
</tr>
<tr>
<td>Height (mm)</td>
<td>225</td>
<td>265</td>
</tr>
<tr>
<td>Wight (gm)</td>
<td>75</td>
<td>847.6</td>
</tr>
<tr>
<td>No. of Ply</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>No. of Stitches</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

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.
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:

<table>
<thead>
<tr>
<th>Type</th>
<th>3 Phase Induction Motor</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP</td>
<td>0.5</td>
</tr>
<tr>
<td>KW</td>
<td>0.25</td>
</tr>
<tr>
<td>RPM</td>
<td>1440</td>
</tr>
<tr>
<td>Hz</td>
<td>50</td>
</tr>
</tbody>
</table>

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,

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

\[ \rho = \text{Density of material} = 1.5 \text{ tonne/m}^3 \]  
[PSG 9.22]

\[ C_r = \text{Factor for type of idler} = 240 \text{ from} \]  
[PSG 9.18]

\[ Q = \text{Conveyor capacity} = 847.6 \text{ gms} \times 1800 \]

\[ 1.1 = 1.11 \left( \frac{847.6 \times 10^{-6} \times 1800}{1.5 \times 240 \times V} \right)^{\frac{1}{2}} + 0.05 \]

Velocity = \( V = 4.78 \text{ m/s} \)

II. Power Calculation

B = 1100 mm

Axle diameter = 20 mm

Rolling resistance to run can be determined by

From PSG 9.18

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

Assuming material is conveying in forward direction therefore,

Consider +ve sign where,

\[ L = \text{Conveyor length} = 10 \text{ m} \]

\[ C_f = \text{Secondary resistance factor} = 2.3 \]

\( f = \text{friction between idler and belt} = 0.02 \)  
[PSG 9.18]

\[ G_g = \text{Weight of conveyed material per meter length} \]
\[ G_b = \frac{Q}{3600 \times \text{Vact}} = \frac{847.6 \times 10^{-6} \times 1800}{3600 \times 4.78} = 0.0885 \text{ kgf/m} \]

\( G_b = \text{Weight of belt per meter length} \)

\[ = 18 \text{ kgf/m} \quad [\text{PSG} 9.19] \]

\( \delta = \text{Inclination of conveyor} = 0^\circ \)

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

\( \text{Spacing for idler in meters} = 0.4 \text{ m} \quad [\text{PSG} 9.19] \)

\[ G_{ro} = \frac{29.9}{0.4} = 74.75 \text{ kgf/m} \]

\[ W_o = 2.3 \times 0.02 \times 10 \left[(0.0885 + 18) \cos 0^\circ + 74.75\right] + 0 \left[0.0885 + 18\right]. \]

\[ W_o = 42.705 \text{ kgf} = \text{Total resistance} \]

\( \text{Power} = P = 42.705 \text{ kgf} \)

**III. Number Of Plies And Thickness Of Belt**

\[ \frac{T_1}{T_2} = e^{\mu \theta} \]

\( \mu = 0.25 \)

\( \theta = 230^\circ \Rightarrow \text{Assume due to snub pulley} \)

\[ \frac{T_1}{T_2} = e^{0.25 \times \frac{\pi}{180} \times 230^\circ} \]

\( T_1 = 2.7279 \times T_2 \)

\( P = (T_1 - T_2) \)

\( 42.705 = (T_1 - T_2) \)

\( T_2 = 24.71 \text{ N} \)

\( T_1 = 67.41 \text{ N} \)

Let us select 360Z grade belt for which working tension \( f_i = 0.71 \text{ kgf/m} \)

\[ i = \frac{T_{\text{max}}}{B \times f_i} = \frac{67.41}{1100 \times 0.71} = 0.0863 \]

\[ i = 5 \quad [\text{PSG} 9.21] \]
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

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 = Centre Length
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.

\[
BM = \frac{\omega L}{4} \\
BM = \frac{25.99 \times 10 \times 400}{4} \\
BM = 25990 \text{ N-mm}
\]

For steel tube,

\[
\sigma_b = 110 \text{ N/mm}^2 \\
\sigma_b = \frac{M}{Z} \\
BM = \frac{\pi}{32} \times d_{\text{axle}}^3 \times \sigma_b \\
25990 = \frac{\pi}{32} \times d_{\text{axle}}^3 \times 110 \\
d_{\text{axle}} = 13.40 \text{ mm}
\]

Selected axle diameter of tube is 20 mm > 13.40 mm

Hence the dimensions selected for the tube are safe.
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.

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>DIMENSION (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td>75</td>
</tr>
<tr>
<td>Outer Diameter</td>
<td>150</td>
</tr>
<tr>
<td>Inner Diameter</td>
<td>30</td>
</tr>
</tbody>
</table>

TABLE 4 Rubber Roll Dimensions

7. CAD MODELS 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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