Design Of Mechanical Systems for Small Scale Harvesting Robot

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Abstract - *Automation is creating revolution in the present industrial sector, as it reduces manpower and time of production. Our project mainly deals with the shearing operation, where the Fruit ,Vegetable or Crop is picked manually and placed in the Holding Compartment for which involves risk factors. Our challenge is designing a pick and place operator to carry the Fruit, Vegetable or Crop from the Tree and place it in the Holding Compartment. We have gone through different research papers, articles and have observed the advanced technologies used in other industries for similar operations. After related study, we have achieved the design of a 3-jointed robotic arm where the base is fixed and the remaining joints move in vertical and horizontal directions. The end effector is also designed to catch or grab the crops. Here we used Solid works 2019 for the Design and Assembly and Ansys 19.2 to simulate and analyze the designed model. The traditional method for harvesting is very labor intensive and time-consuming (eg. hand plucking).*

Key Words: Robotic Arm, Automation and Harvesting

1. INTRODUCTION

A. Problem statement:

i. The traditional method for harvesting is very labour intensive and time-consuming (eg. hand plucking).

ii. Manpower Required is also very large which results in harvesting being very expensive

b. Objectives:

i. To achieve a sufficiently detailed description of the actual agricultural conditions the harvester will have to face.

ii. The objective of this research is to sufficiently reduce labour dependency and harvesting time for small scale farms.

iii. To build a rigid structure of the harvest holding compartment and robotic arm for robust use and should survive in any terrestrial condition.

iv. To optimise the Design such that the bot is light-weighted and cost effective and easily operable.

v. To design a robot arm having enough reach for harvesting targeted crops.

c. Scope:

i. The scope of this project was finalised taking into consideration the available time ,resources, finances and challenges due to the ongoing pandmeic.

ii. The scope for the project is given below:

1. Components:

Robotic arm, Holding compartment, Traction and wheels.

2. Target Crops:

Brinjal, Cherry, Strawberry, Mulberry, Blueberry, Tomato, Grapes, Chilli.

3. Speed: 0 to 5 m/s

4. Time per cycle: 20 to 40 sec.

2. METHODOLOGY

A waterflow approach was followed throughout the process. With this approach we followed one step at a time, reviewed steps and got feedback on it. The project methodology was as mentioned : Understanding the problem, Ideation and brainstorming Defining the scope of problem, Review of literature, Fixing the scope of project, Finalising The Mechanisms of operation, Calculation of different Machine Parameters and Torque, 3DModelling, Final Analysis and Optimization. Ideation and brainstorming sessions led to shortlisting of numerous mechanisms for each functionality. After studying the advantages and drawbacks for each of these options, mechanisms were finalised based on the following factors.

1. Simplicity of design
2. Effectiveness
3. Durability
4. Ease of replacing components
5. Ease of cleaning
6. Cost of Maintenance
7. Ease of Maintenance

3. MODELLING AND ANALYSIS OF ROBOTIC ARM:

The whole design of the robotic arm has been created with the help of Solid works Software. The whole design consists of different portions like base, body, upper arm, forearm and end nozzle. The application of the robotic arm requires reaching. for tree branches and fruits. It should be able to reach the height of the targeted crop. Thus for the application we need a reach of 1. 8m. This was the consideration for the dimensioning of the robotic arm. Since the application requires the arm to harvest fruits and vegetables from all directions it should have sufficient degrees of freedom for the purpose 6 degree of freedom system will be required.

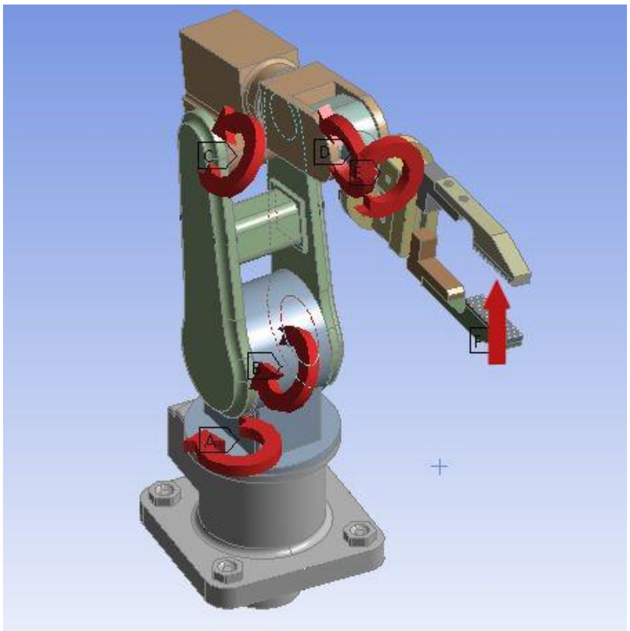

Fig -1: Joints and degrees of freedom

The analysis of the robotic arm was done using FEM method on ANSYS WORKBENCH with its help we found out the different stresses and deformations of robotic arm. The results are given below:

MAXIMUM STRESS	12.67 MPA
MATERIAL	ABS PLASTIC
MESH SIZE	2 mm

Table-1

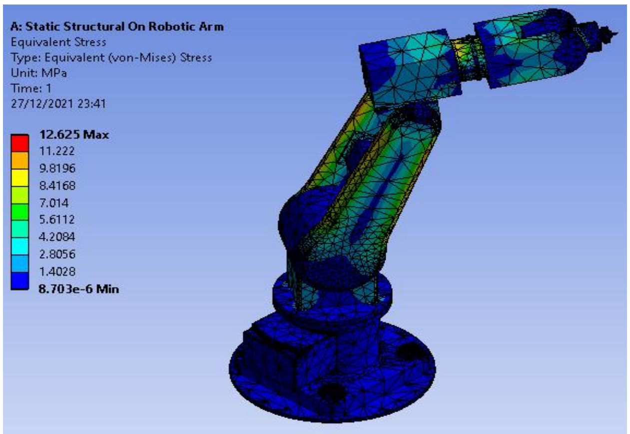

Fig -2: Analysis of Robotic Arm

4. MODELLING AND ANALYSIS OF HOLDING COMPARTMENT:

The whole design of the holding bucket has been created with the help of Solidworks Software. The application of the robot requires it to pick and place fruit and vegetables in the holding bucket. For this the major consideration for design of the holding bucket is the volume of the given crop to be stored in it. From our calculations the holding bucket should sustain 4 to 5kg of harvest. The next consideration is that it should be mounted at an appropriate distance from the robotic arm to avoid damage to the harvest.

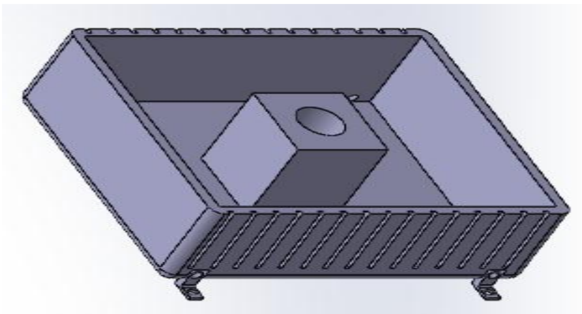

Fig -3: holding compartment

The analysis of the holding bucket was done using the FEM method on ANSYS WORKBENCH, With the use of this software we found out various stresses acting and deformation of the holding bucket. The results are below:

MAXIMUM STRESS	25.40 MPA
MATERIAL	ACRYLIC
MESH SIZE	2 mm

Table-2

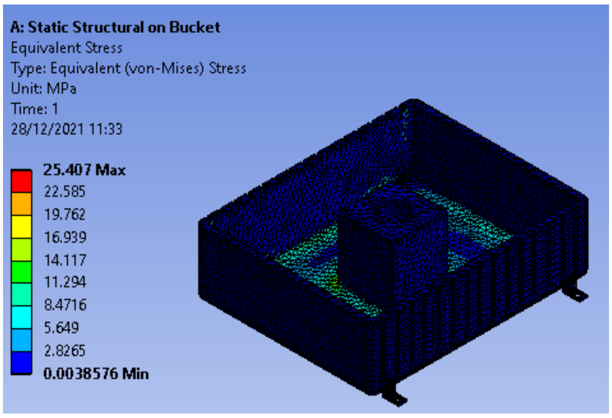

Fig -4: Analysis of Holding Compartment

5. MODELLING OF TRACTION SYSTEM:

The whole design of the Traction System has been created with the help of Solidworks Software. The precise direction control was needed for our application. Thus we have adapted the four wheel arrangement. The terrain of the application is relatively flat thus low power consumption is required for this purpose we have chosen tyres instead of tracks. To increase the traction of the tyres we used deep tread tyres. To increase the pull on wheels individual traction was provided on each wheel.

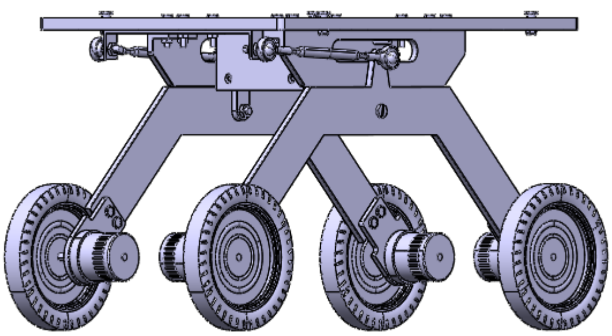

Fig -5: Traction System and Tyres

TOTAL TRACTIVE FORCE	222. 5474N
TYRE SIZE	0. 1749 m
MATERIAL	Polydicyclopentadiene (PDCPD)

Table-3

6. CONCLUSIONS

This project was made keeping in mind the poor and uneducated farmers and it is specially designed to ease the work of the farmers so that harvesting demands can be met easily. Results of agriculture robots serve better than the manual system. This is mainly based on minimising the man power and cost of the equipment, which can be affordable to all the farmers. This robot reduces the manual labour requirement. With the help of this robot we can shape the future of harvesting requirements of the young generation in farming which is very important for the development of the country . Robots can be created as per the requirement of farmers in turn which produces high productivity. Robots are designed for the improvement of life.

7. REFERENCES

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