Study of Existing Fruit Grading Machines: A Review

Aniket V. Joshi[1] , Prof. N. P. Awate[2]

[1]Student, M.Tech CAD-CAM, Department of Mechanical Engineering, GHRCE, Nagpur, India
[2]Assitant Professor, Department of Mechanical Engineering, GHRCE, Nagpur, India

Abstract – In the past few years, Indian agriculture field is moving towards automation step by step from the conventional. Farmers are getting concentrated about using the latest technologies to increase the productivity in their field. They are also conscious about the price of their product. As price depends on the quality of product, their main aim is to improve quality of product. Uniformity is also a major factor which affects the cost of product. It is also taken into consideration while planning for packaging, transportation and marketing. Many of the farmers especially in Maharashtra region are taking fruits like Amla, lemon, Orange, mandarin, mango as a major product in their farms. There are some vegetables also like onion, tomato, garlic. There are many products and varieties are available in market of these products but the quality and uniformity is major price affecting factors. For the ease of operation, every field is getting atomized. The automation will reduce the human interference in work and this helps to reduce the error occurred during operation. Automation also gives advantage of accuracy, time saving, increased productivity and higher efficiency. As like advantages, this may lead to some disadvantages also. Initial cost of machine will be higher. Automation requires fully trained or skilled special labor force, so the labor cost can be higher. As number of components of machines is increased, maintenance cost may increase. By the view of employment, this will lead to unemployment also.

Key words: fruit, grading, sorting, image processing, lemon, onion, garlic

1. INTRODUCTION

In the market and field survey, study of various existing fruit grading machines and various products that can farmers take consecutively in their field is carried out. Along with this, various mechanical and physical properties of some fruits also studied. There are variety of machines are available in market from fully sensitized to semi sensitized. But the available machines can be used to grade particular fruit that are designed for. To design the universal fruit grading machine that can be used for grading all circular shaped fruits from amla to oranges or sweet lemon according to their physical dimensions like major and minor diameters, various research works are studied. By the design point of view, some mechanical and physical properties are required, that are also studied from some research works.

History:
As uniformity increases the price of the fruits, there is need for farmers to grade their fruits according to size before sending it to market. By the study of market and some research works, it is known that there are various machines which are available at distributors. The available machines are highly automated and special purpose machines. Distributors use it for both purpose quality and size grading. As machines are highly automated, special purpose, it costs very high so farmers cannot afford it. And these machines require skilled labor to operate it; most of the farmers cannot operate it. As the machines are not useful at farmer level, farmer cannot get the well price for the products.

Techniques and methods used for fruit grading:

1.   Design of Grading Machine using physical and mechanical properties of Ponkan Mandarin.
The research is carried out to study some physical and mechanical properties of Ponkan mandarin fruit which will be helpful to design the grading machine. Some physical properties are like Diameter, Height, volume, mass, projected area, peel thickness etc are determined. Mechanical properties like average firmness distribution along Ponkan mandarin surface and deformation range are studied.
The major production of citrus fruits takes place in Egypt. About 2.8 million ton of citrus fruits production was taken in 2002. The area of orange was 88.2 hectare and production was 181 ton.

There were various studies carried out from decades. Some of which are to study the various varieties of citrus fruits and others were about the physical and mechanical parameters which are needed to design the grading machine.

Agamia et al. in **1982** carried out research work to study the parameters of various types of citrus fruits. The parameters were mass, volume and diameter. **Sharawy** carried out his study in **1992** to find no. of segments / fruit.

Likewise various researcher studied various parameters. Some of researcher are like **Kinawy** in **1995, Mousa** in **1998, Yehia** in **2001, Awady et al.** in **2004, Khanali et al.** in **2007** have given their contribution to the research work.

To decide materials for machine components and methods of operation, the 100 samples of Ponkan mandarin fruit were taken. And study is carried out considering the parameters of the same. To measure various parameters like mass, dimensions, density, volume, friction angle, angle of rolling, repose angle, bulk density etc; instrumentation is done by using digital vernier caliper, digital balance, penetrometer, deformation tester.

After studying and getting all the parameters which are essential for the design of grading machine, the work is carried further for machine design. The parts of machines are hopper to store and input the fruits to machine, drums with revolutionary motion having holes or sheaving screen and chute for exit of graded fruits. The dimensions of hopper are 100 cm in length, 60 cm in width and 35 cm in height. Side slope angle was more than max. friction angle of fruit with surface of stainless steel, which is kept as 30^0.

The no. of revolving drums are 5, which are having holes along circumference of diameter 40mm, 50mm, 60mm, 70mm and 80mm. diameter of drum is between 40 and 50cm and length 100cm for more productivity are taken. Angle of rolling was more than 24^0.Chute was tilted to more than 170 which is more than max. friction angle between fruits and surface of stainless steel.Following figure shows the concept of grading machine.
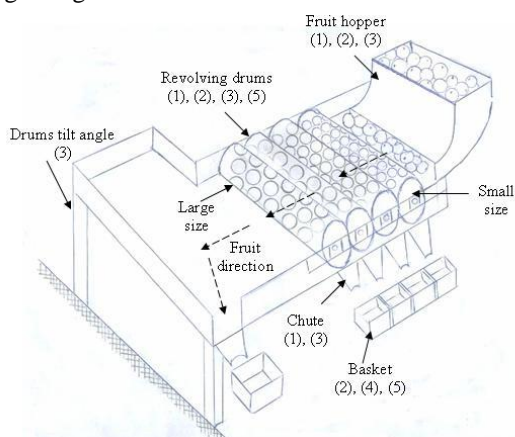

Fig. 2.1: Conceptual model of Ponkan mandarin grading machine

2. Technique for Orange sorting according to size and external defects.

By the study of this paper, we get introduction to an automated technique to sort the oranges according to their size and external defects using image processing. The algorithm is used to divide oranges in two categories i.e. defected and non defected. Only non-defected oranges are further divided according to their size in three groups i.e. small, medium and large. The input data to the machine is given in the form of images and according to that the comparison is done between the images fed and actual orange, and sorting is done.

The main parameters on the basis of which fruits can be sorted or graded are shape of fruit, size of fruit, color, volume and maturity of fruit. In this paper, the fruits are sorted according to defects in three categories i.e. 1) anthracnose, 2) unripe and 3) stem-end injured. Likewise according to size, they are categorized in 1) small, 2) medium and 3) large.

At the first or initial step of working, analysis using red channel is done. This separates the non-defected fruits or stem-end injured fruits from unripe or anthracnose fruit.

At the next step, area of fruit is calculated and according to that value the categorization is done while the latter are sorted according to hue value and saturation value calculated.

At the final stage, non-defected fruits are categorized in three categories i.e. small, medium and large according to size.

As the project work concentrates on size based grading system, the study is carried out on the size wise categorization. Firstly, the fed image is converted into grayscale and corresponding edge map is found. From the edge map encountered, the smallest rectangle in which all the edges of image will fit is determined. The rectangle will give the dimensions along horizontal and vertical directions of fruit. Mean of these two values will give the value of diameter of fruit, which can be used to calculate the area of fruit. By considering the threshold value, we can determine the category of size of fruit.

If two threshold values are considered, threshold value exceeds the larger threshold, fruit can be categorized as big, if threshold is small than small threshold value, fruit is small and in between these two threshold, the fruit is medium. The results obtained has shown 100% accuracy in sorting.

3. Prototype of orange grading machine using phototransistor.

In this paper, the study is carried out to design a prototype which will grade the oranges according to size. In the design of machine various operating components are used like phototransistors and actuators. By using phototransistor, the shadow image of fruit is taken in the form of digital signals and these signals are sent to electronic circuits for further processing. By using these circuits, the size of fruits can be determined. According to the output signals received by system, the corresponding gate will open and fruit will sent

from this gate for storage or packaging. The main parameters considered in designing a prototype are conveyor, velocity of chain, stopping time and percentage of sphericity of fruit, which are the controlling factors. And the parameters which affect the performance are grading efficiency, percentage of damage occurred and productivity.

The other components of the prototype are frame, feeding unit, sensors unit, distributing gates unit, electronic control unit, power control system, timing control system, measuring control system and distribution control system.

The physical characteristics of fruits taken into consideration are dimensions, volume, density, sphericity, projected area, coefficient of friction etc.

All the parts of prototype are assembled together in a 3mm thick square shaped frame which is made up of stainless steel. Feeding unit consists of three parts, hopper, conveyor chain and electric motor which is usually direct current. To measure the height of fruit, sensor unit is used. Height is determined when fruit passes from the vertical arrays of transducers. At the time of passing, the light gets blocked. One transducer is equipped with LED i.e. light emitting diode and other one with phototransistor. The main purpose of electronic control system is to control the feeding rate and to measure the diameter of fruit by using optical circuit. The distribution control unit controls the opening of the gate so graded fruits can fall down from opening.

4. Onion Grading Machine.

In this paper, the study of grading machine which is used for grading of onion is done.

They have used the simple mechanism which uses the cylinder, made by using PVC tubes of 20mm diameter, hopper for to provide feed and frame which is used for supporting purpose. The cylinder is divided into two parts or segments and provided with four outlets. The length of first portion is kept more than that of the second and it is provided with two outlets to separate the small bulbs of onion, which is less than 4cm in diameter. Second part of cylinder is consisting of a single outlet which is used to separate the bulbs in the range of 4cm and 6cm diameter which are graded as medium. And the outlet provided at the end of the machine is used to collect the bulb of onion larger than 6cm diameter, which can be graded as big onions. Length of the first segment is one half of the second. To reduce mechanical damage and to provide cushioning effect, tubes are provided with rubber wrapping. To give rotational motion to cylinder, manual as well as electrical drive is provided. To take advantage of gravity action by weight of onion bulbs, 3^0 inclinations with horizontal is provided to the cylinder. Because of inclination provided and cylinder is rotating, the medium and big onion come down and small will remain at upper position. To achieve maximum efficiency of grading, 15 rpm rotational speed was taken by experiments.

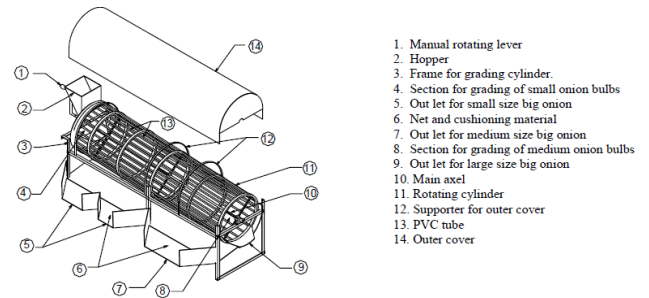Following figure shows the onion grading machine.

1. Manual rotating lever
2. Hopper
3. Frame for grading cylinder.
4. Section for grading of small onion bulbs
5. Out let for small size big onion
6. Net and cushioning material
7. Out let for medium size big onion
8. Section for grading of medium onion bulbs
9. Out let for large size big onion
10. Main axel
11. Rotating cylinder
12. Supporter for outer cover
13. PVC tube
14. Outer cover

Fig. 2.2: Onion grading machine

5. Lemon sorting System.

The lemon sorting technique is based on computer vision and image processing. The parameters like lemon size, color and surface texture, mass are taken into consideration. The algorithm can be used to estimate these parameters. System consists of two cameras, two capture cards, lighting system and computer. To capture the proper image, appropriate adjustment is done. Images of sample lemons are sent to pc in the form of signals. From the captured image, background is removed to determine the exact volume. Image is divided into no. of pixels. After saving the sample images, at sorting stage, the image of lemons that are to be sorted are taken one by one. The image taken is compared with the sample image by thresholds and the volume of lemon is determined. If volume of the lemon is greater than threshold, lemon will be graded as big and if volume is les than threshold, lemon will be graded as small.

6. Orange sorting based on pattern recognition.

In this research work, linear regression technique is used to sort the oranges according to their size. For preprocessing, raw database is prepared from environment of surrounding by removing the noise to make the data readable. The features that are needed for the system working are extracted from this database. The proper image to be fed to the system as a sample image and that is taken by making proper adjustments. The image of the fruit which is to be graded is divided into pixels and that is compared with the sample image pixels fed. The fruits can be graded as small, medium or large according to comparison between sizes.

Conclusion:

Conclusion of the studies can be done on the basis of various parameters. The comparison is done as shown in table below:

techniques of spraying has been studied. We have selected our objective for design methodology.

Comparative analysis on the basis of various parameters.

Sr. No.	Title	Author	Parameters	Remark	Comparison with my model
[1]	Design of Grading Machine using physical and mechanical properties of Ponkan Mandarin.	I. Yehia , M. H. Kabeel and M. M. Abdel Galeel	Mechanism used, parts used, drive, design considerations	Range of the holes on the cylinders are constrained, so the flexibility reduces	Increased range of holes on the cylinders, so flexibility increases and can be used to grade various types of fruits as well as vegetables.
[2]	Technique for Orange sorting according to size and external defects.	Naeem Sattar, Sheikh Ziauddin, Sajida Kalsoom, Ahmad R. Shahid, Rafi Ullah, Amir H. Dar	Equipments used, Method Used	Equipments used are costlier, require technically trained person for use	equipments used are not so costlier, does not require trained person to operate
[3]	Prototype of orange grading machine using phototransistor.	Gamal Rashad Gamea, Mohamed Aly Aboamera, and Maged Elsayed Ahmed	Equipments used, Method Used	Equipments used are costlier, require technically trained person for use, maintenance can be high	Equipments used are not so costlier, does not require trained person to operate, maintenance cost will be lower.
[4]	Onion Grading Machine.	D.M.C.C. Gunathilake, W.M.C.B Wasala, K.B. Palipane	Mechanism used, Size of Machine, Flexibility for use, Angle of Repose, Operational Speed,	The machine is not Flexible to use multiple fruits	Machine will be flexible to grade multiple fruit having variation size.
[5]	Lemon sorting System	M. Khojastehnazhand, M. Omid and A. Tabatabaeefar	Equipments used, Method Used	Equipments used are costlier, require technically trained person for use, maintenance can be high	Equipments used are not so costlier, does not require trained person to operate, maintenance cost will be lower.

Table 2.1: comparative analysis

Determination of various fruits and vegetables diameter according to varieties available.

Sr. No.	Fruit / vegetable	Minimum diameter (mm)	Medium diameter (mm)	Maximum diameter (mm)
1	Amla	37.5, 37.7,35.4		44.3,44.6,45
2	Lemon	49.31		62.85
3	Orange	77.93	84.06	90.4
4	Ponkan Mandarin	49.5	60.19	78.9
5	Onion	<40	40-60	>60

REFERENCES

[1] *I. Yehia , M. H. Kabeel and M. M. Abdel Galeel, "Physical And Mechanical Properties Of Ponkan Mandarin Applied To Grading Machine", Biological Engineering, Misr J. Ag. Eng., 26(2): 1036- 1053*

[2] *Naeem Sattar, Sheikh Ziauddin, Sajida Kalsoom, Ahmad R. Shahid, Rafi Ullah, Amir H. Dar, "An Orange Sorting Technique based on Size and External Defects"*

[3] *Gamal Rashad Gamea, Mohamed Aly Aboamera, and Maged Elsayed Ahmed, "Design and manufacturing of prototype for orange grading using phototransistor", AJAE 2(3):74-81 (2011)*

[4] *D.M.C.C. Gunathilakea, W.M.C.B Wasalaa, K.B. Palipanea, "Design, development and evaluation of a size grading machine for onion" International Conference of Sabaragamuwa University of Sri Lanka 2015 (ICSUSL 2015), Procedia Food Science 6 (2016) 103 – 107*

[5] *M. Khojastehnazhand, M. Omid and A. Tabatabaeefar, "Development of a lemon sorting system based on color and size" African Journal of Plant Science Vol. 4(4), pp. 122-127, April 2010*

[6] *Jyoti Jhawar, "Orange Sorting by Applying Pattern Recognition on Colour Image" International Conference on Information Security & Privacy (ICISP2015), 11-12 December 2015,Nagpur, INDIA, Procedia Computer Science 78 (2016) 691 – 697*