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DESIGN AND DEVELOPMENT OF OLIVE PITTING & GRADING MACHINE

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ELECTRICAL AND MECHANICAL ENGINEERING NATIONAL UNIVERSITY OF SCIENCES AND TECHNOLOGY RAWALPINDI

2022

COLLEGE OF ELECTRICAL AND MECHANICAL ENGINEERING

DE-40 MTS-A

PROJECT REPORT

DESIGN AND DEVELOPMENT OF OLIVE PITTING & GRADING MACHINE

Submitted to the Department of Mechatronics Engineering

In partial fulfillment of the requirements

For the degree of

Bachelor of Engineering

In

Mechatronics

2022

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ACKNOWLEDGMENTS

We would like to thank our Supervisor, Dr. Hamid Jabbar and Co-Supervisor Dr. Umar Shahbaz for his insight, guidance and help in accomplishing this task. It has been a privilege to work under his supervision. We are grateful for his motivation and efforts that he gave us.

Furthermore we feel honored to have been taught by an excellent faculty and to have been graced with peers and friends without whom my pursuit of education would have been less gratifying.

These acknowledgments would not be complete without expressing our appreciations for my family whose continuous and firm support has enabled us to focus on our work without distraction.

We pray that Allah Almighty bestow upon them his blessings and bounties and continue to guide us in our future endeavors.

THANK YOU.

ABSTRACT

The invention in the technological world in Olive processing industry which increases the demand of the Olive industry. Olive pitting machine is mainly used for crushing and pitting of olives. The destoning of olive is the major area of concern in this project. A prototype is designed known as semi-autonomous machine for the extraction of olive and pitting process. Our Project is mainly focus on the Design of the Olive pitting Machine & Grading Machine. This machine will operate on no of mechanisms such as Geneva and slider crank mechanism. The assembly of machine is designed keeping in mind that all sizes of olives can be placed in one go on which pitting process need to be carried out. The major concern of our project lies in passing olives through fruit grading machine and then after this put that passed Olive into the Olive Pitting Machine whose task is to remove the seeds or pits of olives successfully the without damaging the outer part of the fruit. The project we have chosen for our FYP has both commercial and industrial value. The project holds to remove pit from olives mesh and then these olives can serve application in foods we are used on daily basis like tables olives, pickled olives and for extracting olives oil. Our area of target is to design a prototype whose specifications is grading olive one their sizes and destoning of pits.

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CHAPTER 1: INTRODUCTION

Olives play significant role in dietary and for medical purposes all around the world. According to a survey it is estimated that global olive market is projected to reach 17.2 billion dollars by end of 2028. Pakistan has 10 million acres of land for olive production. Olive industry is growing day by day with the in interventions of technological solutions in olives process industry. The one of most important process is removal of pit from olives which is also our required goal. There are two procedures for destoning of olives i.e.

- Partial destoning
- Total destoning

The project we have chosen for our FYP has both commercial and industrial value. The project holds to remove pit from olives mesh and then these olives can serve application in foods like tables olives and oil can also be extracted from the oils and is also used in pickels.

We are to design a semi automated machine whose function is to remove pit form olives. This machine will operate on no of mechanisms such as Geneva and slider crank mechanism. All size of olives can be placed in holes through which pitting needed to be performed [1]. There are 3 major parts in this semi-automated machine i.e.

- Olive feeder
- Olive carrier
- Pit detaching device

Olive feeder is the only semi-automatic part of the machine. In olive feeder olives need to be placed in such a way that it is in perfect contact with tip of needle and needle strike them longitudinally.

Olive carrier is a revolving drum with sockets to hold various sizes of olives in predetermined position. The 24V motor is needed to rotate this drum and when needle encounter olive means when it strikes the olive then drum stop rotating. Usually, the sockets are designed in such way to accommodate 72 olives at one instance. Mainly our goal is to cater destoning of two types of olives i.e., Arbequina and Ascolana.

Pit detaching device consists of system of 9 needles which is capable of destoning 9 olives in just one go. The device is based on phenomena known as Geneva Mechanism. The device is designed in such a way that effective, and accuracy is obtained in destoning of olives. The one thing is to keep in mind that needle should not damage the olives or itself while pitting process. After destoning the olive's flesh and seed is collected at different points. The invention in the technological world in Olive processing industry which increases the demand of the Olive industry. Olive pitting machine is mainly used for crushing and pitting of olives. Pit removal is a major constraint in processing.

A semi-autonomous machine is designed for effective pit extraction. Our Project is mainly focus on the Design of the Olive pitting Machine & Grading Machine. The major objective of the of this project first to pass the olive through the Grading Machine and then after this put that passed Olive into the Olive Pitting Machine which successfully remove the pit of the olives without fracturing the outer part of the fruit.

The pitted Olive fruit can give us the income generating tool by making olive table oils, pickled olive and sliced or chopped olives can be use on pizza etc. The Selected design of the Olive Extracting Machine resembles the cherry machine with modification in the driving mechanism having a Geneva Mechanism Crank-Slider Mechanism for the head of the device with a pitting needle.

The machine is driven by a 24 Volts DC-powered Motor, making it autonomous. Holes of Rollers are selected according to the Grade of Olives needed to be pitted after being graded by the Olive Sorting Machine. The Pitting Machine Also includes Feeder and Collector Assembly for Feeding and collecting olives, respectively.

Mechanical System Based Olive Sorting: Mechanical based system for olive grading is the most used methodology. This system works based on conveyor belts and sorts the olives according to their sizes which can be further sent for processing.

Mechanical Sorting Consists of Feeder Assembly through which olives are sent to conveyor belts arranged so that they are hollow from the bottom and carry the olives while moving forward. The carrier is designed so that the initial distance between the two compartments is less and increasing as it moves forward. The olives fell according to their size and are collected using a collector assembled below the belt.

Problems & Shortcomings in the Previous Design:

- No Testing of olives on Machine was performed because Season was over.
- No Grading Mechanism
- Pin Configuration
- Food Grade Material

A new Enhanced working Olive pitting Machine & Grading Machine will be delivered in our project.

CHAPTER 2: LITERATURE REVIEW

Olives are found in central Tropical, Asia, and Mediterranean tropical and in different regions of Africa. It has also become an emblem of Greek heritage in the modern world. The olive tree is one of the most treasured and sacred trees among Greeks, and its significance is deeply established in Greek mythology and history [1]. Olives are far too bitter to consume raw and can only be relished after treatment, usually curing or pickling. Most olives are turned into olive oil, although some are preserved and used in dishes, mainly Mediterranean cuisine.

Olives roughly provide about 115 to 145 calories per 100 grams or 59 calories per 10 olives. Because of their high lipid content, olives are a unique fruit. Oleic acid is the most prevalent fat in it, and it may offer various health benefits. They also contain 4–6% carbohydrates, the majority of which is fiber. Vitamin E, iron, copper, and calcium are all abundant in olives. If wrapped in saltwater, they could have much sodium in them [2].

Olives are high in antioxidants, which may help with many health benefits like lowering cholesterol, which helps prevent heart diseases and blood pressure. They may also reduce your cancer and bone loss risks [2]. Olives are used in the medicine and textile industry and for manufacturing high-quality cooking oil for kitchen uses.

2.1 OLIVES IN PAKISTAN

Although Pakistan is not famous for its olive production, a wild subspecies of the olive tree known as 'Olea cuspidate' grows in various parts. The environment in Pakistan is ideal for developing olive trees since they grow quickly and thrive in the mild winters that follow a long hot summer [3].

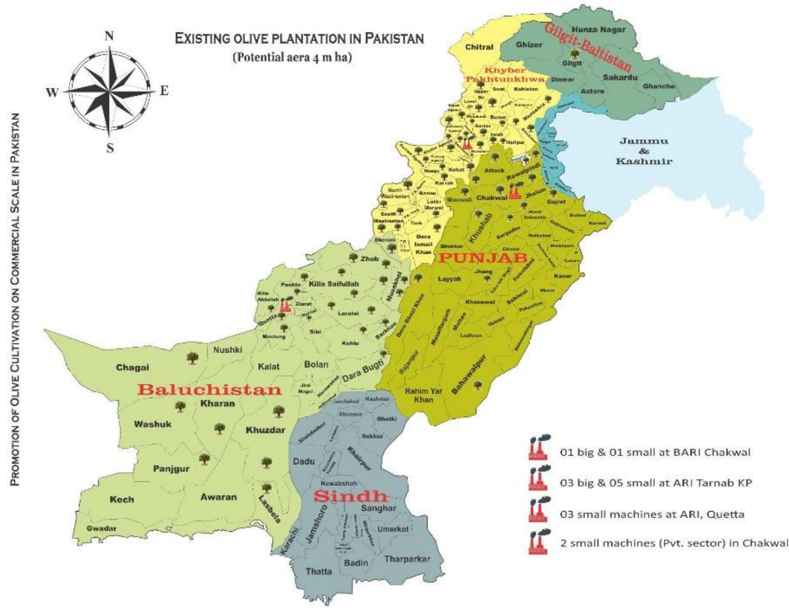


Figure 1: Existing olive plantation in Pakistan.

There are more than ten varieties of olives are being cultivated in different regions of Pakistan. Both Soil and Environmental factors are very suitable for the large-scale cultivation of olives in Pakistan, including the mountainous areas such as Balochistan. The most favorable regions to olive cultivation include Killah Saifullah, Zhob, Chakwal, Musakhali, Khuzdar, Potohar Regions, and the various areas of Balochistan and KPK. [4]

2.1.1 Varieties of Olives in Pakistan

The Top 12 Varieties of olives in Pakistan include Koroneiki, Arbequina, Pendolino, Jerboui, Earlik, Hamdi, Manzanilla, Ascolana, Hojiblanca, Gemlik, Pecual, chemlali [5].

1) Koroneiki

This type has medium vigor and erect branches, and it ripens in October. The fruit is small (0.93g) and is used to extract oil. Fruit yields average 18-22 kg per plant, with a 16.22% oil recovery rate.

Figure 2: Koroneki.Olives

2) Arbequina

This type has medium vigor and erect branches, and it ripens in October. The fruit is small (1.87 g), and it is used to extract oil. Fruit yields average is 20-25 kg per plant, with a 15-18% oil recovery rate.

Figure 3: Arbequina Olive.

3) Pendolino

This type has strong vigor and spreading branches, and it ripens in September. The fruit is small (1.72 g), and it is used to extract oil. Fruit yields average is 25-35 kg per plant, with a 20% oil recovery rate.

Figure 4: Pendolina Olive.

4) Earlik

This type has weak vigor and spreading branches, and it ripens in October. The fruit is Large (3.45 g), and it is used to extract oil and table use. Fruit yields average is 30-35 kg per plant, with a 16-17% oil recovery rate.

Figure 5: Earlik Olive

5) Hamdi

This type has weak vigor and drooping branches, and it ripens in September-October. The fruit is medium (3.67 g), and it is used for table products. Fruit yields average is 25-30 kg per plant, with a 15-17% oil recovery rate.

Figure 6: Hamdi Olive.

6) Manzanilla

This type has weak vigor and spreading branches, and it ripens in September-October. The fruit is large (4.60 g), and it is used to extract oil. Fruit yields average is 20-25 kg per plant, with a 15-17% oil recovery rate.

Figure 7: Maznzanilla Olive.

7) Ascolana

This type has strong vigor and spreading cum erect branches, and it ripens in October. The fruit is large (4.56 g), and it is used to extract oil and table use. Fruit yields average is 20-25 kg per plant, with a 14-15% oil recovery rate.

Figure 8: Ascolana Olive.

8) Jerboui

This type has medium vigor and spreading branches, and it ripens in September. The fruit is medium (2.80 g), and it is used to extract oil. Fruit yields average is 20-24 kg per plant, with a 20-21% oil recovery rate.

Figure 9: Jerboui Olive.

9) Hojiblanca

This type has medium vigor and spreading branches, and it ripens in September-October. The fruit is medium (4.1 g), and it is used to extract oil and table use. Fruit yields average is 22-26 kg per plant, with a 16-18% oil recovery rate.

Figure 10: Hojiblanca Olive.

10) Gemlik

This type has medium vigor and spreading branches, and it ripens in September-October. The fruit is medium (2.76 g), and it is used to extract oil and table products. Fruit yields average is 25-30 kg per plant, with a 15-16% extra virgin oil recovery rate.

Figure 11: Gemlik Olive.

11) Chemlali

This type has strong vigor and spreading cum drooping branches, and it ripens in September-October. The fruit is small (0.32 g), and it is used to extract oil and table use. Fruit yields average is 18-24-25 kg per plant, with a 14-15% oil recovery rate.

Figure 12: Chemlali Olive.

12) Picual

This type has strong vigor and spreading cum drooping branches, and it ripens in September-October. The fruit is small (0.32 g), and it is used to extract oil and table use. Fruit yields average is 18-24 kg per plant, with a 15% oil recovery rate.

Figure 13: Picual Olive.

2.2 OLIVE SELECTION FOR PROJECT

There is a wide range of olive plants in different parts of Pakistan. Olea Europaea, the biological name of olives, is locally known as zytoon in Urdu, shown in Pashto, Khat in Brahvi, and known in Punjabi, Sindhi, and Saraiki.

Upon analyzing the various varieties of olives in Pakistan, it was concluded to opt for two kinds of olives for utilization in the project: Ascolana and Arbequina. As both are readily available and the environment of the region also favors their growth greatly.

2.3 EXISTING OLIVE PITTING MACHINE DESIGNS

Olives are used worldwide, so meeting the demand, olive devices are used worldwide. Here are different types of olive pitting machines used. [6]

2.3.1 Machine Having Belt with Horizontal Punching:

This machine makes use of horizontal pins that are installed on conveyor belts. When olives are placed on these beds, holders are responsible for clamping them. Following this, the conveyor belts beneath the beds transfer the olives to the pitting station of choice. The pitting station is equipped with a network of horizontal needles for piercing olives and removing seeds. As the name mentions, the destoning (seed removal) takes place due to the horizontal positioning of the needles. This machine can pit up to **2000-2250** olive per minute. The con of this machine is that it is costly, and costs up to **$30000,** is huge and bulky. [7]

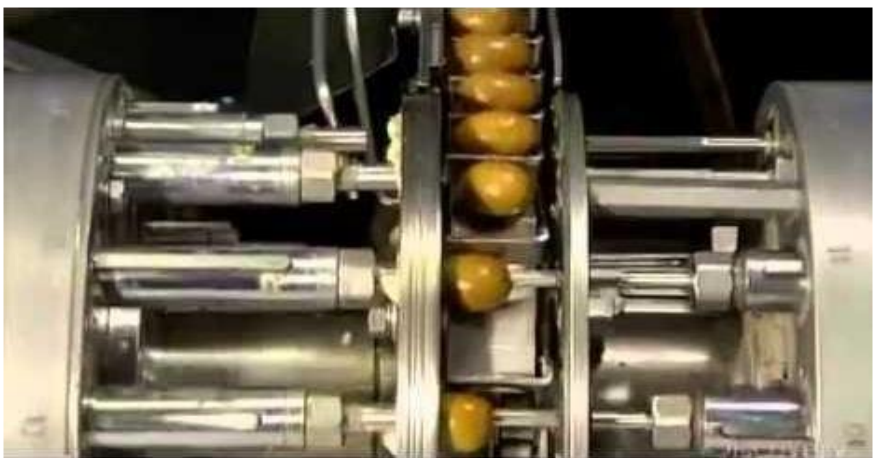


Figure 14: Machine having Belt with Horizontal Punching.

2.3.2 Machine Having Belt with Vertical Punching:

This machine is fundamental, and it consists of massive horizontal conveyor belts. This machine has chambers with pockets where olives may be inserted. This machine use a single pitting network with many needles to puncture the olive machine Vision and retrieve the seed vertically. The range of this machine is destoning **1500** olives per minute. So, this machine has less efficiency as compared to a device with horizontal punching. The con of this machine is that it is expensive and costs up to **$25,000,** and another disadvantage is that it lacks in size ratio.

Figure 15: Machine having Belt with Vertical Punching.

2.3.3 Vertical Punching Machine with Circular Feed Plate:

As the name suggests, this machine consists of a circular feed plate on which olives are placed. This machine uses the circular rotation principle, which says that a circular plate rotates and sends the olives to pitting stations. This pitting station also has several needles that pierce through the olive and remove seeds. The con of this machine is that it is costly, up to **$7000.**

Figure 16: Mini Vertical Punching Machine with Circular Feed Plate.

2.4 SELECTED DESIGN FOR PITTING MACHINE

The Selected design of the machine resembles the cherry machine shown in figure 15, with modification in the driving mechanism having a Geneva Mechanism Crank-Slider Mechanism for the head of the device with a pitting needle. The machine is driven by a 24 Volts DC-powered Motor, making it autonomous. Holes of Rollers are selected according to the Grade of Olives needed to be pitted after being Graded by the Olive Sorting Machine. The Pitting Machine Also includes Feeder and Collector Assembly for Feeding and collecting olives, respectively [8].

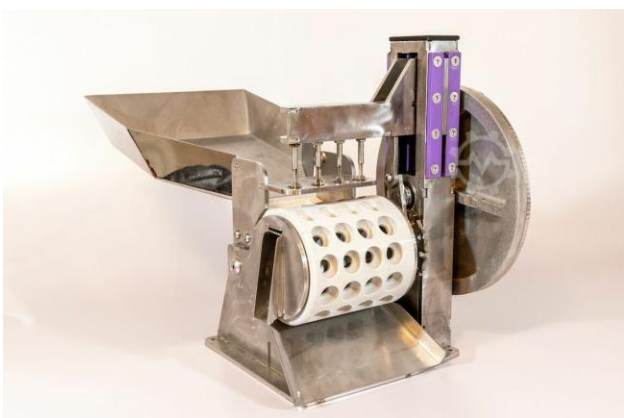


Figure 17: Cherry Pitting Machine. Design resemblance to the selected design of olive pitting machine.

2.5 VARIOUS PARTS OF OLIVE PITTING MACHINE

Each Part of the Proposed Model is briefly explained below [9].

2.5.1 Olive Feeder:

The olive feeder is the essential and primary part of the olive pitting machine. That's why it is marked as the foundation and initial part of the machine. As the name suggests, olives are deposited here. This part of the machine is manually operated. The olive feeder is a container containing Graded Olives before passing over to the pitting station. The olives in the feeder mustn't get overcrowded, so it is necessary to keep check and balance.

2.5.2 Olive Carrier:

Once the olives are successfully placed in the feeder, the next step is successfully transferring olive to the pitting station so that it doesn't get harmed. This is done using a smooth mechanism to place olives in specific and desired orientation for the pitting needles. If the olives are not placed in a particular order, it may disfigure them, so for overcoming this issue, the carrier is in the form of a roller drum. This roller consists of pockets responsible for holding olives into their desired position so that the removal of seeds takes place correctly. The roller drum is powered by a motor using a Geneva mechanism.

2.2.3 Pit Detaching Device:

It is an essential part of the machine as it removes seeds from the olives. This device consists of multiple needles arranged and organized in a specific order which are responsible for destoning. Another thing to note is that limiting or fixing the number of needles is unnecessary. Still, the machine can use any amount to remove seeds or stones depending upon the number of holes in the carrier.

2.6 MECHANISMS USED IN OLIVE PITTING MACHINE

There are two types of mechanisms required for the machine. One is the slider-crank mechanism (converts rotational motion to linear motion), and the other is the Geneva mechanism (exhibits intermittent motion). Both mechanisms are responsible for transmitting the motor power to the pitting head of the machine and for the carrier.

2.6.1 Slider Crank Mechanism

It is a 4-bar link mechanism that has vast applications in automobiles and actuators. It converts linear motion into rotational motion and vice versa. There are two types of it named inline and offset. The requirement of a slider-crank mechanism is completed using an offset slider-crank mechanism. Three revolute joints are used in the slider-crank mechanism for converting linear to rotational motion and vice versa. With the help of a compliant mechanism, lubricant is less necessary, and maintenance issues are also solved [11].

Following are the significant components of the slider-crank mechanism:

1) Slider

It is used for linear motion over the surface. The distance between ending points or extreme points are dictated by the radial rotation distance of the crank.

2) Crank

The crank is responsible for rotational motion. The distance covered by the slider between extreme points is always **greater than** twice the crank radius.

3) Coupler

It is a connecting rod attached at one end with the crank and the other with the slider. It converts the rotational motion of the crank into the linear motion of the slider.

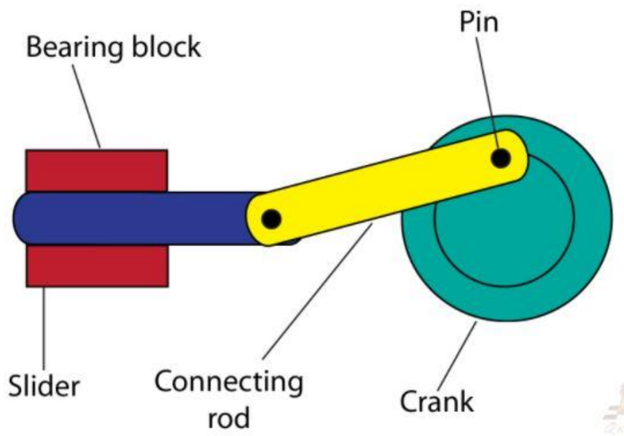


Figure 18: Crank Slider Mechanism.

2.6.2 Geneva Mechanism:

The Geneva mechanism is a cam like a mechanism that is used for intermittent motion. Due to periodic motion, it holds importance as it is used in many automatic machines. The reason for producing intermittent motion is due to the configuration of its parts. Geneva mechanism has three types:

- Internal
- External
- Spherical

The best type is one having an external configuration. Following are significant components of the Geneva mechanism.

1) Crank

It exhibits rotatory motion with the help of an external motor. The crank rotates at uniform angular velocity and catches the slot of the Geneva disc to exhibit intermittent motion. The crank moves one complete rotation to exhibit periodic motion of Geneva Disc,

` **2) Geneva Disc**

It is responsible for intermittent motion. The crank and slot of the

Geneva disc are mutually perpendicular to each other at the time of engagement and disengagement. The periodic motion is dependent upon the number of slots. The minimum number of slots required for the Geneva disc is **three,** increasing up to **12** depending on the machine's complexity.

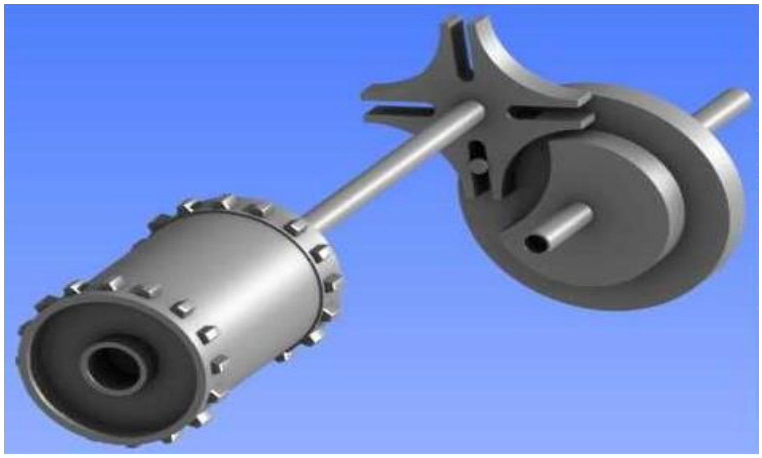


Figure 19: Geneva Mechanism.

2.7 SOME PREPROCESSING FOR OLIVES

Before putting olives for the removal of seeds or stones, it has to go through some processes. These processes include checking the quality of olives to ensure no cavity or moisture faces are there, Grading/Sorting of Olives. The olives that come into the market have a high risk of other elements, such as stems, leaves, or other foreign elements. So, to avoid any malfunctioning, these elements need to be removed manually. The second method is specific for both black and green olives. These olives need to be soaked into bine solution for almost **30-40 minutes** so that the olives get soft, and the needle can easily penetrate through it; otherwise, the needle can break or cause malfunctioning in the machine.

2.8 GRADING/ SORTING OF OLIVES

Food Grading and Food Sorting may seem similar but have a primary difference in the industry. Food Grading is a producer used to differentiate fruits/vegetables based on more than one property: color, weight, cavity, processed or unprocessed. In sorting, food is distinguished based on only one property: color, weight, cavity, processed or unprocessed.

Based on research, Food Grading/Sorting Include Two Basic Methodologies being used in the industry. Machine Vision Driven Grading and Mechanical Based Grading. Although The Machines may vary in design and material/electronic used, the primary methodologies remain the same. Both Methodologies being considered for Olive Sorting Machine are briefly explained below.

2.8.1 Food Grading by Machine Vision:

In this modern era of industrialization, machine vision has become the most influential factor in revolutionizing the food industry. Food grading, including the size, orientation, Volume, weight, color, and checking the quality of a particular food type, has become very easy using computer vision. Machine Learning and Machine Vision make the perfect artificial intelligence system used for food processing. [10]

1) Working:

The most used Computer Vision Grading of Olives include grading by Size and color. Modern image processing techniques are used to distinguish the difference in color and sizes. For imaging, High-Speed Cameras are used to capture images as fast as up to 120 frame rates. Data Acquisition Card (DAC) is used to control the system. Machine Learning is a must to process and compare the data to provide the best results. For color identification, Machine Learning techniques are used to easily differentiate between two colors that vary in intensities [11].

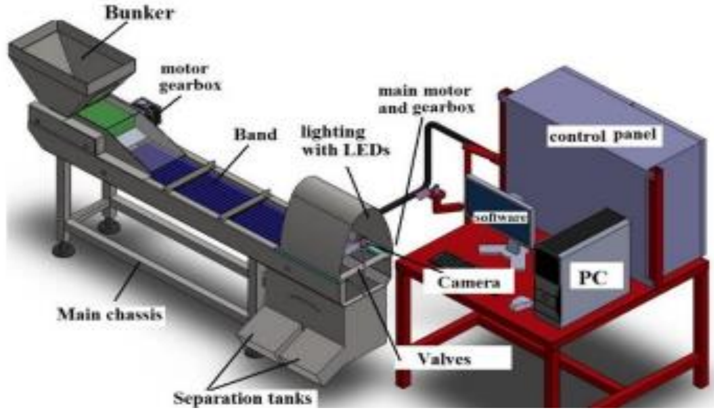
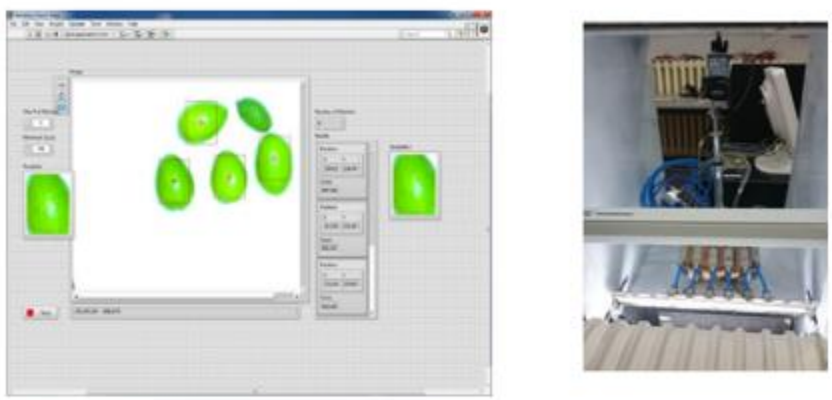


Figure 20: Olive Grading Machine Based on Machine Vision.



(a) (b)

Figure 21: (a) Shows the machine’s interface (b) shows the high-speed cameras.

2.8.2 Mechanical System Based Olive Sorting:

Mechanical based system for olive grading is the most used methodology. This system works based on conveyor belts and sorts the olives according to their sizes which can be further sent for processing [10].

1) Working:

Mechanical Sorting Consists of Feeder Assembly through which olives are sent to conveyor belts arranged so that they are hollow from the bottom and carry the olives while moving forward. The carrier is designed so that the initial distance between the two compartments is less and increasing as it moves forward. The olives fell according to their size and are collected using a collector assembled below the belt [10].

Figure 22: Shows the Mechanical Olive Sorting Machine Based on Sizes.

2.9 FOOD-GRADE MATERIALS

Fruit that passes through the pitting machine shouldn't get corroded or change their properties due to mixing up with elements or moisture present in the surrounding or on the material. Food safe material ensures that there is no mixing up of hazardous substances with the food. The FDA's Food Rule also tells us the exact terminology of preventing food from harmful substances and imparting taste, color, or smell. Such materials are required to be

- Corrosion-resistant
- Safe
- Nonabsorbent and durable
- Manufactured in a sense that can easily be cleaned or washed.

It is the utmost duty of the manufacturer to keep strict supervision on these food handling materials. They should be conscientious about choosing the food-graded material.

Let takes an example that says that if a manufacturer or user takes a good quantity of salt that contains chlorides and metal that is being used is reactive to chloride, then corrosion occurs. So, manufacturer should keep a proper check and balance.

There are two most common types of Food Grade materials in Industry, metals and plastics. But not all metals and plastics are food grade.

Also, a machine is only food-grade if there is no crack in any part of the machine and is cleaned regularly to prevent any fungus from growing on it. Also is manufactured using food-grade materials.

2.9.1 Food Grade Metals:

Here are some examples of food metals that can be used in the food industry but with some limitations [12].

1) Cast iron:

Cast iron can be used for cooking purposes only on cooking surfaces and in utensils for serving food. But for other purposes, cast iron cannot be used as there are certain limitations to it. One important thing to ponder is that iron without a protective layer would quickly react with moisture and corrode.

2) Aluminum:

Aluminum is another food metal that is commonly used in the food industry. Here are some advantages of it:

- Temperature tolerance
- Corrosion resistant
- Lightweight and low cost

However, despite having advantages, it also has some disadvantages. It has low tensile strength and can easily be broken down.

3) Copper:

It is a metal used in the food industry for limited purposes as acids can quickly attack it. Here are some of the limitation’s coppers were given below:

- Not suitable for large-scale manufacturing.

• Copper and its alloys that have pH below six cannot be used in the food industry, e.g., brass

4) Stainless steel:

Stainless steel comes in different varieties and types used in the food industry. Given below are some of its types:

a) Fruit Grade 304 Stainless Steel:

They mostly used stainless steel is 304. It is mainly because of its corrosion resistance.

Its surface is very easy to clean, and it can be electro polished to a smooth and shiny surface. But excessive exposure to salts can degrade the steel, and there are high chances of corrosion.

b) Fruit Grade 316 Stainless Steel:

This steel has a high percentage of nickel and chromium present in it. It requires a very high temperature of more than (800 degrees centigrade or 1472 degrees Fahrenheit). The 316 stainless steel has the upper hand over 304 steels because it is highly resistant to acids, alkalis, and chlorides.

c) Fruit Grade 430 Stainless Steel:

It is the primary stainless-steel type with the same chromium percentage, but nickel concentration is different. It uses less nickel percentage than 316. The 430 stainless steel is magnetic, and it is resistant to stress corrosion cracking (the growth of cracks that causes failure in the environment). It is also resistant to many other elements, e.g., sulfur, nitric acids, organic acids. One of its drawbacks is that the low percentage of nickel is not immune to reducing acids.

CHAPTER 3: DESIGNING OLIVE PITTING MACHINE

3.1 DESIGN OF OLIVE PITTING MACHINE:

The design of olive pitting machine is not just based on olives characteristics but also mechanism needed for machine. The material used for machine should have following properties given below:

- Symmetric Geometry
- Uniform thickness
- Corrosion resistance
- Recyclability
- Strength and high endurance both at high and low temperature

So, the material we have selected for our machine which fulfills all required criteria is stainless steel. The olives which we have chosen for our project are Arbequina and Ascolona. We have chosen these types of olives as these are found in extensive parts of Pakistan during harvesting season and hence suitable for our project.

Now we're talking about a system that will convey the olives from where they are on the machine to where they will securely arrive in the container following the destoning operation. The olives should not be damaged in this whole process otherwise it would lose its commercial value.

3.2 COMPONENTS OF THE MACHINE:

Our machine design consists of six (6) components given below:

- Roller
- Stationary frame

- Needle box
- Geneva mechanism
- Olive feeder and olive collector
- Ac induction motor with inverter

3.2.1 Roller Drum:

The roller drum is the basic and fundamental component of machine used to hold olives in predefined position. It has an advantage in a sense that it is detachable and can be used for other types of olives. It consists of 8 lines of pockets for holding olives and each at angle of 45 degree from one another. The total pockets in roller drums are 72. The roller revolves along with needle box for perfect destoning of olives. The roller is opened from one side and closed at other side. The enclosed side is connected to Geneva mechanism for intermittent motion of the roller. The size of each pocket is 12.5/15 (width/length). The width of roller drum is 60. 96cm.The 2D drawing of roller drum is shown in figure below:

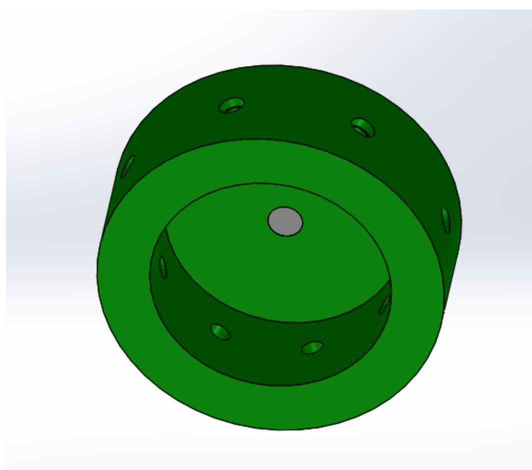


Figure 23: Drum Roller Assembly

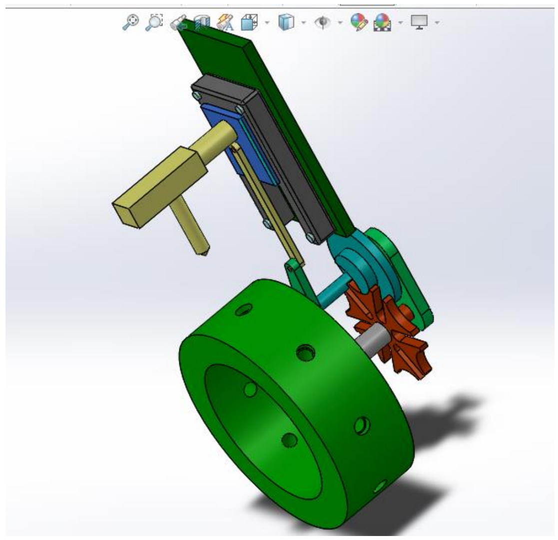


Figure 24: Baseless Assembly

3.2.2 Needle Box:

The function of the needle box is to remove the pit from olives. The needle box consists of needles that will pierce through the olives and remove pit from it. The needle box can also be customized just like roller drum. There are 9 needles in the boxes one for each pocket. The needles are used to pierce into olives present in the pockets at regular intervals. The width of needle is 7mm and length is 20mm. The 2D drawing of needle is shown below:

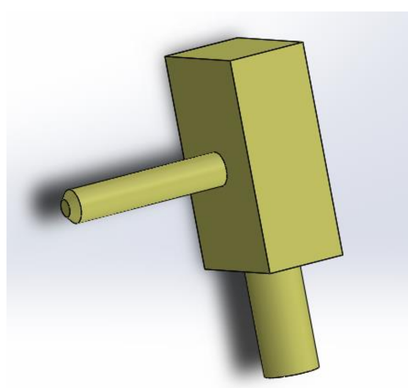


Figure 25: Needle Box

3.2.3 Geneva mechanism:

The Geneva mechanism will provide an intermittent rotary motion to the machine. It consists of following parts:

- Geneva driving wheel
- A locking plate with a pin
- Driven wheels with groves/slots

This mechanism also includes a connection that connects the roller box to the needle. This connection is connected to the prime mover on one end and the needle box on the other. Because the driven wheel contains 8 slots in this design, the driver must revolve 8 times for each 45-degree rotation to accomplish 1 revolution. The pin drives the Geneva driving wheel at regular intervals, supplying the necessary intermittent motion. The CAD model of Geneva disc is shown below:

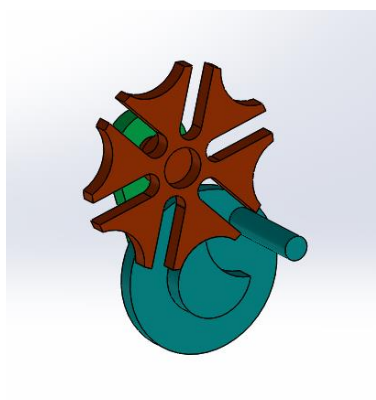


Figure 26: Geneva Mechanism

3.2.4 Olive feeder and Olive collector:

The trays that will hold the olives are the olive feeder and carrier. The machine will begin with the olive feeder, and the placing of olives on the olive feeder will be monitored by a human operator. The olive feeder will be inclined at 45 degrees to ensure a smooth movement of olives from feeder to drum. The CAD model of olive feeder is shown below:

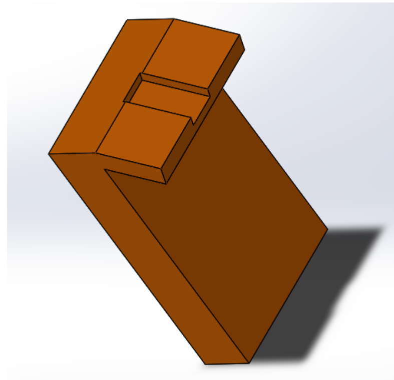


Figure 27: Olive Feeder

3.2.5 Seed Collector

Seed collector is used to collect the seeds after the olives have been successfully pitted. It is placed inside the roller drum. The seed collector has 9 sockets aligned with same number of sockets i.e., 9 with roller drum. The seeds of olives are dropped in seed collector which provide non-mixing of olives flesh with its seeds. The seeds can afterwards be used for extraction of olive oil or for various purposes. The 3D model for seed collector is given below:

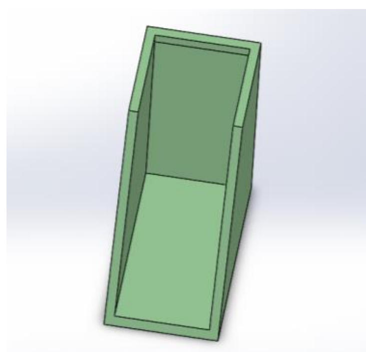


Figure 28: Seed Collector

3.2.6 AC induction motor:

For our project we have shortlisted some of motors such as DC stepper, AC synchronous and AC induction motor. We have analyzed these three motors and come to the point for using AC induction motor. It is a single-phase motor. The motor has total power rating of 30 watts and 220 volts. The required ratio for functioning of the motor is 1:50.

3.2.7 Slider Crank Mechanism

Just like Geneva mechanism the cad model of slider crank mechanism is divided into small several components which then assembled to form slider crank mechanism. The first and most important component is crank. The crank is responsible for rotational motion of mechanism that is converted into linear motion. The crank is attached at one end with rotary motor and other end with coupler. The 3D model is given below:

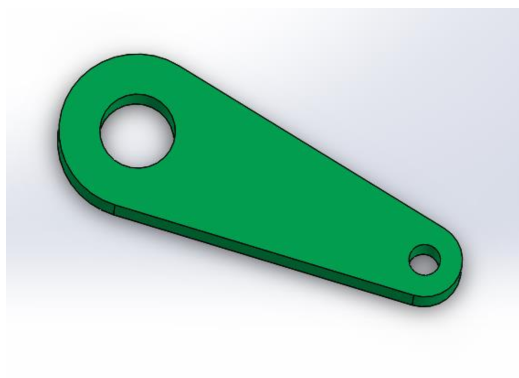


Figure 29: Crank

The next component which makes slider crank mechanism is slider. It is the moving part and its exhibits linear motion. The distance moved by the slider between its limiting points is always greater than twice the radius of the crank. Coupler is used as joint to connect slider with the crank. The 3D model is given below:

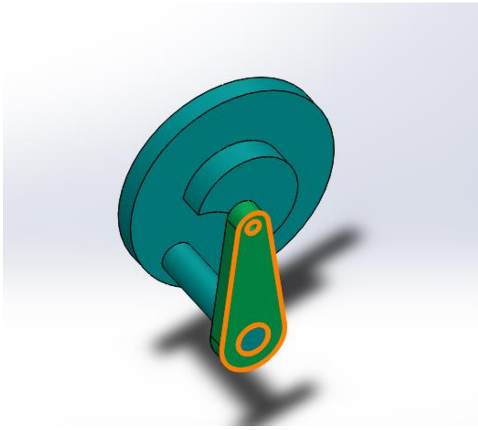


Figure 30: Coupler joined with crank

Coupler is responsible for converting rotary motion into linear motion. It behaves like link which is attached at one end with slider and other end with crank.

The base of the slider crank mechanism holds the structure upon which the slider slides. The 3D model of base is given below:

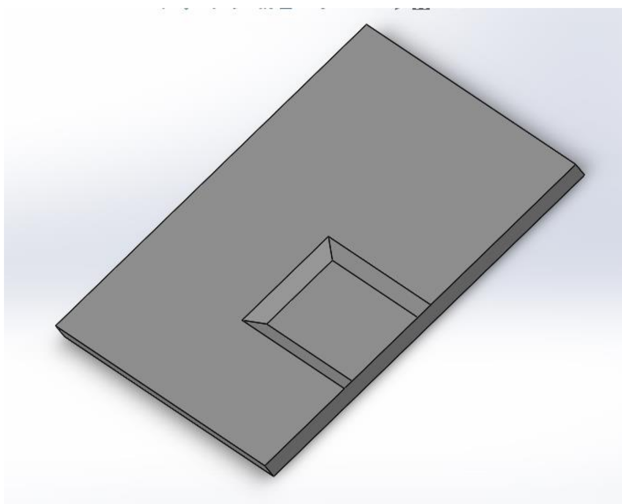


Figure 31: base of slider mechanism

The final assembly of slider crank mechanism obtained after making cad model of different components and the assemble them together is given below

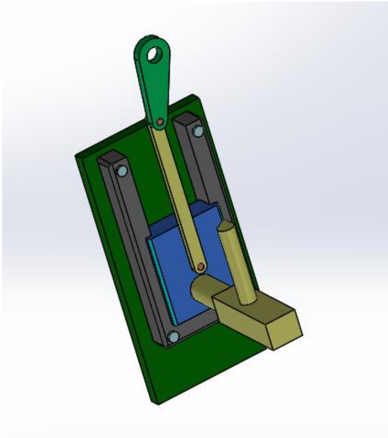


Figure 32: Slider Crank Mechanism

3.2.8 Figures of important parts of pitting mechanism:

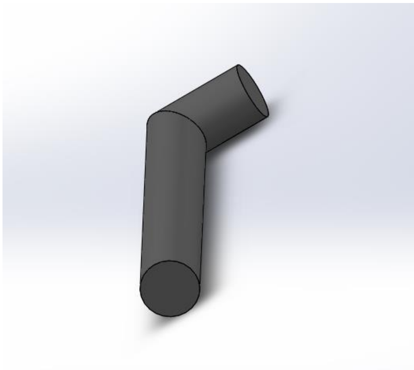


Figure 33: Rod Atos

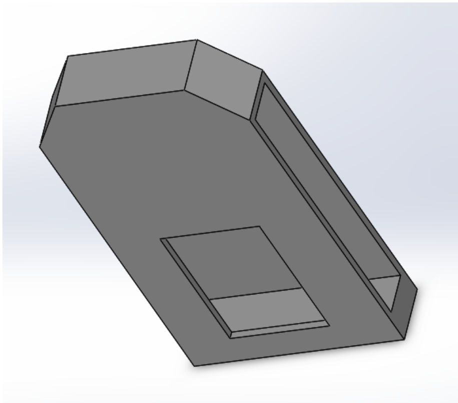


Figure 34: Structure

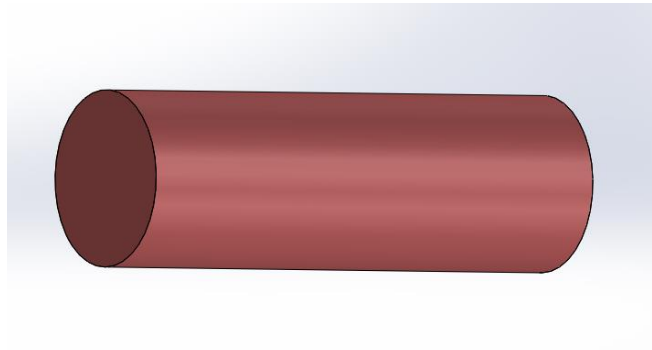
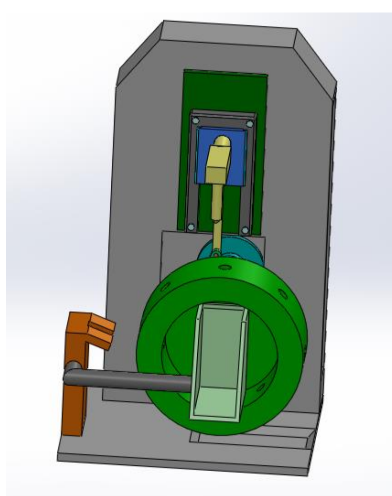


Figure 35: Pin

3.3 Complete assembly of Olive Pitting Extracting Machine:

After combining various mechanisms and components, the entire assembly of Olive Pit Extractor machine is obtained. The shaft of the prime mover in the Geneva mechanism is connected to the crank in the slider crank mechanism. The primary mover's wheel will be turned by an AC induction motor. The crank would generate rotational motion, which would be transformed into linear motion by the slider. The needle box is attached to the slider, and when linear motion is produced, the needle box moves along with the slider to conduct pitting operation. When the shaft of the prime mover catches on the slot of the driven wheel, it rotates the roller drum 45 degrees and aligns the roller drum sockets with those of the needle box for correct olive pitting. The complete assembly of olive pitting extraction machine is given below:



CHAPTER 4: DESIGN OF OLIVE GRADING MACHINE

Before moving onto practical implementation of machine it is necessary to conduct it simulation as the priority to check whether there is shortcoming or not and then design it practically. In this chapter we will discuss about designing of the olive grading machine i.e., Cad Cam model of machine and assembly of machine.

4.1 CAD MODELING:

Computer Aided Design has greatly accelerated the prototyping process. The creation of the product is improved by visualizing it in 3D. Solid Model can be used for further mechanical and functional analysis using different software.

The software we used for designing of machine is Solids Works 2018. It is such a software developed by Dassault's systems. This software is selected as this provide no of functionalities. It is used for Cad Modelling of various parts of Olive Grading Machine. Two designs of the machine were developed based on requirements. The first design is capable of pitting 72 olives in one complete revolution of machine. The second design is based on the first one and is for prototype.

Before cad modelling it is necessary to evaluate the dimensions of olives that will be used in our machine as the roller drum and needle box will be customized keeping the dimensions of olives in mind. As discussed earlier we have selected two types of olives i.e., Arbequina and Ascolona. We have chosen arbequina for testing the prototype.

4.2 PROPOSED DESIGN:

After several set of calculations and iterations the complete design of olive pitting machine is obtained. The design is capable of grading 100 olives in one complete revolution of roller drum. Several components of machines are designed separately and then assembled with pitting machine for the complete working mechanism. Following are the important components of machine.

4.3 2D MODEL OF OLIVE GRADING MACHINE

The 2D model of the olive grading machine is designed on the Auto Cad. In the following figures: the measurements of the different parts of grading machine are explained.

4.3.1 2D Design of Base Frame

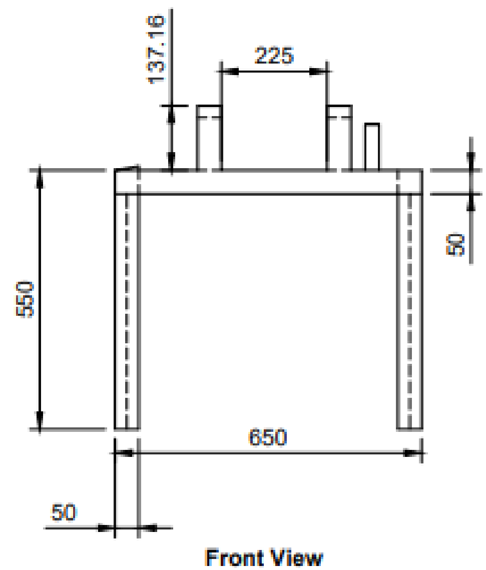


Figure 37: Base Frame

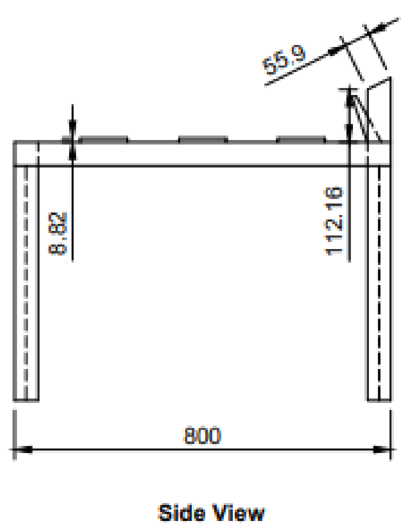


Figure 38: Side View of Base Frame

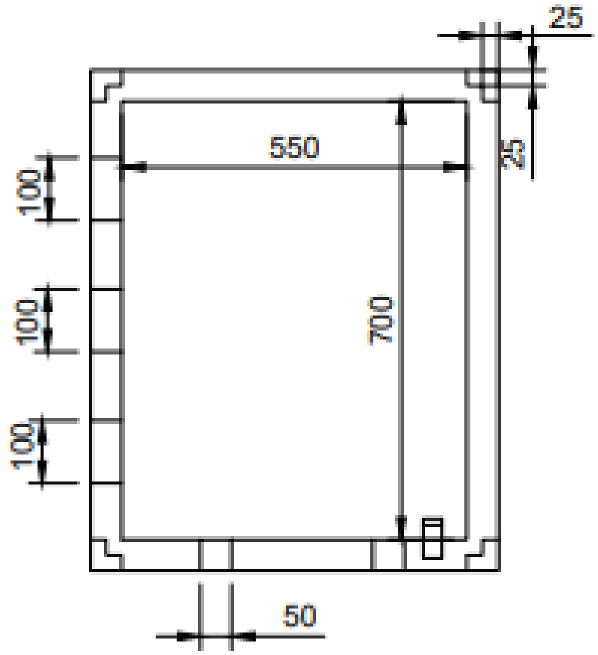


Figure 39: Top View of Base Frame

4.3.2 2D Design of Hopper

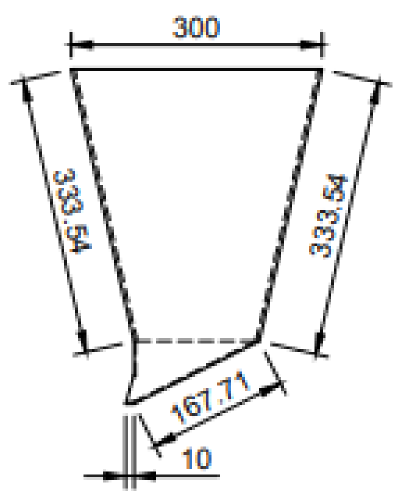


Figure 40: Side view of Hopper

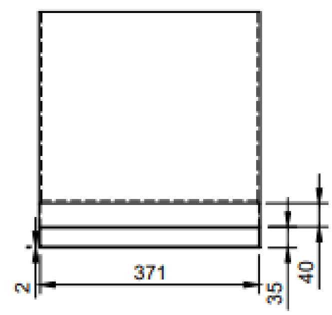


Figure 41: Top View

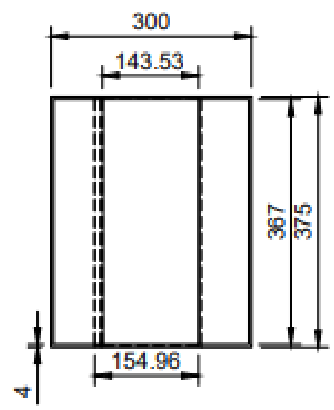


Figure 42: Side View of hopper

4.3.3 2D Design of holes on the roller drums

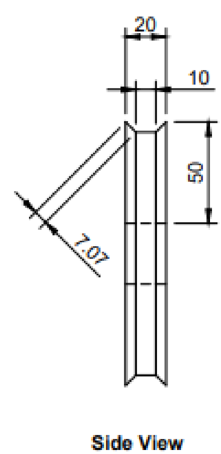


Figure 43: Diameter of Roller Drum Holes

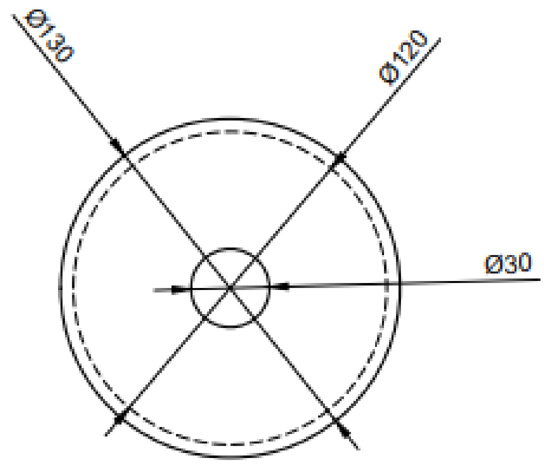


Figure 44: Front view of roller drum holes

4.3.4 2D Design of Roller Drums

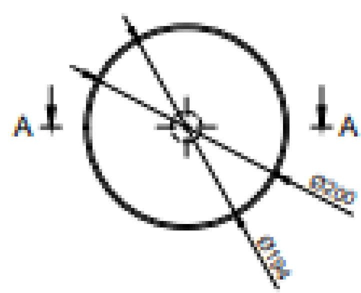


Figure 45: Front view of roller drum

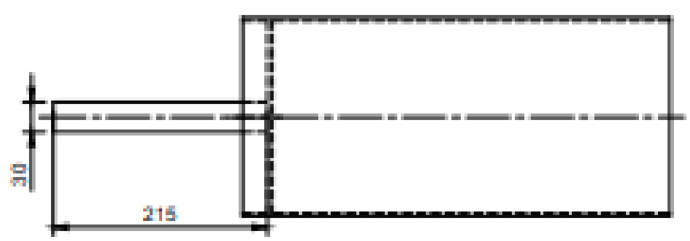


Figure 46: Side view of roller drum

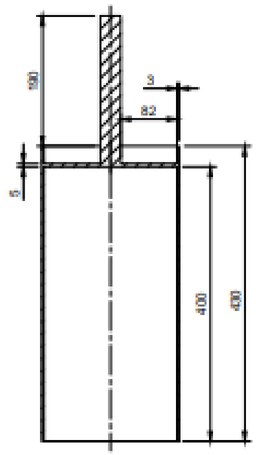


Figure 47: Section View of rolling drums

4.4 3D CADMODEL DESIGN OF GRADING MACHINE

4.4.1 Flat Plate

1) Olives are delivered on this plate from the hopper. Width of the Flat plate is 140mm and the length is 304mm.

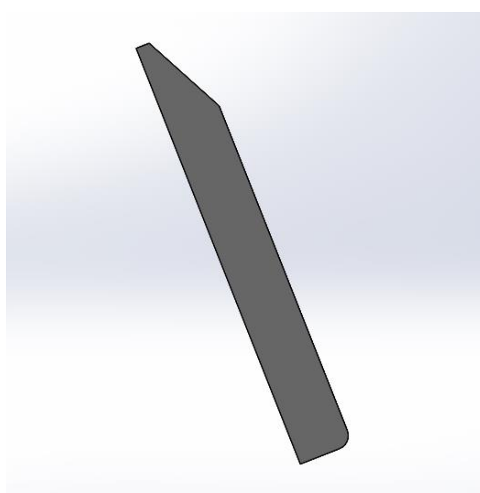


Figure 48: flat plate

4.4.2 Motor

220 volts AC supply motor is used to run the roller drums and the pulleys attached to the machine.

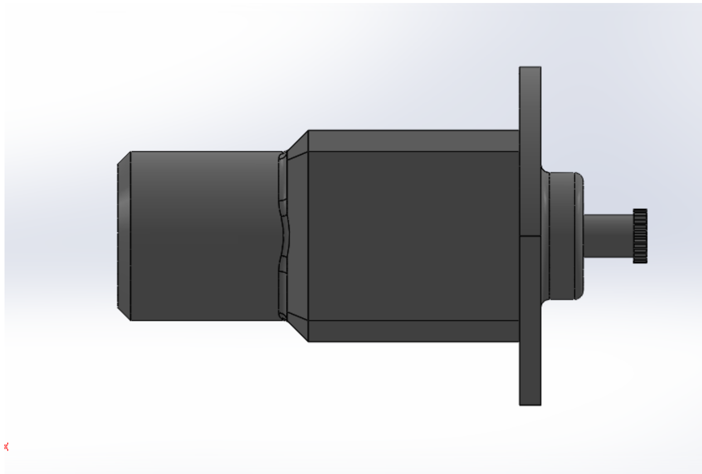


Figure 49: Motor

4.4.3 Base

The length of the base frame is 330mm or 1.08 feet, width is 458mm or 1.5 feet. The legs of the frame are 203mm or 0.66 feet.

Figure 50: Base

4.4.4 Rollers

1) Roller 1:

The length of the rolling drum is 1 feet or 305mm, 157 holes are present with diameter 20 mm of each hole. The diameter of the drum is 92 mm or 3.6 inch.

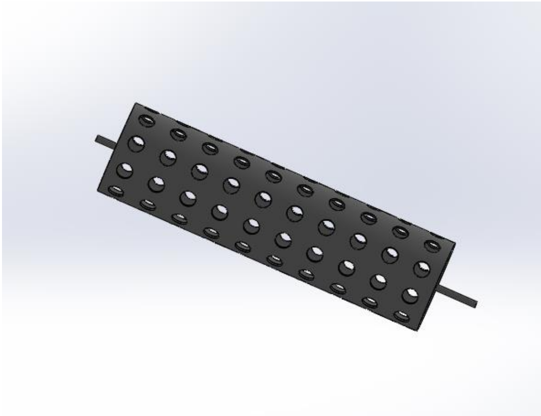


Figure 51: Roller 1

2) Roller 2:

The length of the rolling drum is 1 feet or 305mm, 137 holes are present with diameter 25 mm of each hole. The diameter of the drum is 92 mm or 3.6 inch.

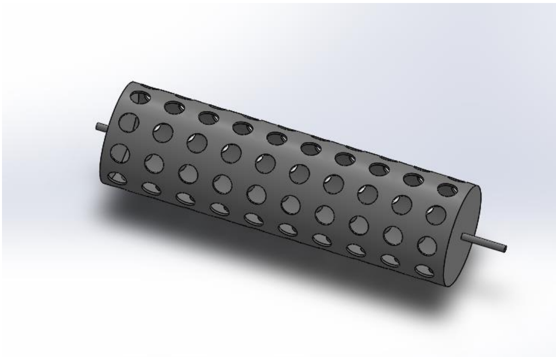


Figure 52: Roller 2

3) Roller 3:

The length of the rolling drum is 1 feet or 305mm, 124 holes are present with diameter 30 mm of each hole. The diameter of the drum is 92 mm or 3.6 inch.

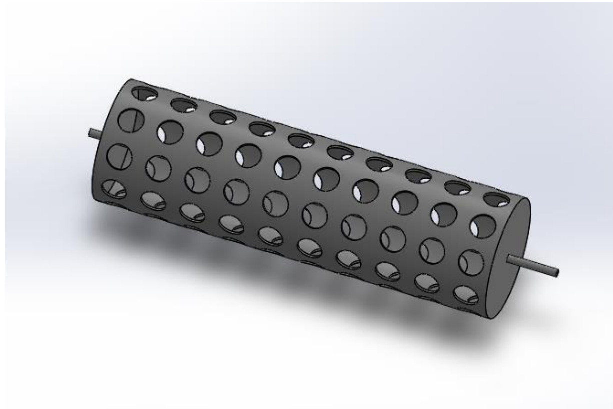


Figure 53: Roller 3

4.4.5 Exit Plate:

Width of the exit plate is 140mm and the length is 295mm.

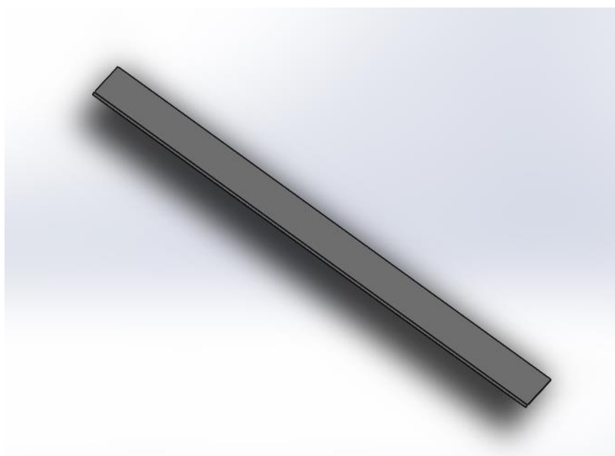


Figure 54: Exit Plate

4.4.6 Sprocket:

1) Sprocket

The teeth's of the sprocket are engaged with the chain to move it through the machine. Length of the shaft is 1 feet or 12 inches. Diameter of Sprocket is 2.25 inch or 57.15 mm.

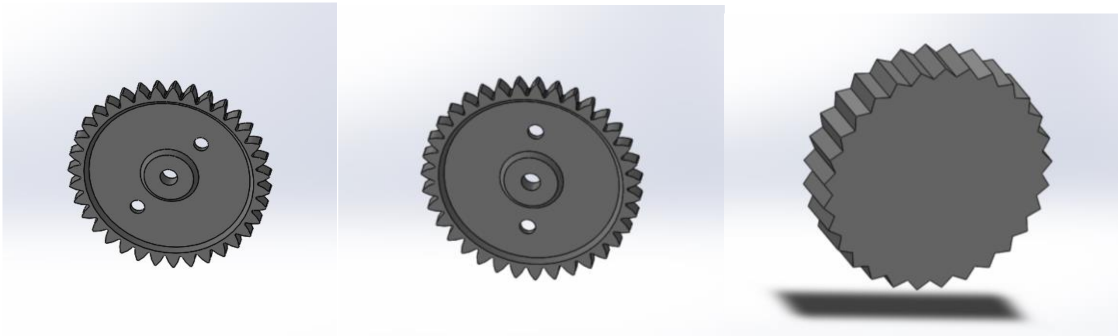


Figure 55: Sprocket

4.4.7 Delivery Plate

Length of 1 compartment is 18 inch or 257 mm and its width is 5 inch or 127 mm.

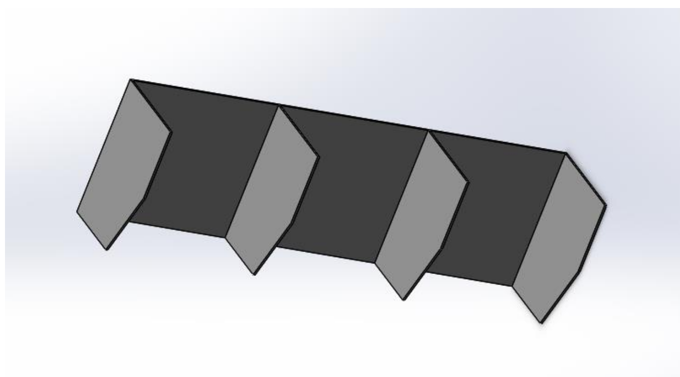


Figure 56: Delivery Plate

4.4.8 Timing Belt and Chain

The teeth on the timing belt turn the camshaft in sync with the crankshaft.

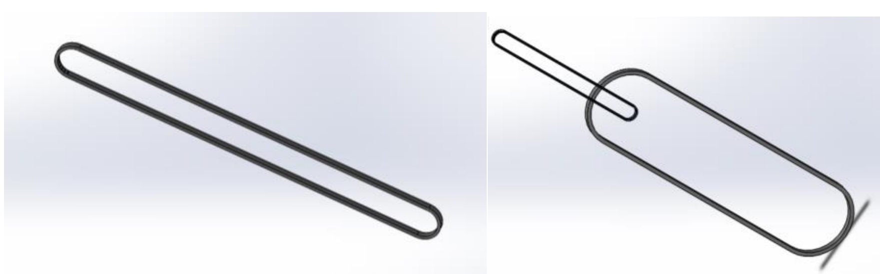


Figure 57: Timing belt

4.5 FINAL 3D CADCAM MODEL

This is the final achieved 3D CAD model of olive grading mechanism, after assembling all the parts discussed in chapter 4.

We entered the olives in 3 stages. First we put 5kg of olives then 10kg and in 3rd stage we put 15kg of olives in the hopper, by 220 volts motor placed on the other side of the machine, the rolling drums starts to roll. Respective olives fall in 3 different categories according to their diameters which varies from 19mm diameter to 29mm.

Figure 58: Final 3d Cad Model Of Gradig Machine

CHAPTER 5 - MATERIAL AND METHODS

5.1 FRUITS:

We will be discussing 2 types of olive crops in this study; “Ascolana and Arbequina”. An approx. of 100 olives were used in our study. We collected the olive to be tested from the farms in Barani Agriculture Research Institute, Chakwal. Then the measurements were taken of the selected olives.

5.2 GRADING-MACHINE:

Following figures shows us the different parts being used in the grading machine, schematic diagrams helps us to understand the parts of the grading machine. The parameters depicted on the diagram are essentially those that will be determined for olives as a result of this investigation, in order to alter the grading machine to perform efficiently with this fruit. [12]

Figure 59: Top view of assembled machine

Figure 60: Side view of assembled machine

5.2.1 Designed Grading:

1) The Revolving Drums

Three revolving drums are made up of volcanized steel with following parameters: Diameter 92mm, length 305 mm, spacing 6mm, thickness 4mm. The three grading-drums have holes of diameters are 20, 25 and 30 mm number of holes are 156, 137 and 124.

Iron metal-sheet of 330mm length, 457 mm width and 1.5 mm (14 gauge) of thickness was assembled above grading-drums spacing and bolted on two sides of fruit boxes.

2) Fruit output unit

The output unit is made up of volcalnized steel with length of 457mm and width of 127mm. Three fruit cutoffs were inserted into the three grading drums and fixed to the left side of the frame. The fruits slide down the concave surface of the output unit and fall into funnels. The curved section prevents fruits from being jammed. The inclined angle of output unit calculated is 12 degrees.

5.2.2 Motor and Transmission System:

The grading system consists of 0.04 HP motor installed and chains are given below:

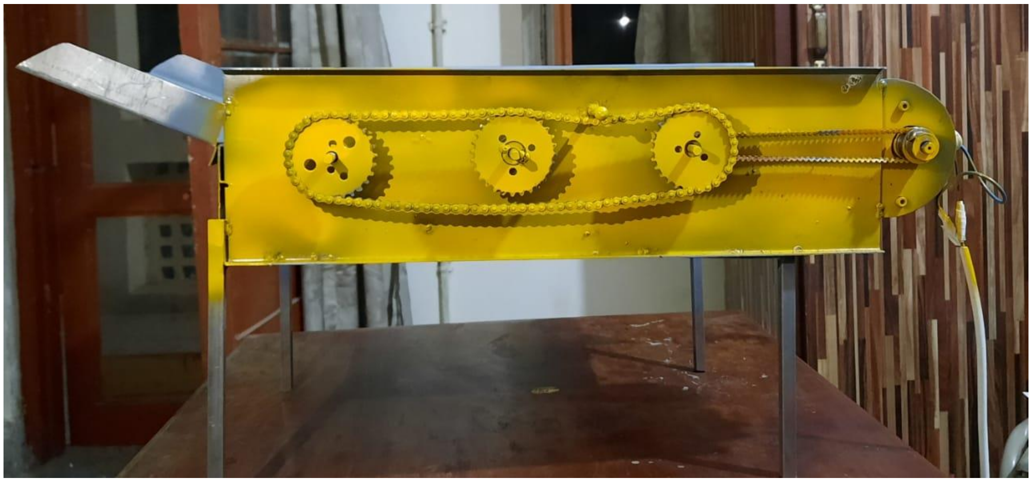


Figure 61: Chains side view of assembled machine

5.3 DEVELOPMENT PHASES AND GRADING MACHINE COMPONENT SPECIFICATIONS

The overall parameters of the olive hopper, grading drums with holes; the length and diameters of drums, diameter and total number of holes and exit fall of the development grading-machine are included as follows.

5.3.1 Olive hopper:

The top dimensions are of 350 x 330 mm and bottom dimensions of 350 x 80 mm. The frictional angle made with the hopper and 1st drum is 30 degree.

5.3.2 Grading Drums:

The fruits are graded into three sizes using revolving drums. The diameter of the holes of the drum must be greater than the olives.

The fruit > 30 mm exit from the end of the machine. As there are 3 grading drums for 3 different types of olives. Rotating/Grading drums and holes in it of varying diameter is 20mm. Length to accommodate 305 cm.

The tangential angle of the drums in the fruit output direction must be more than 17 degree rolling angle between the olive fruits and the volcanized steel of grading machine. The tangential angle of the drums at the direction of drum motion is 7 degrees.

5.3.3 Olive output unit

The tangential angle of the drums of rolling angles between the olives and volcanized steel surface must be kept greater than 17 degree.

5.4 INSTRUMENTS INVOLVED IN THE PROCESS

5.4.1 Vernier Caliper

By the help of the Vernier Caliper with accuracy of 0.01mm we measured the different dimension of the olives.

5.4.2 Digital balance

The accuracy of the digital balance is 0.2g it is used to measure the mass of the olives.

5.4.3 Graduated cylinder

For calculation of the density and volume of the olives by immerging in water of 1000ml with an accuracy of 25ml.

5.4.4 Friction and rolling-angle measuring device

An inclined plane was used to measure friction and rolling angles.

1) Friction angle measurement

The fruits are grouped together in a group on a horizontal surface, and the angle of inclination is progressively increased until the fruits begin to slide without rolling. Friction angles were calculated for each fruit group in a sample size of ten.

2) Rolling angle measurement

The fruits are placed one by one on flat plate, and the angle of elevation is progressively raised until the olives start rolling. Two rolling angles are calculated for each olive in an average sample (50).

5.5 Studied factors and measurements

The development grading-machine variables investigated were:

5.5.1 Grading speed:

Four different grading speeds 5, 8, 11 and 14 rpm (0.05, 0.08, 0.12 and 0.15 m/s).

5.5.2 Feeding rate:

Four different feed rates of 5, 10, 15 and 20 kg.

5.5.3 The Measurement were:

(1) Grading efficiency,

(2) Fruit damage

(3) Grading productivity.

5.6 Equations and Calculations

5.6.1 Sphericity Ratio

Sphericity ratio = fruit height (H) / fruit diameter (D) [13]

For olives: S.R = height / diameter

Table 1: Sphericity Ratio

Height (mm)	Diameter (mm)	Sphericity ratio
18.5	17.5	1.05
19.5	21.5	0.90
22.5	26.5	0.84

5.6.2 Projected Area

Projected area = $4/\pi$ (D * H)

Table 2: Projected Area

Height (mm)	Diameter (mm)	Projected area (mm^2)
18.5	17.5	412.21
19.5	21.5	533.08
22.5	26.5	759.16

5.6.3 Real Density

Real density = Mass / Volume; Volume = 4/3 (3.14)(r^3)

Table 3: Real Density

No.	Mass (kg)	Volume (mm^3)	Real Density (kg/mm^3)
1	5	2758.33	0.0022
		3882.42	0.0013
		5694.12	0.0009
2	10	2758.33	0.0036
		3882.42	0.0025
		5694.12	0.0018
3	15	2758.33	0.0054
		3882.42	0.0038
		5694.12	0.0026

5.6.4 Grading Productivity

According to; [14]

$$P = \frac{3600 * M}{T}$$

P = Grading Productivity (kg/h)

M = Mass in sample (kg)

T = Time in seconds (s)

Table 4: Grading Productivity

Mass in sample (kg)	Time in seconds (s)	Grading Productivity (kg/h)
5	120	150
10	180	200
15	300	180

5.6.5 Grading Efficiency

According to [14], the grading efficiency of each outlet was computed as follows.

$$\mu 1 = M_{01}1/Mi1$$
$$\mu 2 = M_{02}1/Mi1$$
$$\mu 3 = M_{03}1/Mi1$$
$$\mu 4 = M_{04}1/Mi1$$

Where;

$\mu 1$, $\mu 2$, $\mu 3$ and $\mu 4$: Grading efficiency of fruits for each outlet in the machine, (%)

Mi1, Mi2, Mi3 and Mi4: Mass of each class inside olive hopper, (kg)

M_{01}, M_{02}, M_{03} and M_{04}: Mass of olives for each outlet in the machine, (kg)

5.6.6 Total Grading Efficiency:

The total grading efficiency can be calculated by the following equation:

$$\mu = (\mu 1 + \mu 2 + \mu 3 + \mu 4) / 4$$

5.6.7 Mechanical damage

Percentage of the mechanical damage was calculated by the following formula:

$$D.F = Nd / Nt \times 100$$

Where;

Nd = No. of damaged olives

Nt = Total olives

Table 5: Mechanical Damage

damaged olives	Total olives	D.F
25	100	25
28	80	35
35	75	46.67

5.7 Results and Discussions

5.7.1. Physical properties of olive fruits:

Dimensions, sphericity, mass, volume, actual density, and projected area of olive fruits are shown in Table 1. These statistics were collected on 100 fruit samples using the criteria established. [13]

5.7.2. Dimensions of fruit

If the sphericity is less than 0.9; if the sphericity is larger than 1.1, the fruit is classified as oblong. Roundness is assumed for the remaining fruits with intermediate index values [15]

The majority (85%) of olive in sample were round (sphericity 0.9 - 1.1), with oblong olive fruits accounting for 15% of the sample (sphericity 1.1 - 1.4).

CHAPTER 6: SIMULATION ON ANSYS

In this chapter we will design software model of our project. To evaluate this design of machine it has been simulated and analyzed on different software named as Solid works and Ansys. Different set of analysis and constrained has been performed on machine.

6.1 ANSYS SIMULATIONS:

6.1.1 Static structural Analysis of Grading Machine:

Roller drum tis subjected to different simulations and the result shows that design of base of grading machine so strong and robust. The Mild steel has Young Modulus of 2.10 x 10^9 pascal, which is used in manufacturing of needle. The poison ratio is 0.40 and mesh size is 20 mm .Following are the analysis run on this mechanism to test its robustness.

ANSYS software is used to perform analysis on different parts of grading machine. Force being applied on the bottom plate of the machine, pressure being applied on the rolling drums after olives are placed for grading and fixed supports of the machine, the figures are as below

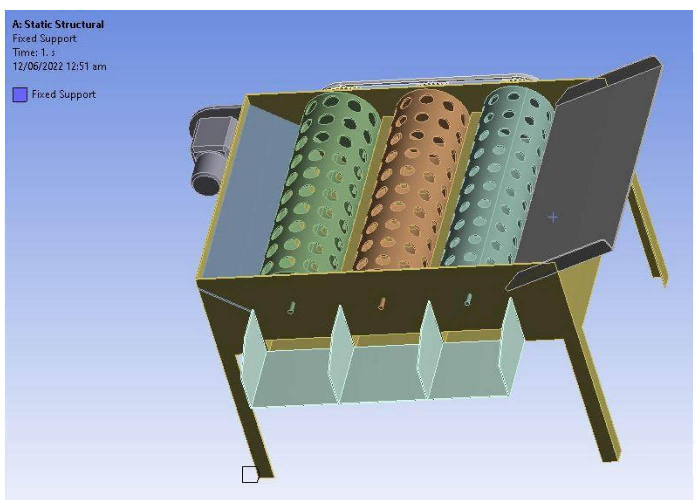


Figure 62: Fixed Support

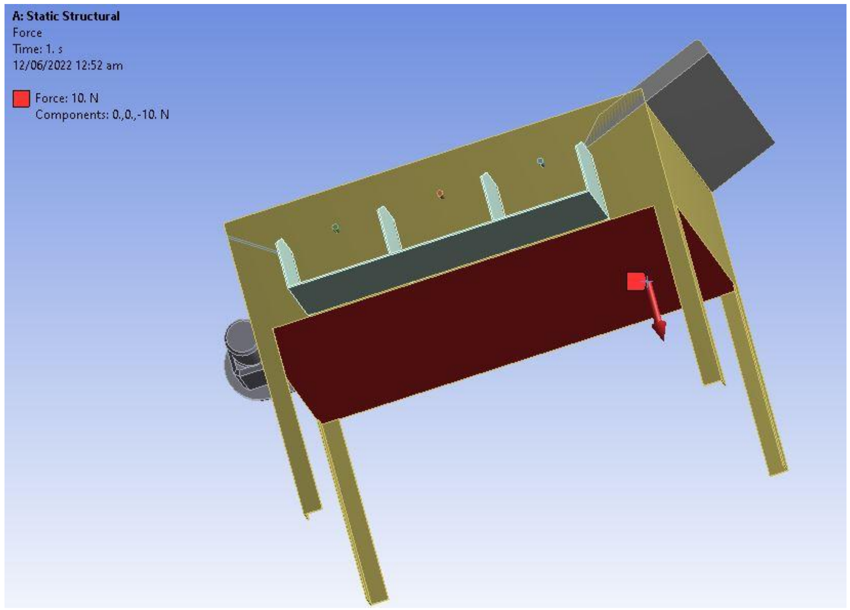


Figure 63: Force on the bottom plate

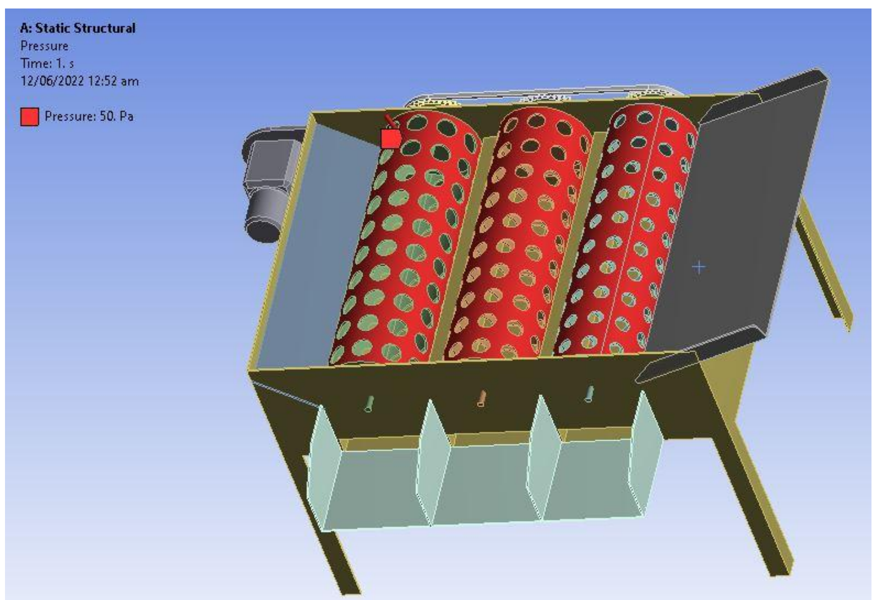


Figure 64: Pressure on Rolling Drums

6.1.2 Simulation by load of 50N:

1) Directional and total deformation on x-axis:

A deformation option that displays all of your model's deformation results in three coordinates (X, Y, and Z). We can examine the deformation result of your physical model in this direction by entering a coordinate (X, Y, or Z) in directional deformation.

The directional deformation in x axis is applied on the roller drums. 50N load was applied. The results shows that the stress is high, but it doesn't exceed certain limit. The pictorial representation of the result is shown below:

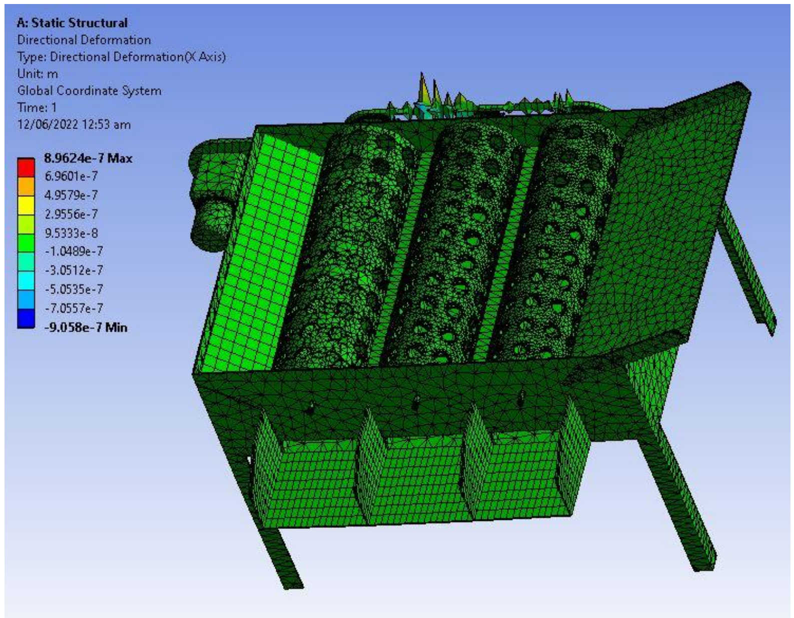


Figure 65: Directional Deformation in X axis – 50N

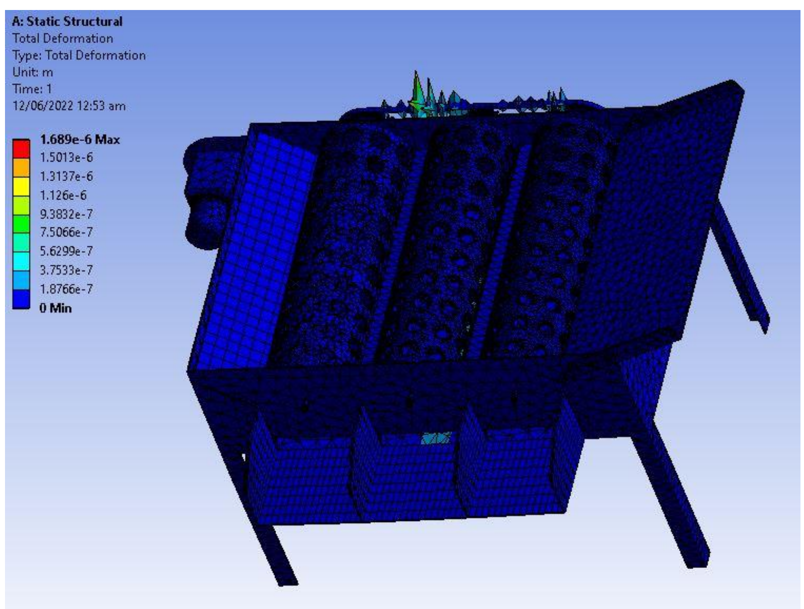


Figure 66: Total Deformation – 50N

2) Von Mises Stress and elastic strain:

The drum is subjected to elastic strain and von misses stress are analyzed. 50N loads were applied to the drum. The results prove that drum is within limit and there are no chances that it will fracture. The following pictures shows the result carried out:

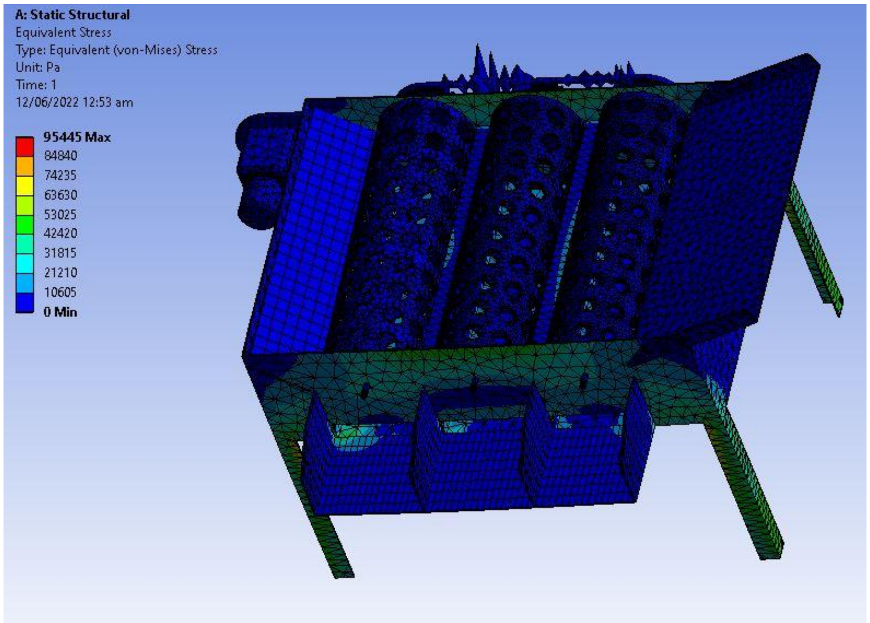


Figure 67: Analysis of Von-Mises Stress - 50N

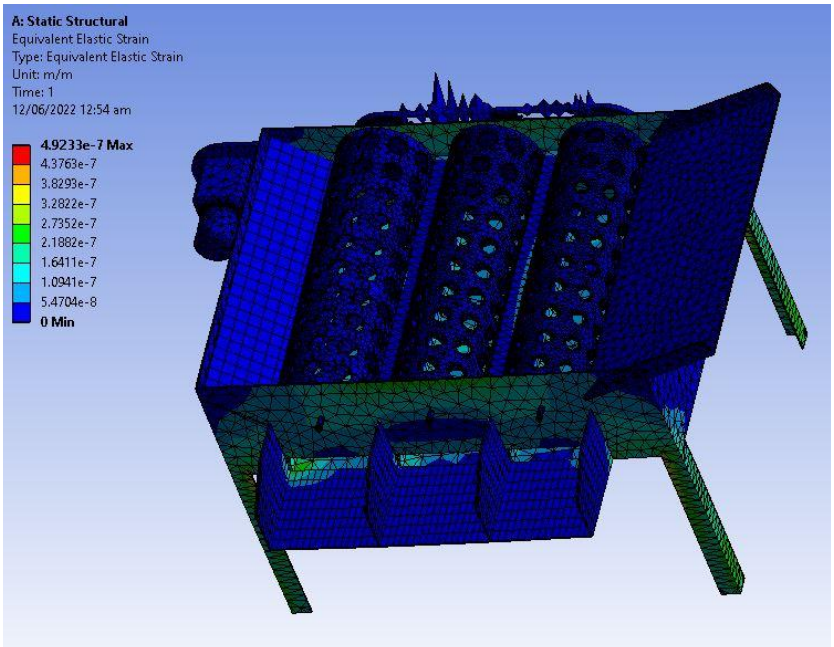


Figure 68: Analysis of Elastic Strain – 50N

6.1.3 Simulation by load of 75N:

1) Directional and total deformation on x-axis:

The directional deformation in x axis is applied on the roller drums. 75N load was applied. The results shows that the stress is high, but it doesn't exceed certain limit. The pictorial representation of the result is shown below:

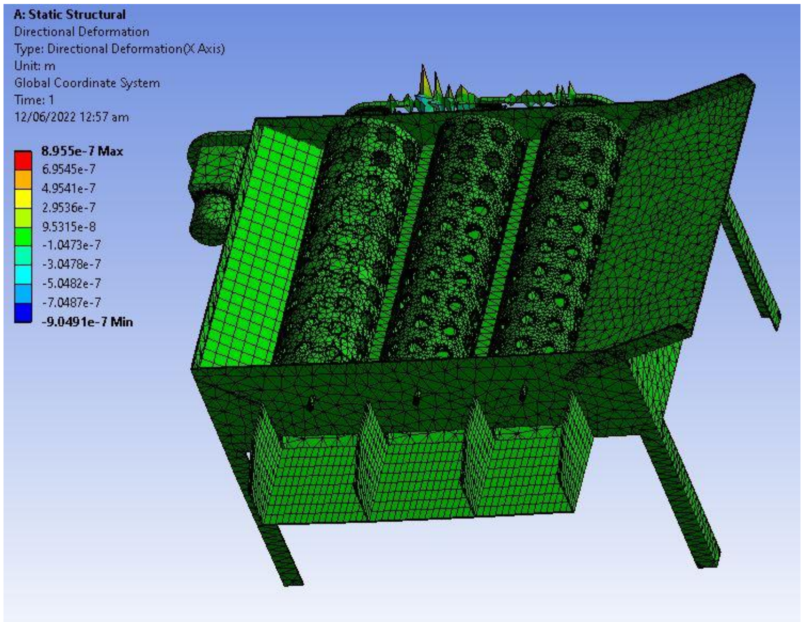


Figure 69: Directional Deformation in X axis - 75N

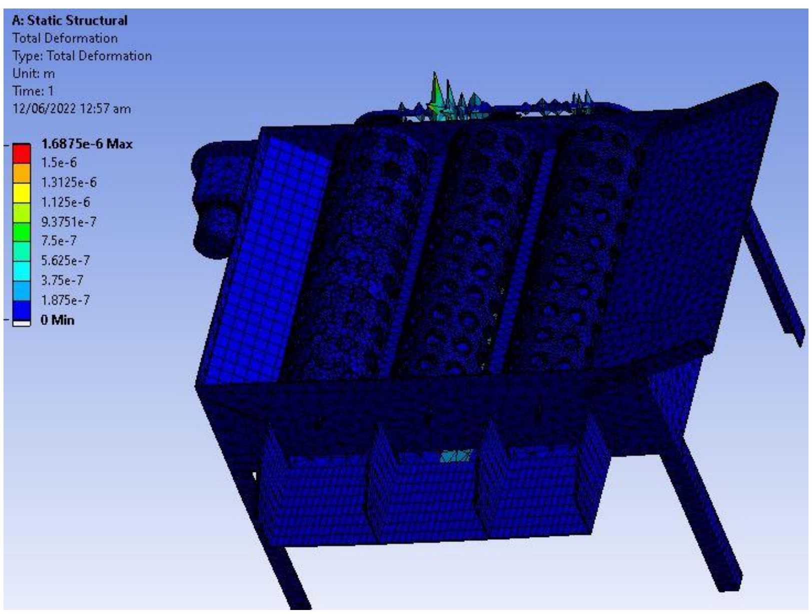


Figure 70: Total Deformation -75N

2) Von Mises Stress and elastic strain:

The drum is subjected to elastic strain and von misses stress are analyzed. 75N loads were applied to the drum. The results prove that drum is within limit and there are no chances that it will fracture. The following pictures shows the result carried out:

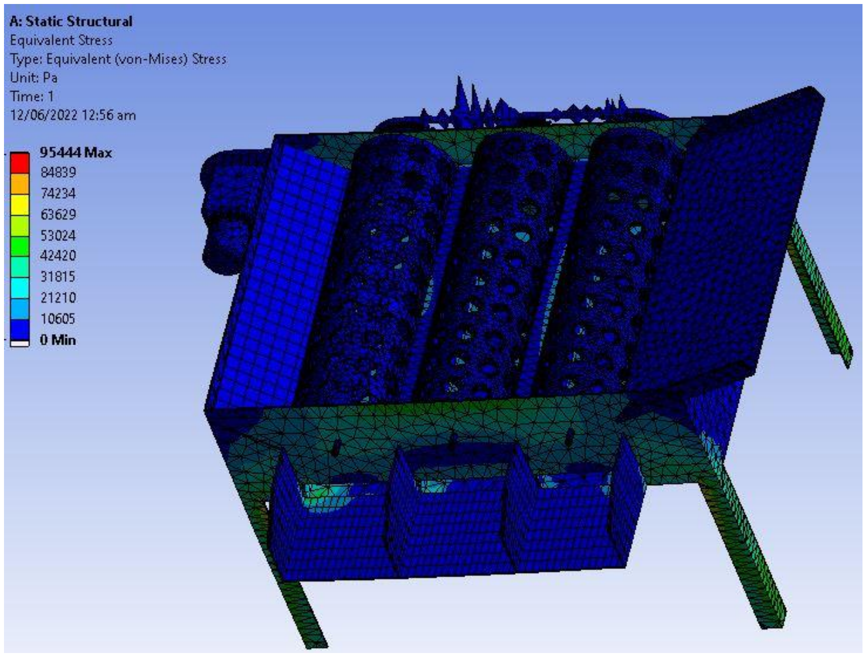


Figure 71: Analysis of Von-Mises Stress – 75N

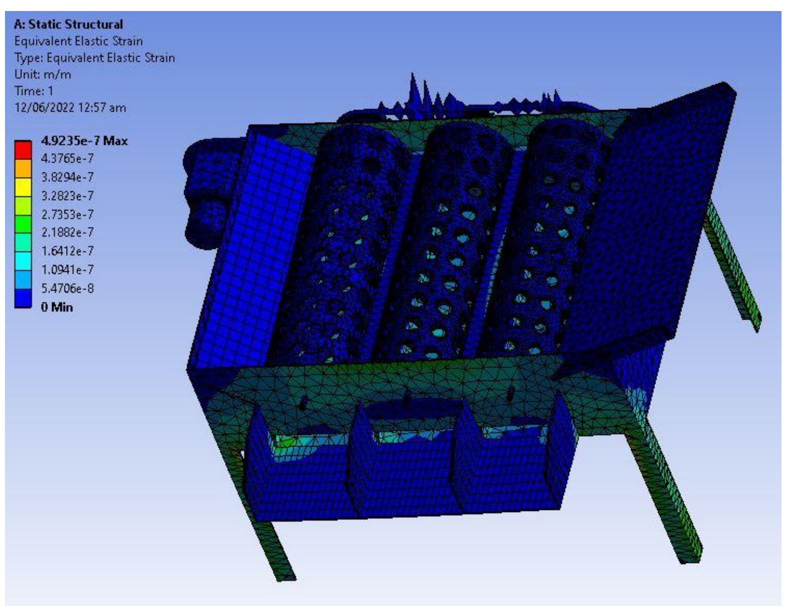


Figure 262: Equivalent Elastic Strain – 75N

6.1.4 Simulation by load of 100N:

1) Directional and total deformation on x-axis:

The directional deformation in x axis is applied on the roller drums. 100N load was applied. The results shows that the stress is high, but it doesn't exceed certain limit. The pictorial representation of the result is shown below:

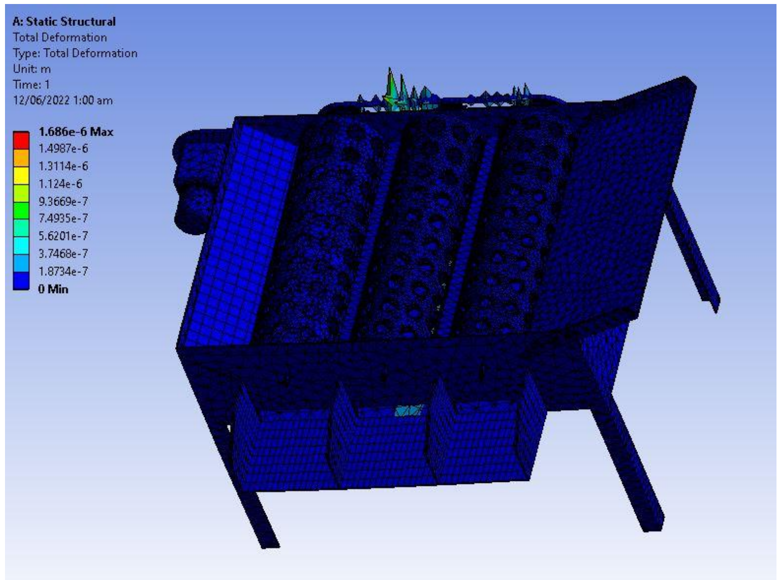


Figure 73: Total Deformation – 100N

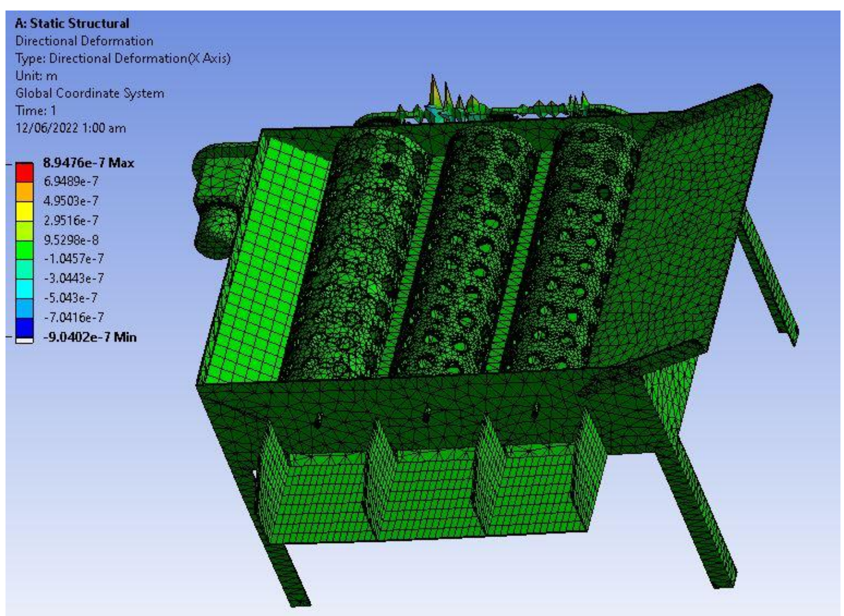


Figure 7427: Direction Deformation in X axis – 100N

2) Von Mises Stress and elastic strain:

The drum is subjected to elastic strain and von misses stress are analyzed. 100N loads were applied to the drum. The results prove that drum is within limit and there are no chances that it will fracture. The following pictures shows the result carried out:

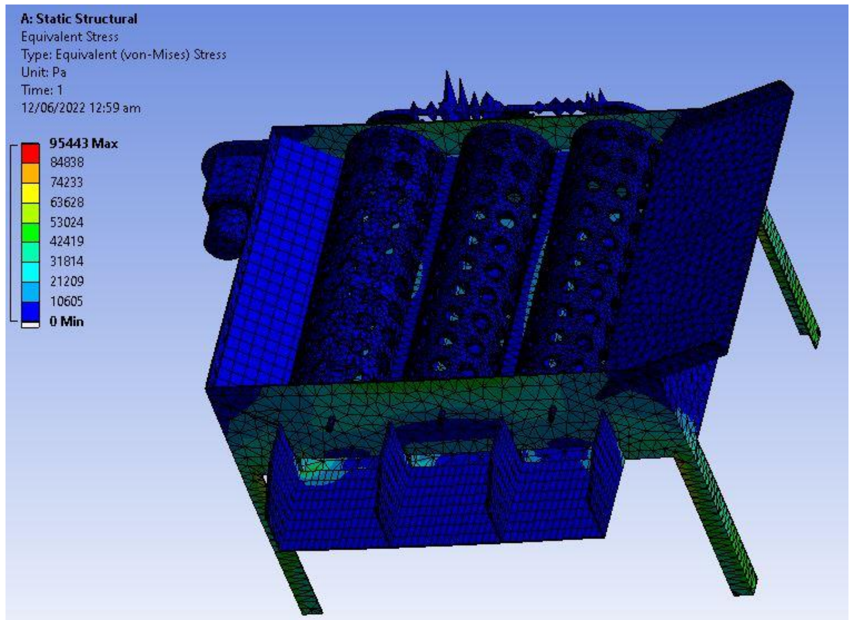


Figure 7528: Analysis of Von-Mises Stress – 100N

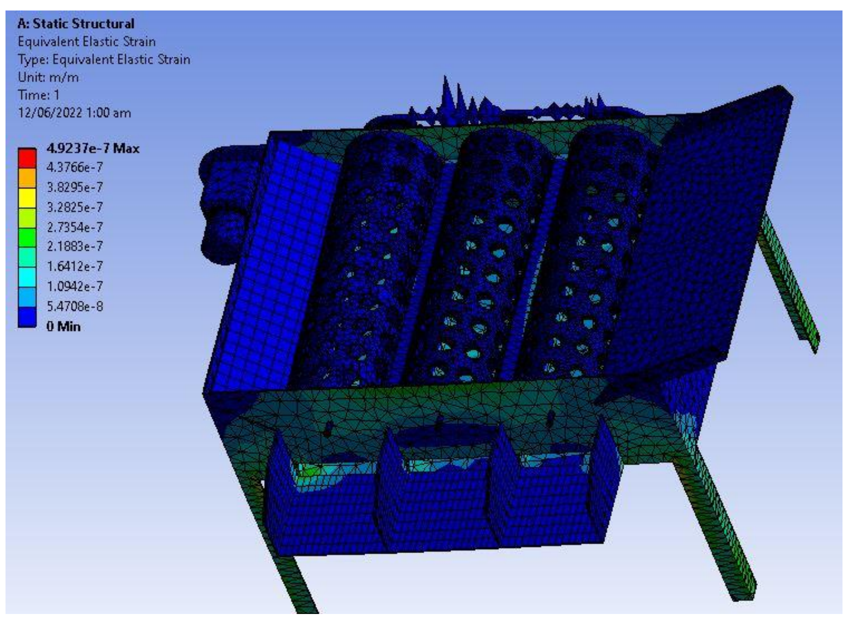


Figure 7629: Equivalent Elastic Strain – 100N

6.1.4. Roller Drum Carriers of Olives:

Roller drums are used for converting rotary motion to linear motion of fruit from the delivery plate. The coupler link was subjected to different simulations. The material for coupler is stainless steel and with Young Modulus of 2.10x10^7 pa. The mesh size is 20mm and poison ratio is 0.40. Following are analysis run on roller drums and complete structure of grading machine shows its robustness.

6.2. Output of Machine:

The olive pitting and grading machine is simulated in SOLID WORKS for motion analysis. The analysis shows that it is capable of grade 3 lines in 40 sec. We can conclude that machine is capable of grade 40-50kg of olives under certain conditions after analyzing the result.

Chapter 7: Conclusion and Future Work

Our grading machine established a mechanism for grading and pitting of olive fruits that has vast applications as table salt and used for the extraction of olive's oil. In addition to project our senior degree we have designed a grading prototype machine for sorting of olives on their sizes. The comparison of cost relative to other grading and pitting machines. The procedure we have carried out shows that olive pitting and grading machine holds importance both technically as well as from engineering point of view. The importance of this machine is obvious from the fact provided that the production of such machines in Pakistan is nonexistence due to lack of self-awareness and academic background. For pitting of olives, the slider crank and Geneva mechanism is used but there are high chances of wear and tear of these components so there are utmost requirements of some modifications in this design. Also, in grading machine of olives there are also some errors carried out in making the holes of drum roller for sorting of olives. Some holes are big enough that olives pass through it without going through grading process. The research and academic work on this machine lacks in quality and quantity of data needed for design of such machine.

The results we have carried out on this machine are given below:

The maximum fruit damage during pitting and grading process was 6.3 to 6.6%. This was obtained with the grading speed of 8.2rpm (0.08 m/s) and feeding rate of 19kg. With the grading speed of 11.1 rpm the minimum damage obtained was 3.2 to 3.4 % with the fruit size of 20mm and feeding rate of 6kg. The maximum range of grading machine productivity for olives of 112-835 was obtained with grading speed ranging from 6-15 rpm (0.06-0.16 m/s) and feeding rate was 19kg. The minimum range of grading machine productivity for olives fruits of 100-685 was obtained with grading speed of 5-14 rpm (0.06-0.15 m/s) and feeding rate of 5kg. The effective cost of our grading machine was from 38-40k.

Every machine has some error in it which arises due to certain conditions and factors, so our machine has also some error in pitting of olives due to fruit damage as calculated earlier and some holes of grading machine was not up to the mark for sorting of olives so in future, we need to optimize this machine using different tools and techniques. The advancement in the machine can made by converting it to fully automatic from semi-automatic machine. In this way labor effort and cost is reduced and high efficiency can be obtained. This advancement in the machine can serve as economic booster in country as there is high demand of olive's oil. Another approach for future is data analysis techniques for machine and this can be carried out by doing different calculations on the machine, making the table for different dimension for parts of machine and performing mathematical calculations and doing different software analysis using Ansys software. This improves the machine performance and efficiency. As this is the continuous project from our senior degree which have worked on just pitting process and we have done both pitting and grading processes. So, this is the advancement factor we have made in our project by sorting olives on their sizes so that they can be utilized for olive oil extraction or for food use. The grading machine we have made is semi-automatic that requires motor for the start of roller drum. The motor starts by just plugging wire into switch. The drum rotates and olives are fed to them the olives which are comparable to holes passes through it and the ones which are bigger passes through next drum roller and there are collecting tray for collecting of olives once they are graded.

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