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Design of Automated System for Coconut Segregation

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ABSTRACT: India is the third largest coconut producing country in the world with annual 21,500 million tonnes of production. Several works have been carried out in the area of developing automated systems for sorting fruits and vegetables using the optical sources and pneumatic devices. Machineries are available for spherical fruits like apple, orange, kiwi, tomato etc. including completely shaved coconuts are available; segregating husked coconut is being a challenge in Indian market.

An automation system for husked coconut segregation (ASC) has not been reported in open literature. An effort is made to design ASC with three sub-assemblies namely loading unit, Conveying unit and segregating unit. The design of specialized rollers in segregating unit can segregate into 4 different sizes of coconuts at different segregation units.

KEYWORDS:ASC, Husked Coconuts, Indian market, Visual skill, Sorting, Grading, Hooper, Conveyor, Special roller, Segregator,

I. INTRODUCTION

According to data available from various sources it is evident that our country, India has made unmatched progress in cultivation of coconut in past 6 years [1]. It is one among leading supplier in world. Our country is the 3rd largest country in the world with 21,500 million tonnes coconuts production annually.

A single Coconut has layers like outer Shell, husk, inner shell, Coconut meat, coconut water; Figure 1.1 has the details of products available from a single coconut [2]. Packed coconut water, coconut flesh, coconut oil, vinegar, organic acid and coir are few of the products available from the coconut [3].

The coconut removed from tree are processed to remove husk and obtain inner shell and sold in retail shops for consumption of retail consumers who use it for food preparation and at temple for offerings, also sold in whole sale market in bulk to hotels, and catering industry. Catering industry uses the coconuts for preparation of food and also for traditional gifting purpose called tambula. Further the husk is supplied to fibre extracting industry, coconut milk and coconut meat is supplied to food industry [4].

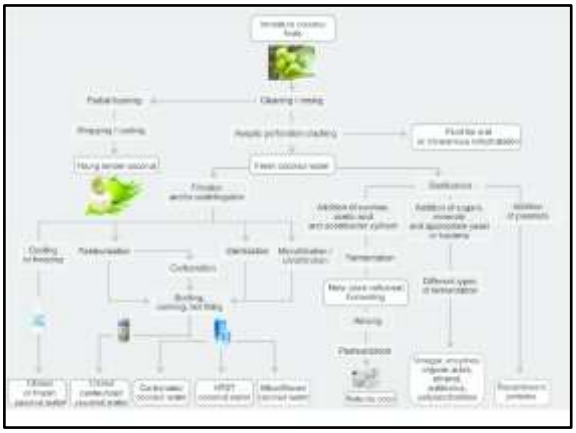

Figure 1, Coconuts by-products

But the need of Indian market is different. Most of the Indian consumers do not prefer completely shaved coconut instead they go with coconuts with partial husk at one side as per religious custom, which is called Juttu in Kannada and we can call it "Husked Coconut" for further reference. The coconut with outer shell, Husked coconut and clean shaved shell is shown in figure 2.

Figure 2, Coconut variety available in market.

With this the entire market will be different to Indian coconut supply industry. The husked coconut are different from completely shaved coconut, the demand is more in Indian retail market where different sized coconuts are used for different

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purposes. The opportunity for completely shaved coconuts is there other than Indian market. Machineries available for spherical fruits like apple, orange, kiwi, tomato etc. including shaved coconuts are available; segregating husked coconut is being a challenge in Indian coconut industry and automation industry.

II. MOTIVATION

In a survey done with **PRP Coconut Tiptur Pvt. Ltd** of Karnataka it is found that they have annual turnover of 6 crore with 2 offices in Bengaluru [5]. Every day PRP coconut industry will segregate around 2 lack coconuts at 5 to 6 range of sizes and weight, where the each labour will segregate approximately around 20 thousand coconuts manually. Visual skill is needed to manually segregate with the time of 8 hour a day (which is not sufficient). Figure 3 shows the manual segregation of coconuts in one of their branch at Yelahanka Bengaluru.

Figure 3, Manual segregation of coconut.

order to supply to market demand, it requires high amount of man hours of skilled manual labour. With hardship involved in the manual segregation of coconut it has become difficult to source sufficient human resource for meeting the demands of the industry and also considerable issue of increase in labour cost.

With a huge demand in the market for the husked coconut of various sizes and with no suitable machines available, and in order to mitigate the effects of manual labour, high labour cost and labour shortages, there is a need to develop an automated system for segregation and collection of husked coconuts. The fore said machine will be addressed as ASC further. ASC machine for segregation of husked coconuts typically for Indian market

III. LITERATURE REVIEW

Several works have been carried out in the area of developing automated systems for sorting fruits and vegetables using the optical sources and pneumatic devices.

JW Von Beckmann and NR Bulley had worked extensively to color differentiate 14 variety of tomato's and electronically segregate the tomato's at 5 per minute [6].

AnuradhaGawande, Prof.S.S.Dhande, worked on identifying infected fruits by a case study on fruits and vegetables and classified them as low, medium, high, extremely high and fully infected categories.[7]

SaurinSheth ,RahulKher , Rushabh Shah, ParthDudhat, PratyushJani. The work was done in the machine vision involvement in segregation. Signal from conveyor sensor will be given to microcontroller, which says the presence of object on it [8].

The **Direct industry** web page provides many sorting machines available in market like, Magnetic Sorting machine, Visual sorting machine, Tomato sorting and grading machine, coffee seeds sorting machine, tobacco leaf sorting machine [9].

ASM (Advanced Sorting Machines)from Italy is more than 30 years old company expertise in sector of optical sorters and it holds strong foot in the market as a benchmark in this sector [10].

In a recent publication from a popular media the local vendor had used an innovative and easy way of sorting pomegranates. Figure 4 shows the news published photo of the man using simple technique to sort pomegranate [11].

Figure 4, News report on sorting technique

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Machineries are available for spherical fruits like apple, orange, kiwi, tomato etc. including completely shaved coconuts are available; segregating husked coconut is being a challenge in Indian market. An automation system for husked coconut segregation has not been reported in open literature.

IV. OBJECTIVE OF ASC

The Project work titled "Automated System for Coconut Segregation (ASC)" has been carried out with following objectives:

1. To develop a concept design of an automated system for coconut segregation.
2. To design and analyse automated segregation.
3. To detail design of an automated segregation.

V. CONCEPTS OF ASC

There are 5 considerable concepts generated for the design of ASC machine. They are as follows and discussed in detail.

1. Belt conveyor segregation system:

Hooper is used to feed the coconuts over the belt conveyor; the system is designed to hold the pile of coconuts loaded at an elevated height manually or by dumping trucks. Hooper will help in placing the coconuts one by one on to the conveying units and further to segregation.

The belt conveyor is used to convey the coconuts over to the segregation units. The segregation units are designed with a carry mechanism where the coconuts are rolled over to the segregating plates with the pockets matching the different size of coconuts. Each segregating unit has different size pockets to segregate the coconuts. In this process the smallest coconuts are segregated first and the next size to be in respective following units.

The coconuts are dropped over the guide tray which is placed below each segregation unit. The tray is provided with a draft of 45 degree and routed to the collecting unit where big bags are placed to collect segregated coconuts. Figure 5 shows the belt conveyor concept sketch.

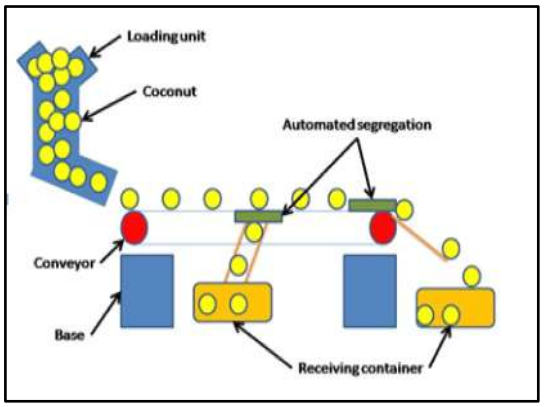

Figure 5, Belt conveyor concept

2. Screw Conveyor Segregation System Concept:

Coconut is loaded in a tank placed at ground level or below, manually or by dumping trucks. The size of tank can be varied with requirements and the tank can be constructed with concrete or bricks.

The screw conveyor is used to convey the coconuts over to the segregation units. The coconuts are lifted from the tank using screw conveyors. The effort of loading at elevated height is removed and screw conveyor can lift individual coconuts without piling in conveyor unit.The segregation units are designed using segregating plates with the pockets matching the different size of coconuts. The covering of the screw conveyor is divided in to multiple segments and the segregating units are placed in it. Each segregating unit has different size pockets to segregate the coconuts.

In this process the smallest coconuts are segregated first and the next size to be in respective following units.The coconuts are dropped over the guide tray which is placed below each segregation unit. The tray is provided with a draft of 45 degree and routed to the collecting unit where big bags are placed to collect segregated coconuts. Figure 6 shows the screw conveyor concept sketch.

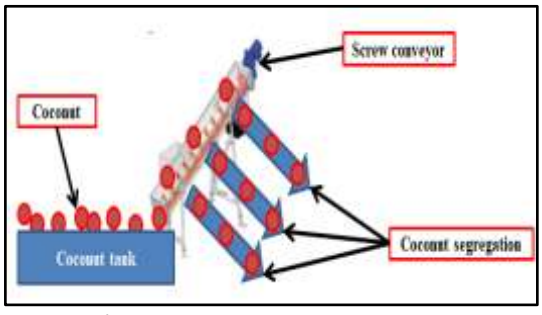

Figure 6, Screw conveyor concept

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3. Rotary table Segregation System Concept

Hooper is used to feed the coconuts over the belt conveyor; the system is designed to hold the pile of coconuts loaded at an elevated height manually or by dumping trucks. Hooper will help in placing the coconuts one by one on to the conveying units and further to segregation. The vibrator attached to the hopper will move the coconuts over the rotary table one by onethere is no conveyor used in this design concept. The coconut is slides through the draft provided at the Hooper and moves over the rotary table and get in to the pockets as the rotary table moves.

The coconuts are directly placed over the. Rotary table which has the segregation unit integrated in it. The segregation is done in the pockets made over the rotary table which accommodates the coconuts in it. The draft given in the pocket and the opening provided at collecting draft sheets will segregate.

The tray is provided with a draft of 45 degree and routed to the collecting unit where big bags are placed to collect segregated coconuts. Figure 7 shows the Hooper filter segregation concept sketch.

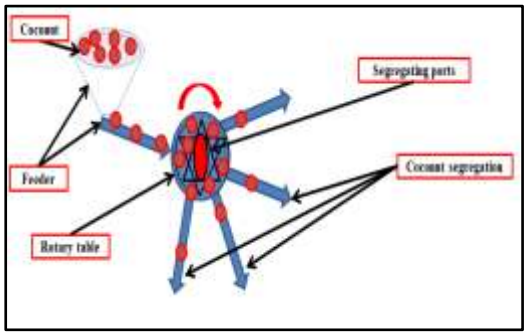

Figure 7, Rotary table concept

4. Hooper filtering segregation system concept

In this concept the Hooper is used to feed the coconuts and segregate at multi-level Hooper's. The system is designed to hold the pile of coconuts loaded at an elevated height manually or by dumping trucks. Hooper is provides with a rotating fins and a perforated holes at base. This will help in placing the coconuts one by one on next hooper below which has similar mechanism with next sized coconuts pockets. The vibrator attached to the hopper will move the coconuts over the rotary table one by one.

There is no conveyor used in this design concept. The coconuts are directly placed over the first Hooper which has the segregation unit integrated in it. The segregation is done in the pockets made at the base of the Hooper. Each Hooper will have different sized pocket the top Hooper will hold big sized coconuts and rest is dropped down. Similarly it will go in other Hooper's after some tine the Hooper is tilted to collect the filtered coconuts.. Figure 8 shows the Hooper filter concept sketch.

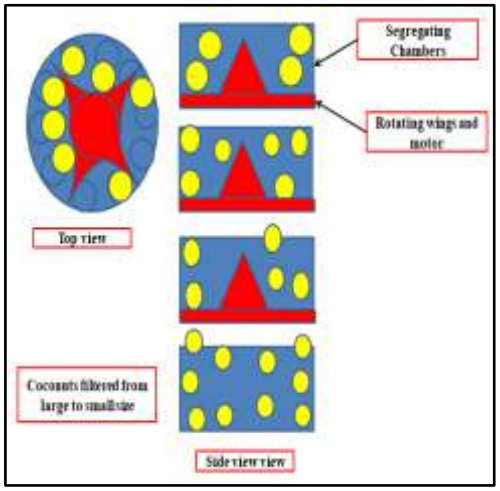

Figure 8, Hooper Filtering concept

5. Roller conveyor Segregation System Concept

This concept is almost similar to the first concept where instead of belt conveyor roller conveyor is used to segregate coconuts. Hooper is used to feed the coconuts over the roller conveyor; the system is designed to hold the pile of coconuts loaded at an elevated height manually or by dumping trucks.

The roller conveyor is used to convey the coconuts over to the segregation units. The segregation units are designed with special pocket type rollers placed where the coconuts are dropped in to the segregating guide plates, with the roller gap matching the different size of coconuts. Each segregating unit has different size roller gap to segregate the coconuts.

In this process the smallest coconuts are segregated first and the next size to be in respective following units.The coconuts are dropped over the guide tray which is placed below each segregation unit. The tray is provided with a draft of 45 degree and routed to the collecting unit where big bags are placed to collect segregated coconuts. Figure 9 shows the roller conveyor concept sketch.

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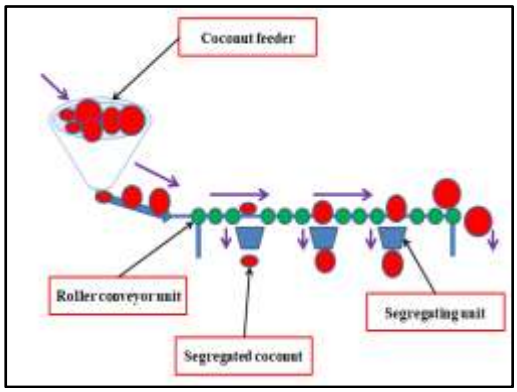

Figure 9, Roller conveyor concept

VI. FEASIBILITY STUDY

The study to determine the proposed concept is feasible or achievable before going in to system design. A brief look in to major factors like

1. Technical Feasibility

Ensure whether the existing technical resources such will support the design of the proposed concept. During the virtual analysis it was found that the Conveyor works independently with no synchronization with other machinery, i e it is an independently operating unit and in case any technical issue arise in the developed concept than the issue will be limited to that particular machine and will not affect other operations on the shop floor. Any design developed can be easily implemented as it will be done on an independent machine. Therefore, it can be concluded that the proposed system is technically feasible.

2. Economic Feasibility

It is very important to take under consideration the cost effect on the present and on the system being developed. An automated system will have initial high installation cost, but in long run it will be profitable. So economic feasibility is not a constraint in this proposed automation project. The proposed project is designed for reducing the production by 42%, Assuming total Segregation per minute with present system is 480 coconuts per minute, (as per conveying speed data). That is maximum of 8 coconut is segregated every second. Total Segregation expected to be produced from automated system is 201600/ 7 hour. Total hours in a shift of the factory currently is 12, so increase in production will be 145600/-. Current working hours: 12 hours. Coconuts segregated per day with automated system: 345600/-. Coconuts segregated per day with the existing system: 200000/-. That is 145600 more coconuts per day will be produced with the proposed automation project. By this increase in production it is evident that the proposed automation system will be economically feasible.

3. Operational Feasibility

The system, which was going to be implemented, obviously will have some effect and in turn Change the working environment but that must not be drastic and the users must feel Comfortable handling the new system developed. Industry can utilize the existing human resource working on segregation to other progressive domains to positively expand the operations of organization. By this increase in production and effective utilization of resources it is evident that the proposed automation system will be operationally feasible.

VII. DECISION MATRICES.

The process of evaluating the concepts with respect to the need of customer and comparing the strength & weakness of the concept is defined as Concept rating. The concepts of ASC are tabulated in decision matrix and rated as shown in table 1

The 5 concepts made were placed in to decision matrix and rated to finalize the best concept in them. As per the rating the Roller conveyor concept was selected for further feasibility study. With the completion of rating and feasibility study it is concluded that the roller conveyor concept 5 is selected to develop the system design and analysis.

Sl no	Weightage for 100% / Rating 0 - 5 / For particulars	Weig htage	Concept's									
			1. Belt conveyor		2. Screw conveyor		3. Rotary table		4. Hooper filter		5. Roller conveyor	
			Rat ing	Weig htage	Rat ing	Weig htage	Rat ing	Weig htage	Rat ing	Weig htage	Rat ing	Weig htage
1	Husked coconut Filtering	20%	3	0.6	1	0.2	1	0.2	1	0.2	5	1
2	Area of installation	10%	2	0.2	4	0.4	4	0.4	4	0.4	4	0.4
3	Complexity of design	10%	4	0.4	1	0.1	1	0.1	4	0.4	5	1
4	Ease of manufacture	10%	3	0.3	1	0.1	1	0.1	4	0.4	4	0.4
5	Ease of handling	10%	4	0.4	3	0.3	2	0.2	3	0.3	4	0.4
6	Ease of use	10%	4	0.4	3	0.3	3	0.3	3	0.3	4	0.4
7	Durability	15%	3	0.45	3	0.3	3	0.3	4	0.6	4	0.6
8	Portability	15%	3	0.45	1	0.15	1	0.15	5	0.75	4	0.6
	Total	100%	26	3.2	17	1.85	16	1.75	28	3.35	34	4.8
d	Rank		3		4		5		2		1	
e	Continue		no		no		no		no		YES	

Table 4.1, Decision matrix table

VIII. SYSTEM DESIGN

An automated machine is designed. With help of Inventor Student edition CAD software provided by Autodesk Computer Aided Design was carried out. Segregation unit with automated system is developed using the Conveyor and gravity feeding unit. The most challenging part was to segregate the unit was to segregate the different sized coconuts. For which many concepts were considered and had their own disadvantages while segregating. The

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specialized roller concept proved to be more convincing to all the issues listed in other concepts. Rollers were designed to hold the specific sized coconuts and convey the larger sized coconut to next segregating unit. Guide sheets and friction rollers can convey the coconuts in proper orientation and assist to segregate as shown in figure 10

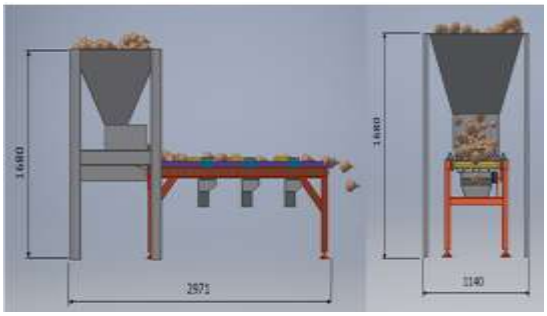

Figure 10, Automated Segregating system layout

IX. ASC SYSTEM SPECIFICATION

The detailed specification of the ASC systemas shown in table 2

Sl	Description	Specification	Parameters
1	Machine Layout	Length	2971 mm
		Width	1140 mm
		Height	1680 mm
		Diameter	70mm
2	Roller	Material	polymer with grip
		Spacing	100 mm
		Projection	No Projection
		Diameter	96 mm
3	Segregating roller	Material	polymer with grip
		Spacing	100 mm
		Projection	13 mm
		OEM	SKF 6023
4	Bearing	Type	Ball
		Material	Steel
		Capacity	9.5 kN.
5	Drive	Type	Sprocket and Chain
6	Frame	Type	C-Channels
		Size	100 x 45 x 5 (mm)
		Material	EN8
7	Motor	Power source	Electric
		Capacity	0.5 HP / 3 phase
		Voltage	230V/ AC / 460V / AC
		Speed	80 rpm
8	Conveyor	Speed	60 rpm
9	Segregation	Speed	480 per minute
10	Total weight	Curb weight	500 Kg

Table 2, ASC Specification

X. WORKING OF ASC MACHINE.

Automated segregation for coconut machine consists of 3 main parts: Figure 11 shows the typical units of the ASC machine.

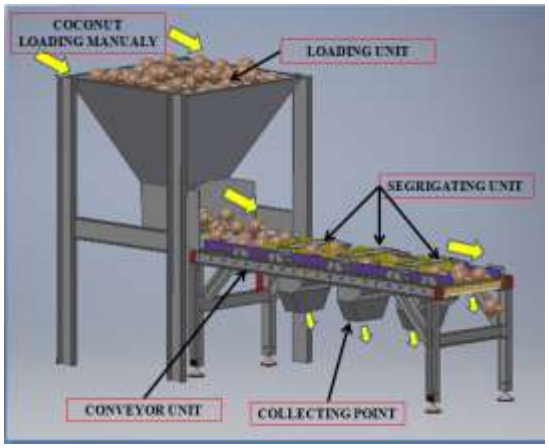

Figure 11 ASC system

Hooper mounted over a frame will assist in feeding the coconuts and conveyor will move the coconuts on to the roller which will further take the coconuts guided over to the segregation units. The segregation unit will sort the coconuts as per the sizes at each station and final open draft channel will take the last sized coconuts to collecting baskets. Details of the design of each unit are discussed here after.

1. Feeding unit:

Feeder system is supported by C-Channel frame. The frame has 4 legs supported by side rails all the components are welded to join as a single frame which can withstand a load of 2 tons. Weld of thickness 3 mm is maintained all around the frame. The frame is implanted in to concrete base which makes it rigid.

The Hooper is designed with an opening of 1000 x 1000 which has an inverted pyramid cut at top and bottom as inlet and outlet of the feeding unit. The draft channel is provided at end of the outlet which will guide the coconuts over the

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conveyor directly. The opening of outlet is kept 500 x 250 which will allow 3 to 4 coconuts to fall in to guide the draft channel is elevated such that the coconuts are not clogged in path and can free fall on to draft sheets. The draft of 45 degree will also help in moving the coconuts slide over the conveyor naturally without any additional aid. The gravity force and weight of the coconut is sufficient to feed to conveyor eliminating use of vibrator and additional mechanism.Figure 12 shows the Feeding unit model.

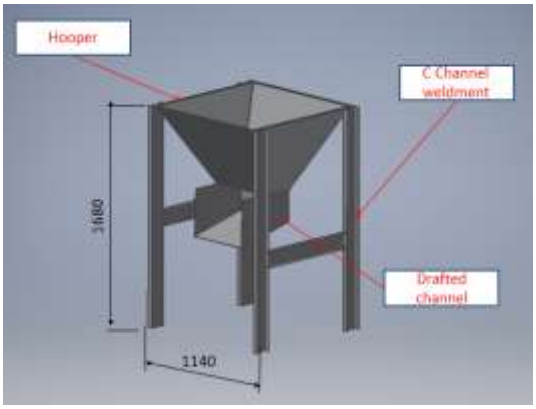

Figure 12, Feeding unit isometric view

2. Conveyor Unit:

Conveyor unit is designed with EN8 C Channels of 100 x 45 x 5 mm. the 4 legs stand apart with base length of 2072 mm, width of 677 mm and height is 666 mm. the frame is welded with 5mm all around fillet weld which makes the structure rigid. The entire four pillars are provided with four M16 adjustable legs. Motor mounting bracket is placed on one of the side support of the frame. Roller set, top bracket, drive set, motor mounting bracket are the major parts of the conveyor assembly. The figure 13 shows conveyor unit and its main parts.

The C- Channels with EN8 materials are chosen from market. The structure can withstand a load of 50 kg/mm with a bending of .5mm at the centre of the frame around 1026 mm length. The frame is supported at the sides with horizontal beam and inclined gusset of same sized C-Channel. Machining to accommodate rollers, top bracket and motor bracket is provided on the respective positions. The holes are drilled after the frame is welded and this is a cost adding but accurate job in the structure

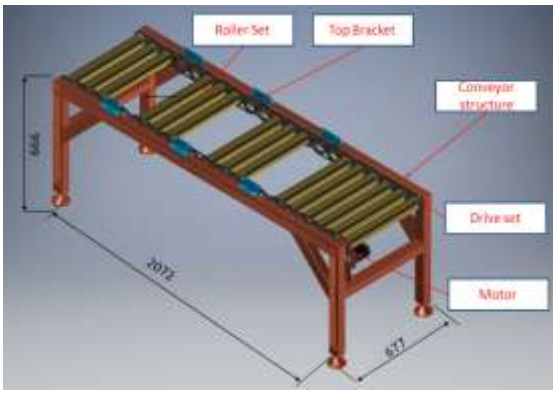

Figure 13, Conveyor unit isometric view.

There are 15 rollers set where each set is made of Roller drum manufactured by polymer material, sprocket and bearing housing made of MS material shown in Figure 14

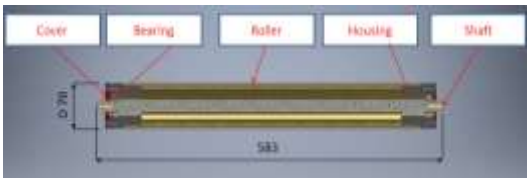

Figure 14, Roller Set sectional view.

The shaft is designed with 20 mm diameter and rollers of 70 mm diameter. Bearing outer diameter is 40 mm and further details shown in technical specification sheet in figure 5.6. Circlip is used to lock the bearing inside the housing.

M6x12, Fasteners are used bolt the cover the housing on both ends which encloses the bearing with shaft and housing. 0.5 HP motor was selected with 80rpm speed.

3. Segregation Unit.

Segregating unit has the layout sized with base length of 583 mm, width of 363 mm and height 393 mm. The special roller bracket or the idle roller bracket will hold the segregation cover on top and guide sheet at bottom. The secondary guiding and orienting sheets and primary guide sheets are fastened to the segregation cover at top. This entire assembly with segregating cover guide sheets and guide cover is mounted on the bracket which is mounted to the conveyor assembly top bracket. With the support of M8 fastening set the segregating bracket is mounted over the top bracket placed in conveyor assembly.

The guide and orientation sheets are provided to avoid clogging of coconuts in the line and also to orient the coconut to roll on to the special roller. The orientations will also assist in allowing coconuts one by one in to segregation unit. The segregation cover will assist by not letting the

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coconuts pile one over the other during segregation process. Figure 15. Shows the segregation unit.

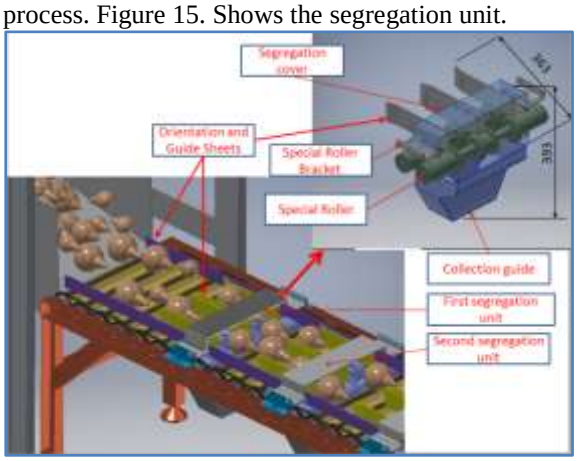

Figure 15, Segregation unit isometric view

Special rollers are designed exactly with same features and materials used in roller set shown in figure 14, the only difference is the roller is provided with a special pocket feature to hold the different size coconuts. Figure 16 shows the special roller details. Figure 17 and table 3 shows the different sizes of coconuts and respective rollers pocket width.

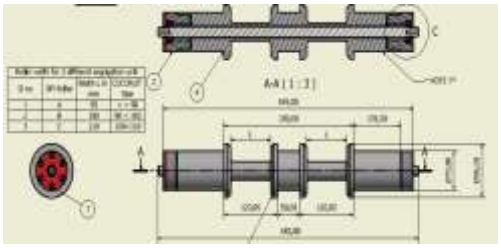

Figure 16, Special roller specification

Specimen no	Coconut shell Diameter	Coconut height	Coconut weight	Segregating roller pocket width
1	90 mm	140 mm	350 gm	90 mm
2	100 mm	160 mm	500 gm	100 mm
3	105 mm	180 mm	600 gm	105mm

Table 3, Coconut size and roller size tabulation

Figure 17, Coconuts S1, 2, 3, 4 respectively.

XI. CYCLE TIME ESTIMATION

Cycle time in general is a term how long it takes to do a repetitive job each time or in other terms it's the time taken to get through a process from start to finish. With the manual Operating cycle time is it practically found that 4 coconuts are segregated per second with 4 6 labors, but customer demand is 8 parts per second so as to produce exactly 200000/- segregated coconuts in 8 hours.

Concept must be applied so as to produce as per demand. In practice knowing Time for specific product will help us understand the level of effort you will have to exert to meet customers demand.

Data:

- Conveyor speed: 40 rpm
- Conveyor length = 2072mm
- Roller Diameter = 70 mm

The formula for circumference of a circle is 2 x pi x r(radius)

C=2 x pi x r
C= 2 x 3.14 x 35
C= 219.9 mm

The linear travel of material per second is calculated by multiplying the circumference of roller with rpm of roller.

Linear travel time = C x rpm
Lt = 219.9 x 2400
Lt = 2619.9 sec

Travel time for one coconut till end of conveyor is

Travel time on conveyor = conveyor length / Linear travel time
Tt = 2072/ 2619.9
Tt = .79 sec

It takes .79 sec to travel on the conveyor to extreme end. There are 3 segregating units in between the conveyor which can segregate 6 units at a time and with final unit to just pick we can take 8 units at a time. As the travel time is 1 sec to travel 2072 mm length then in a second, so after initial 6.88 sec the conveyor can filter or segregate 10 coconuts every second.

Each second there is a segregation of total segregation (Ss) at a time divided by time needed to travel on conveyor

Ss = 8 / .79
Ss = 10.12 per second

Segregatins of 2 lakh coconts is calculate as follows

Total no of coconut Segregated in a minute
Sm= 10.12 x 60
Sm= 10.12 x 60 = 607.59 per minute

Total no of coconut Segregated in a hour
Sh= 607.59 x 60
Sh= 607.59 x 60 = 36455.69 per hour

Total no of coconut Segregated in a hour = 36455

For 2 lakh coconuts time needed is

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Time needed = 200000 / 36455
Time needed = 5.48 = 5 hours 28 minutes

If the current industry can segregate 2 lakh coconut in 12 hour then the ASC machine can handle same capacity of coconuts are segregated by machine in five and half hour. The comparison chart is presented in table 4

Current operation	Proposed automation	Result
200000/- coconuts segregated per day with 4 to 6 labours for 12 hours	200000 /- coconuts segregated in 5.28 hour 2 labours to load and receive	Reduced hour of work by 6.32 hours. Increased segregation rate

Table 5.4 Segregation time Comparison

XII. ASC OPERATING PROCEDURE

The ASC machine installed at the work site operates is presented step by step

Step 1:

Coconuts are placed in to loading unit by operator. Parts will be not oriented as placed due to profile of coconuts. Due to gravity and Draft of loading unit the coconuts are fed to conveyor.

Step 2:

Switch on the motor to start conveyor which will pull the coconuts from loading unit and conveys to segregating units.

Step 3:

Coconuts are rolled over conveyor and the guide plates will assist to orient the coconuts in to segregating unit. As shown in figure 18 below.

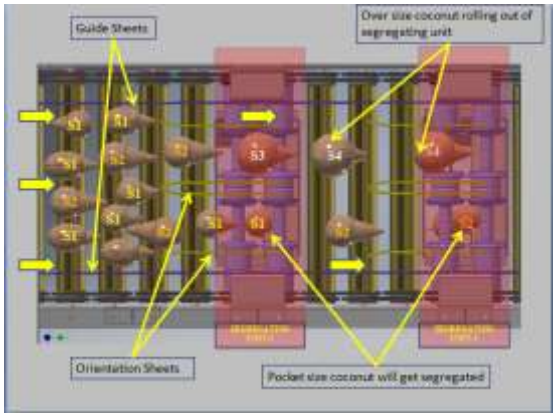

Figure 18, Orientation and segregation process

Step 4:

The segregating unit has 3 different rollers with 3 different profiles to segregate the coconuts with respect to size. The special roller is designed to have pocket which fits the S1, S2, and S3 in respective segregation unit. S4 will roll out through guide at end of conveyor. The process of segregating coconut is represented in the Figure 19.

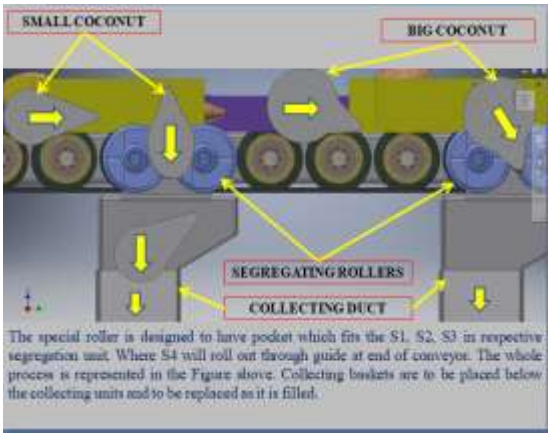

Figure 19, Segregation process

Step 5:

Collecting baskets are to be placed below the collecting units and to be replaced as it is filled. Replace the baskets as and when it is filled.

XIII. CONCLUSION.

With the design of an ASC system project work it can be concluded that the Initial five concepts were generated for Automated System for Coconut Segregation.The roller conveyor concept was selected among the 5 concepts drafted with the support of Decision Matrix.In the technical, economical and Operational feasibility study was performed; it was found that the concept is fit to be designed in detail.

ASC system was designed from the selected roller conveyor concept to segregate husked coconuts, sizes starting from 90, 100 and 110 mm; any oversized coconuts will be pushed forward to next segregating unit as roller size will not allow it to fit in pocket.

The time taken for segregate 200000 unit's coconuts was estimated to be 5.28 hours as compared to the manual process of segregation which would take 12 hours. The design of ASC will serve the purpose of segregating the husked coconuts and will increase the overall profit of the industry by meeting the demand of Indian market.

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