Fabrication of Low Cost Automated Lime Colour Sorter

Tharmatharsanan.R[1], Alvappillai.P[2]

Department of Agricultural Engineering, Faculty of Agriculture, University of Jaffna, Sri Lanka

Abstract— *Among fruit crops lime has high demand in the world. There are varieties of products being made from limes at various stage of maturity. Colour is the vital parameter of maturity indication of most agricultural produces. Colour of lime produce varies from green to yellow. Although yellowish limes are preferred by some category of people and processers, for exporting purposes greenish limes are being used because of their longest shelf time. Thus, sorting based on its colour is crucial for consumer acceptability and also for further processing. Both greenish and yellowish limes are harvested together and sorted through post-harvest operation of colour sorting. This is often performed by manual labourers. The main limitation associated with hand sorting is less accuracy, as human evaluation may vary person to person. Therefore, automated grading system is becoming popular due to its superior speed, consistency, and accuracy. This paper discusses about a new approach to develop a lime colour sorter at a minimum price using TCS230 colour sensor. The identification of the colour is based on the frequency analysis of the output of TCS230 sensor. Arduino Uno was used to control overall process. Stepper motor was used to sort limes into two different classes. All the mechanical parts were designed through Auto CAD software. Fabricated sorter was tested at various environmental light intensities, the results shown there is no influences by the sexternal light.*

Keywords— Arduino Uno, Auto CAD, Colour sorting, Stepper motor, TCS230 colour sensor.

I. INTRODUCTION

As a group of fruits citrus has high demand in the world due to its cultural, social and economic impacts in our society. Among citrus, lime is the third most important fruit crop after orange and mandarin which is native to Asia [1]. Lime (Citrus aurantifolia) belongs to family Rutaceae, is grown tropical and sub-tropical countries in world [2]. In Sri Lanka it is grown in organized small orchards and home gardens in dry and intermediate zones. Uva and north western provinces are the major lime growing areas in Sri Lanka [3].

Lime is widely used for culinary and non-culinary purposes. It is consumed as beverages, refreshing drinks, pickles, jams, jellies, snacks, candies, and sugar boiled confectionaries, and culinary throughout the world. Extracted oil from the peel is extensively used in soft drink concentrates, body oils, cosmetics, hair oils, tooth pastes, toilet and beauty soaps, disinfectants, mouth washes, deodorants and innumerable other products [4]. The substances flavonoids, alkaloids present in limes have biological activity such as anti- bacterial, anti-fungal, anti-viral, anti-cancer and anti-diabetic activities [4].

In world, India, Mexico, Argentina, Brazil, Spain, China and United states are the main lime producers, in which Argentina is the world largest lime producer, produce over 1 million metric tons annually [5]. Extracted juice from the pulp and zest has high markets in the world and, it is prepared from ripened limes. Success of this liquor caused emergence of small industries in Sri Lanka also and it has positive impact in our economy.

In agricultural side, product quality and quality evaluation are the two most important parameters in food industries. The quality is improved through the postharvest operations of washing, sorting, grading, packing, storing and transporting [6]. When consider the lime, it is an oval or round, its colour varies from green to yellow, and it is harvested throughout the year. During harvesting, they are harvested together, because both green and yellow limes have demand at markets [7]. However, consumers, they prefer to have the things with similar shape, same size and similar colour [1]. These can be achieved through sorting and grading process.

Quality grading of many agricultural products can be made through its outer and inner parameters. The outer parameters are those size, shape, texture, colour intensity and colour homogeneity, and sweetness, acidity and incidence of disease are the inner parameters. Although in most, accurate classification of sorting is achieved by considering their colour and size [8], [9]. In general, the color of a produce indicates its level of maturity, and the presence of defects [10], [9], [11]. Thus, colour sorting gets its priority due to this reason.

This sorting process is done manually or through automated machineries. Despite, to provide good quality products within the short time automated grading system is becoming popular among farmer association [12]. This automated system is getting its priority due to its superior speed, consistency and accuracy. The traditional visual quality inspection of manual sorting and grading, which are performed by hired labourers is tedious, time-consuming, slow and inconsistent and also it is difficult to hire the labourers who adequately trained and willing to undertaken the tedious task [13], [14].

Therefore, this automated grading system in agriculture and related industry will help to supply the increasing demand for high quality food products as much as quick at the same time it will have positive impacts on growth and development of that particular industry [15]. Thus, researches in this field will help to freeing the people from traditional hand sorting and it will help to improve product quality [13]. There are several approaches for continuous recognition and sorting of objects according its outer parameter into desired location. But, this study focuses on a new approach and design for sorting, specifically for limes by using colour identification sensor TCS230, Arduino Uno a micro controller and stepper motor.

II. MATERIALS AND METHODS

2.1 Determination of physical properties

At first, physical properties of limes were determined for our mechanical design. For this, particular size group of random lime samples at various colours had been selected. Average weight of limes was determined by using precision electronic balance to an accuracy of 0.01 g [16], [17]. Bulk density was determined through its bulk weight and volume by dropping the limes from 15 cm of height into a capacity known container [16]. Major diameter of taken samples were measured by a digital caliper with 0.1 mm sensitivity [17]. Then, the repose angle to protect the produces from mechanical defects was tested upon the tin surface, the material used for our mechanical design [18].

By considering above physical properties, mechanical parts were designed through Auto CAD software for making perfect cuttings upon the tin material.

2.2 Mechanical design

In our design the mechanical parts are hopper for bulk feeding, tunnel for feeding one by one in a line, single feeding and sorting system and two outlets for sorting into two categories. Based on physical parameters of selected groups of limes, every dimensions and slops were kept. Each slopes were designed to the repose angle.

2.2.1 Hopper design

The hopper walls were designed as the four trapezoidal walls are to the repose angle as shown in fig “2.1”, “2.2”, “2.3” and “2.4”through the equations as shown in “(1)”, “(2)” and “(3)” and another four rectangular walls were used to have enough capacity as shown in the fig “2.5”.

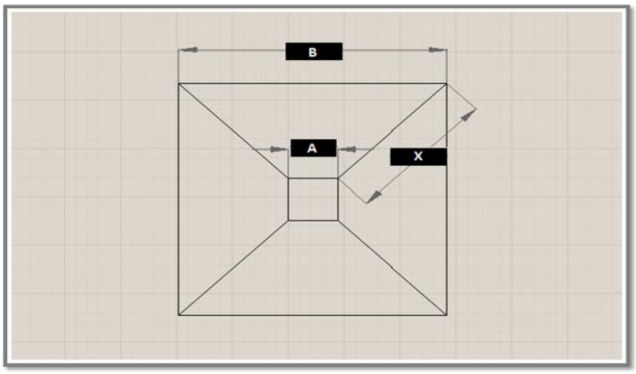

FIGURE 2.1: HOPPER DESIGN PARAMETERS – A.

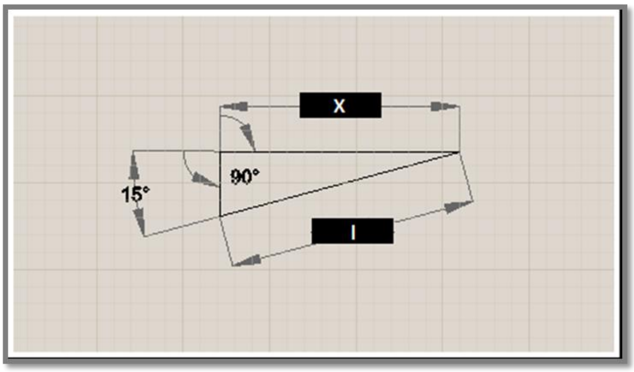

FIGURE 2.2: SLOPE DESIGN PARAMETERS.

$$X = \frac{\sqrt{(B^2 + B^2)} - \sqrt{(A^2 + A^2)}}{2} \tag{1}$$

$$l = \frac{X}{\cos 15^\circ} \tag{2}$$

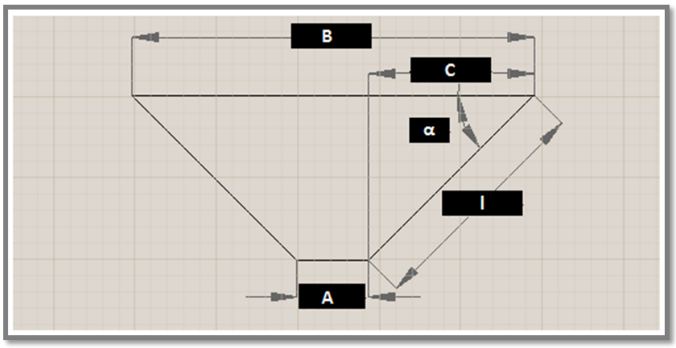

FIGURE 2.3: HOPPER DESIGN PARAMETERS – B.

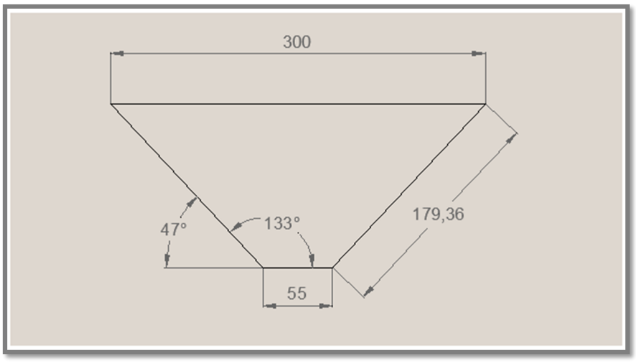

FIGURE 2.4: OBTAINED HOPPER DIMENSIONS

$$\alpha = \cos^{-1}\left(\frac{C}{l}\right) \tag{3}$$

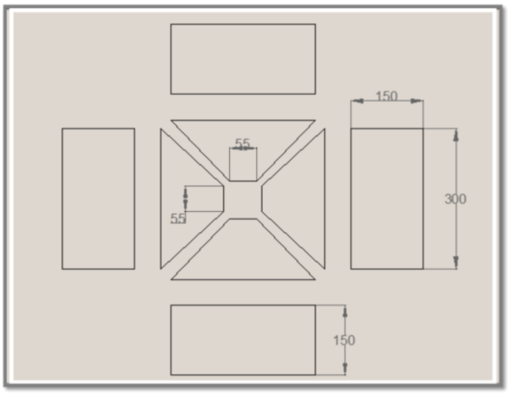

FIGURE 2.5: PARTS OF HOPPER PRIOR TO ASSEMBLING

2.2.2 Tunnel design

The dimensions of each tunnel walls were as shown in Fig "2.6". Tunnel width was kept little above the maximum diameter of selected lime group and the length was taken based on our preference. The slope was kept to the repose angle to minimize the produce defects.

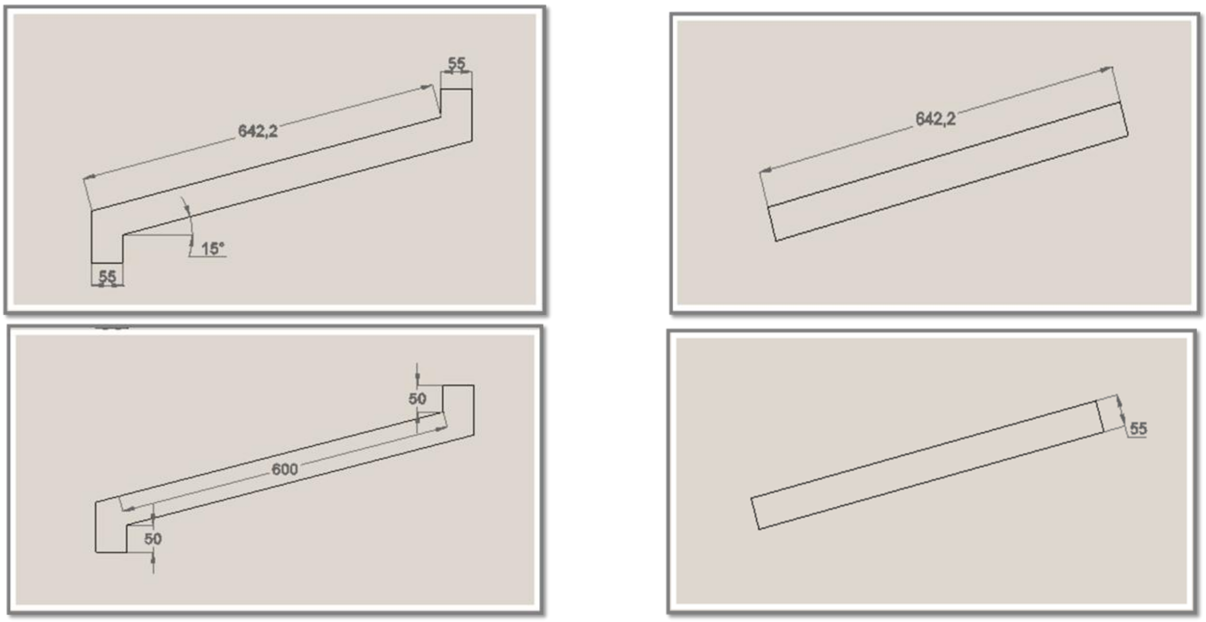

FIGURE 2.6: DIMENSIONS OF OTHER TUNNEL PARTS

2.2.3 Single feeding and sorting system

It was designed through two square boxes inner and outer square boxes as shown in fig "2.7" and "2.8". The height of inner square was kept to the lime size and outer square's height was kept little greater than the lime size.

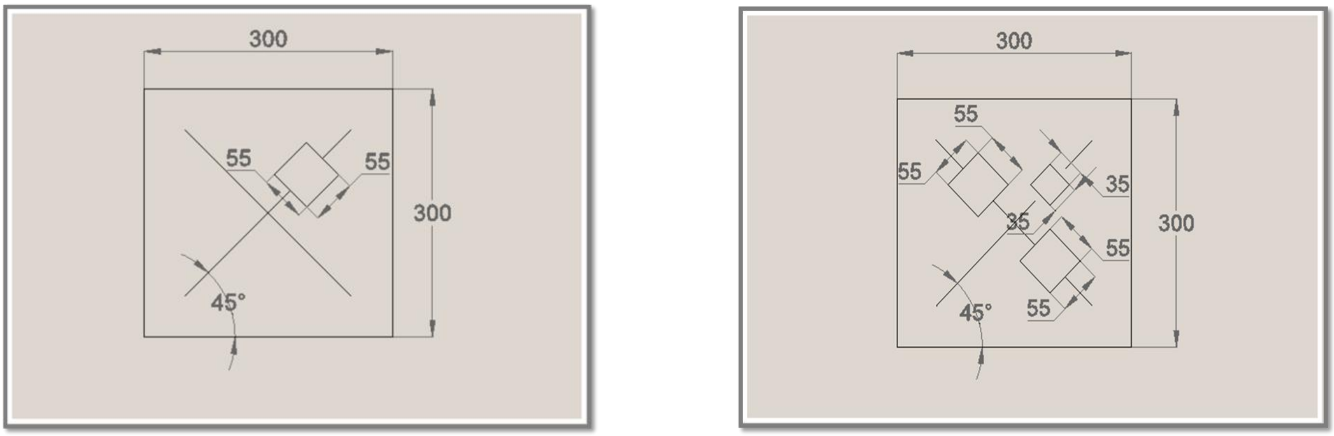

FIGURE 2.7: UPPER AND LOWER SURFACES OF OUTTER SQUARE BOX.

FIGURE 2.8: UPPER AND LOWER SURFACES OF INNER SQUARE BOX.

2.2.4 Outlet design

In our system there are two outlets, which were designed as shown in fig "2.9". Here the angle was kept to the repose angle.

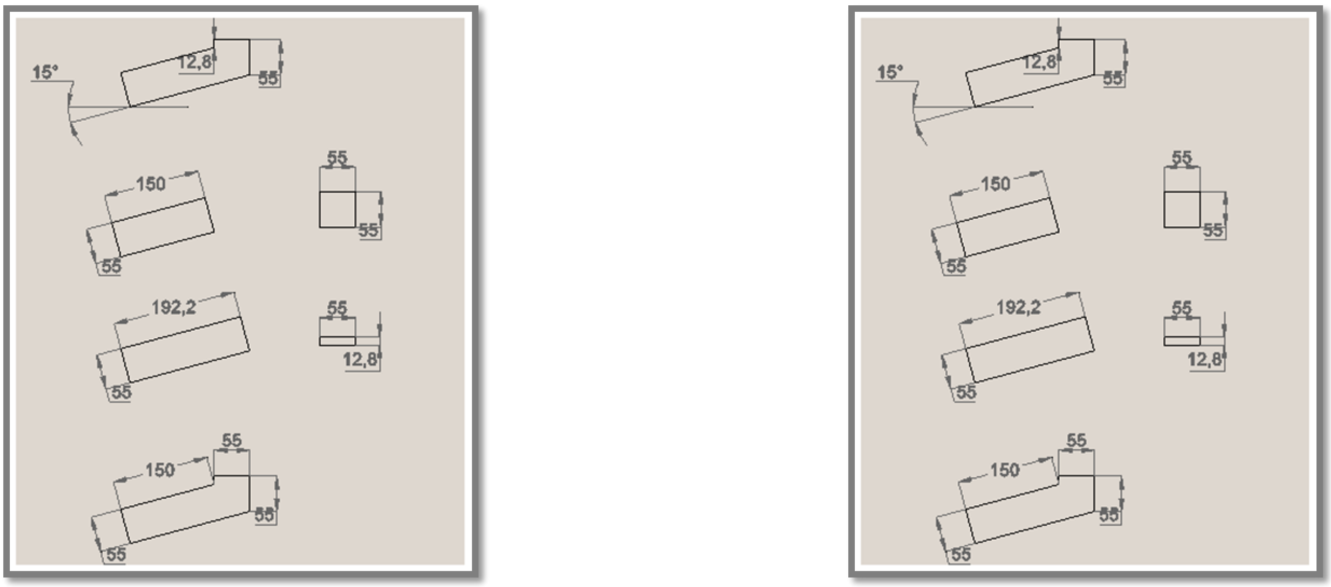

FIGURE 2.9: PARTS OF TWO OUTLETS OF THE SORTER

2.3 System automation

The final system was automated using microcontroller (Arduino UNO), colour sensor and a stepper motor. The void setup and loop functions were fed up through Arduino IDE software. Based on colour identified by the TCS 230 sensor the motor will turn to the left or right. All the process is controlled by the Arduino UNO.

III. RESULTS AND DISCUSSION

3.1 General description of colour sorter

The developed colour sorter (Fig "3.1") has feeding capacity of 120 – 150 limes at a time and it able to sort limes into two categories. Here, we aimed to sort light green and green into one category and yellow and light yellow into another. Its functional voltage is 12 V, and its power consumption is 3.72 W.

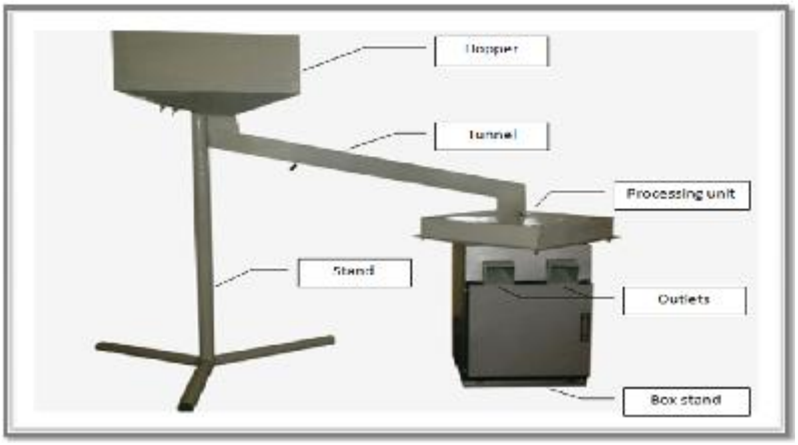

FIGURE 3.1: DEVELOPED LIME COLOUR SORTER

Including mechanical and electronic components, altogether total manufacturing cost of this colour sorter was around 25,000 Rupees which is far cheaper than other commercially available colour sorters.

At this set delay time near the sensor 50 ms, delay time between steps 50 ms and the delay time at the outlet 50 ms, it takes around 2.6 minutes to sort 30 lime samples with 100 percentage of sorting efficiency. Thus, to sort 150 samples it will take 13 minutes. This time can be further reduced by setting the outlets closer to the sensor which was set 90 ^{0} in our design.

3.2 Influences of external light intensity on sorting process

TABLE 3.1
R, G, B INTENSITY READING FOR VARIOUS LIME SAMPLES AT VARIOUS TIMES IN A DAY.

Lime category	8.00 a.m 92 lx			12.00 noon 360 lx			8.00 p.m 10 lx			(Fluorescent bulb) 345 lx		
	R	G	B	R	G	B	R	G	B	R	G	B
Dark green	19	23	26	19	23	26	19	23	26	19	23	26
Light green	16	18	22	16	18	22	16	18	22	16	18	22
Light yellow	11	15	19	11	15	19	11	15	19	11	15	19
Yellow	09	13	17	09	13	17	09	13	17	09	13	17

Table "4.1" shows the R, G, and B intensity values are exactly same all the time for each groups above, which means there is no any influences by the external light on sensor reading. This is because the sensor was placed in a dark environment. Thus this machine can be used at any time in a day with 100 percentage of sorting efficiency in indoor condition.

IV. CONCLUSION

This machinery was designed to sort limes of particular size into two different groups, which are light green and green into one category, and light yellow and yellow into another category. Although, it also possible short into four categories, along with decayed one almost five categories possible based on this principle. The sensor TCS230 has ability to recognize and differentiate lime produces more efficiently. In case of agricultural produces the colour distribution is not even all the time.

Thus, use of more than one sensor to sense several portion of these produces will increase the accuracy and reliability of this sorting process. This system was developed for particular size group of limes, which size is commonly used for exporting purpose. In future, it can be developed further as multi-diameter for sorting other size lime groups or in other way this same system can be used for other size as well by using flap valve mechanism for single feeding. To ensure the optimum feeding through the tunnel, vibrator can be attached at the hopper zone. Many of available sorters are fixed and their cost is high. This sorter was developed at minimum cost and it is a portable one. The real contribution of this system is that it is able to save time of sorting based on colour. Thus, this system has a huge potential to go into the market with proper implementation. This mechanism can be used for other agricultural products as well including grains.

ACKNOWLEDGEMENTS

I would like to express my profound gratitude to my supervisor Senior Lecturer, Dr. P. Alvappillai, Department of Agricultural Engineering, Faculty of Agriculture, University of Jaffna for his encouragement, motivation and support during the tenure of this project.

I am very much obliged to Mr. N. Kannan, lecturer Department of Agricultural Engineering, Faculty of Agriculture, University of Jaffna for the help extended throughout this research period.

I would like to express my thanks to Dr. (Ms).V. Cynthujah, Lecturer, Department of Electrical and Electronic Engineering and Ms. H. Krishnarajah, Lecturer, Department of Interdisciplinary Studies, Faculty of Engineering, University of Jaffna. I very much appreciated their assistance, encouragement and friendship throughout the study period. This research and my study would not have been a success without their help and support. I wish to thank you both very much for your patience, critical reading and many suggestions for my thesis writing.

My gratitude and sincere thanks go to Dr. Mr. M. Prabhakaran, Head, Department of Agricultural Engineering, University of Jaffna and Dr. (Mrs).T. Mikunthan, Dean, Faculty of Agriculture, University of Jaffna for granting permission to carry out this research.

Finally, I would also like to acknowledge the help and support I received from my parents (Rajadurai, Sivagamasundari), my brothers (Nirujan, Thanushan), my sisters (Meruthiga, Shameetha) and friends (Sivarajah, Vithyatharan, Sanjayan, Purusothaman and Thurka) who always gave me moral support and love.

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