Design and Fabrication of Automatic Plastic Cup Thermoforming Machine

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Abstract - *A thermoforming machine is used to manufacture disposable glasses of different sizes from 48mm to 80mm. We have received complain regarding arrangement of plastic cup. This problem can be solved with the help of belt conveyer system. Rate of tea glasses is 1650 glasses in a minute. Rate of water glasses is 630 glasses in a minute. These all glasses are collected in a large container and then labors arrange these glasses in a proper manner and bunch them as per required number. We have to design the mechanism that can help us to arrange that glasses in series as per desired quantity. After glasses gets packed into plastic bag and then it is carried to boxes for packaging. Counting of glasses takes place with the help of LED sensor system or with the help of paper strip. Aim of project is that we get more production with the help of this automatic mechanism without stopping production due to lack of storage capacity of industry. Ultimately, we can save labor and labor cost. We have made the satisfactory solution of this problem by making of prototype of length 2m, width 18inch and height 1m.*

Key Words: **Stacker mechanism, Pulley, Electric motor, Bearing, Brush, Belt etc.**

1. INTRODUCTION

The disposable plastic cups are manufactured by thermoforming technique. They are fast replacing conventional cups. Ice-cream and other dairy products are packed in disposable cups. Besides Ice-cream industry, hotels, restaurants, canteens etc. have been increasingly using disposable cups as against conventional glass-wares or ceramic cups. Disposable cups are mainly used for food items and are made out of polypropylene or polystyrene sheets. Sheets having thickness 0.35mm to 18mm are used for these items in thermoforming machine. The disposable cups are gaining popularity due to attractive look, low weight for container, ease of transportation and low impermeability. Organizations like Railways, Airlines are using disposable cups for serving coffee, tea etc. now-a-days.

Polypropylene/Polystyrene sheet feeding reels of pre-set length is dragged from bobbin reel in the thermoforming plant. The conveyor chains carry the sheet through the heater assembly to the forming table. The heated sheet is punched to form the shape of the mound. The cups thus formed are stocked and the punched waster sheet is wound on scrap sheet winder. To get printed cups, the sheets are printed before forming into cup. Taking 200ml. cup as yard stick as it is mostly used for serving coffee/tea the installed capacity of the machine with 5 cavities mound is approximately 52500 cups per shift. In terms of weight, a 200ml cup made of 0.7mm thick High Impact Polystyrene sheet is approximately 2.58 gm. Therefore, the total weight of output per shift is 135 Kg. The average weight of sheet required per cup is 3.2gms. (Which implies wastage of approximately 0.62gms per cup). As the raw material wastage is very high the scrap needs to be recycled. The scrap can be ground and extruded in sheet extruder.

1.1 Thermoforming

Thermoforming is a plastic manufacturing process in which the thermoplastic sheets are formed with the application of heat and pressure in a mold. The thermoplastic sheet is held horizontal layover a mold surface and clamped with a holding device. The sheet is heated up to predetermined temperature using a heating element called heater. The thermostat is used to maintain the temperature of the heater. When the temperature becomes substantially high in the mold, the temperature is controlled by adjusting the heater and providing the cooling air. The thermoplastic sheet softens with the application of heat and is pressed into or stretched over the mold surface by application of air pressure or by any other means. The softened sheet conforms to the mold shape and it is held in place until it cools. The mold cavity is opened and the thermoformed parties released. Some of the plastic materials require air cooling in order to make those rigid quickly, because plastic materials have low thermal conductivity. The excess material is then trimmed out from the formed part. Excess material can be reground, mixed with unused plastic, and again reformed into thermoplastic sheets. Thin sheet (up to 1.5 mm) and thick sheet (about 3 mm) can be formed easily. Thermoforming set-up usually consists of the clamping unit, heaters, mold, and air cooling system. The molds should be cleaned after every cycle, as materials in the mold can cause the change in the shape of the finished goods. There are mainly three

Fig -1: Thermoforming Process

Different types of thermoforming process depending upon the pressure required i.e., vacuum forming, pressure forming and matched die forming.

1.2 Problem Identification

Fig -2: Problem Specification

The problem is occurring when the cluster of the glasses is very large and labor cannot capable to make the bunches of glasses at that much of high fast rate so the production must be stopped for temporary time to overcome that much of excess production. This will cause reduction into productivity.

1.3 Objective of Research

In this project we are going to find out innovative and cost-effective ways to replace or mitigate the problems that we could observe in the company by the use of best possible knowledge that we have. All the solutions to the problems are found out with the aim of keeping in mind their practical acceptability and feasibility. Our main focus is going to be the design by the use of INVENTOR software and fabrication of stacker mechanism. After this we are to provide a feasible solution to the company to increase production and profit and reduce labor cost. Other parameters of the problems in the company are also going to be tackled by rigorous brainstorming using new and advanced techniques to replace the existing ones in the company.

2. DESIGN METHODOLOGY AND WORKING

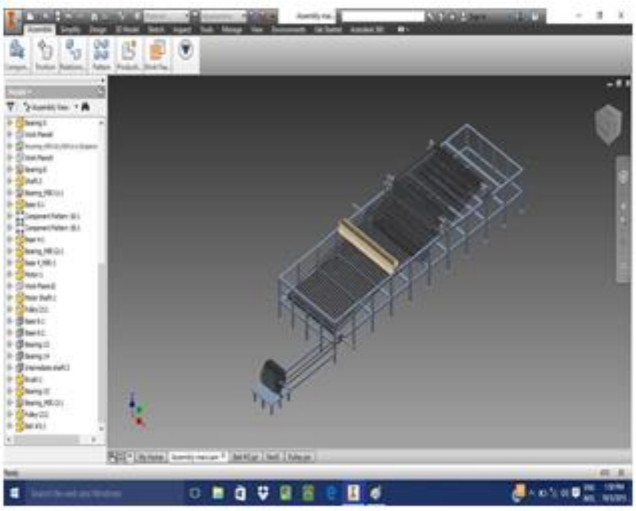

Fig -3: 3D view of Assembly (snapshot inventor)

2.1 Mathematical modelling of Stacker Mechanism

Given data:

We assume that glass take 5 second(t) to reach destination.
Distance between two pulley centers d=1420mm
Outer diameter of both pulley $d1=d2=50$mm

- Running speed(V):
  V =d/t
  =1420/5
  =284mm/s
- Length of Belt(L):

$$\therefore L = \left(\frac{\pi}{2}\right)(d_1 + d_2) + 2x + \frac{(d_1 - d_2)^2}{4x}$$

$$\therefore L = \left(\frac{\pi}{2}\right)(50 + 50) + (2 * 1424.46) + \frac{(50 - 50)^2}{(4 * 1424.46)}$$

$$\therefore L = 3000mm$$

Here load on belt is approximately negligible, so we can choose any belt at F.O.S. 0.5. So, we choose belt of 3m long with available width of 15mm.

$$\sigma = \left(\frac{T_1}{bt}\right)$$ where σ=maximum pull stress

T_1=tension on tight side

b=width, t=thickness

- Angular speed of pulley:
  Speed of belt V=284mm/s

$$V = \left(\frac{\pi dn}{60}\right)$$

$$\therefore 284 = \left(\frac{\pi * 50 * n}{60}\right)$$

$$\therefore n = 108.48rpm$$

2.2 Parts required

Table -1: Bill of Material

Sl. No	Particulars	Quantity	Cost
1	Electric motor	3	800
2	Shaft	1	700
3	Frame	1	1550
4	Pedestrial ball bearings	1	800
5	Gear	1	1200
6	Belts	1	640
7	Brush	2	80
8	Pulley	2	300
9	Miscellaneous	-	2000
		Total cost	=8072

Hence our prototype cost is estimated as Rs. 8072/-

2.3 Packaging Process

The blown-out glasses fall on the belt drive mechanism. There are 18 belts and glasses get fitted between two belts. The glasses then carried away to convert themselves on horizontal plane by another conveyer belt system. The glasses that do not fit in between belts are thrown out by a rotating brush to make them properly fit in the belt mechanism. The fitted glasses pass through the brush as there is clearance between brush and belt of 2mm so only properly fitted glasses can escape it.

Fig -4: Packaging Process

Further glasses arrange themselves into bunch by the push of belt after whenever themselves on horizontal plane by belt mechanism.

Fig -5: Working of Prototype

We have make a prototype it is working as only on a one belt and this belt at initial stage is rotated by worker then it is replaced by the electric motor. As earlier says it has only one belt on this prototype and further this is added by the additional number of the belt, which is to be require for making of tea cups or cold drinks cup because we have required less number of belt in cold drink cups rather than the tea cups require more number of belts. Finally, glasses are collected at the end of the belt and they are bunched as per required number of quantity.

2.4 Result

- **Old Design calculation:**

This the data of the Raj team industries as per current condition and its calculation is as follows and at the end of the calculation we are able to compare old design and new design.

No of Labor required= 10 nos.

Packaging cost per box= 80 Rs.

Labor can pack 4 boxes every day

So, Total labor cost per Day= No of labor*Packaging cost per box * No of boxes packed

= 10*80*4

= 3200 Rs. /day

No. of motor required = 1 nos.

Power rating of motor = 5.4 KW/hour

According to Government of Gujarat cost of Power (per KW/hour) for Industrial area = 9.42 Rs.

Normally working hour of machine are 9 hour every working day.

So, cost of electricity = 9.42*9*5.4

= 457.81 Rs.

Total cost of packaging per day = Labor cost + Electricity cost

= 3200 + 457.81

= 3657.81 Rs.

- **New Design calculation:**

After calculating the old design cost now, we have to find our new design cost as per our prototype is working and then the additional requirement of the electricity as follow. At the end of the calculation we are able to find thee profit of the project that we are going to apply with the industries.

No of Labor required= 5 nos.

Packaging cost per box= 30 Rs.

Labor can pack 8 boxes every day

Total labor cost per Day = No of labor*Packaging cost per box * No of boxes packed

= 5 * 30 * 8

= 1200 Rs. / day

No of motor required = 3 nos.

Power rating of main motor = 5.4 KW/hr.

Power rating of secondary motors = 0.75 KW/hour * 2 = 1.5 KW/hour

According to Government of Gujarat cost of power (per KW/hour) for Industrial area= 9.42 Rs.

Normally Working hours of machine are 9 hr. every day.

So, Cost of electricity= 9.42 * 9 * (5.4 + 1.5)

= 584.98 Rs.

Total cost of packaging per day= Labor cost + Electricity cost

= 1200 + 584.98

= 1784.98 Rs.

Profit = cost of old design – cost of new design

= 3657.81 – 1784.98

Profit = 1872.83 Rs. per Day

Table -2: Comparison of old and new design

Parameters	Old Design	New Design
No of labor required	10	5
Total cost of labour(per Day)	Rs. 3200 /-	Rs. 1200/-
Power consumption(Per Day)	48.6 KW	62.1 KW
Cost of power required(per day)	Rs. 457.81/-	Rs. 584.98/-
Total cost per day	Rs. 3657.81/-	Rs. 1784.98/-

Table -3: Benchmark of project

Parameters	Old Design	New Design
Production Rate	High	High
Packaging rate	Low	High
Wastage	More	Very less
Floor space occupied	More	Less
Production cost	High	Less
Time consumption	More	Less
Inventory	More	Less

From the above calculation and result we are able to see the advantages of new design is much better than the old design like production rate, packaging rate are increased and simultaneously wastage, production cost, required floor space area, time consumption is decreased.

3. CONCLUSIONS

After completing this project, we have finally get a conclusion that with our proposed stacker mechanism for process of packaging of glasses in bunches and wrapping of them in plastic bag is speed up significantly. With our mechanism they can continue both production of 50 and/or 100 quantity of bunches at a time. Now they can increase production rate without worry about inventory, wastage of glass, row material and human error. Hence, we can **save Rs. 1872.83/- per Day** by applying stacker mechanism.

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