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Modeling And Analysis Of Cost Effective Lemon Harvesting Robot

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Abstract

Agriculture is one of the most significant and complicated work when compared to other work. In this sector the major problems are lack of mechanization and the cost of the labor involved. A good number of the agricultural operations in larger parts are carried manually using simple and conventional methods; this is unique in case with small and marginal farmers resulting in huge wastage of labor and low yields per capita labor force. Agricultural tools and mechanism are a key contribution for proficient and appropriate agricultural operations, facilitating numerous cropping and thereby increasing production. This paper reveals an innovative mechanism which helps the farmers in picking the lemons.
This machine is a robot with robotic arm, which cuts the lemon from the tree. This robot needs only a single person to collect the lemons from it. This paper confers the information about the cost of the machine, the advancements that can also be done to the machine and the method of operation. This machine will help the farmers in doing their job effortlessly reducing the labor. This paper also provides information about the mechanisms that can be used to run the machine and gives a guide to the users how to operate and maintain the machine.

Keywords:-Lemon harvest; Mechanical harvest; Path planning, Catia software

I. INTRODUCTION

In Agriculture sector the cost of labor involved is increasing enormously day by day.

Considering this drawback, robots are being designed that can replace humans. In this paper a mechanism is developed to eliminate manual work. As of definition Mechanism is nothing but a set of links that convert an input into a desired output. In general there are mainly two types of mechanisms. They are

- Simple Mechanism
- Compound Mechanism

Based on the type of mechanism, all the machines works i.e. a machine is a mechanism or a set of mechanisms. The majority of highly developed machines like the Robots can't work without a mechanism. It is mostly probable to see mechanisms everywhere from watch to digging machine or even a Robot that stroll like a human.

Now, let's consider the agriculture sector. We have plenty of machines and advanced techniques of forming, but the question is why the farmers are diminishing year to year? Of course, it has many answers like unseasonal rains, low profit and huge investment, new diseases to plants and many more. Some major reasons which are forcing the farmers to sell their fields and going for an alternative are the cost of the labor involved and lack of mechanization. Considering the problems of lack of mechanization, in this paper we are mainly focusing in the area of working environment so that the work which is being done manually with lot of efforts and difficulties can be automated and the job can be simplified. This is the main reason for initializing this Lemon harvesting robot.

II. EXPERIMENTAL SETUP

A. WHEELS OF THE MACHINE

The wheels of the lemon harvesting machine are similar to that of a four wheeler. The rear wheels of the machine will follow the front wheel and the front wheels are guided by a sensor to move along the path made around the Lemon trees. The wheels and the sensor altogether form a path following robot.

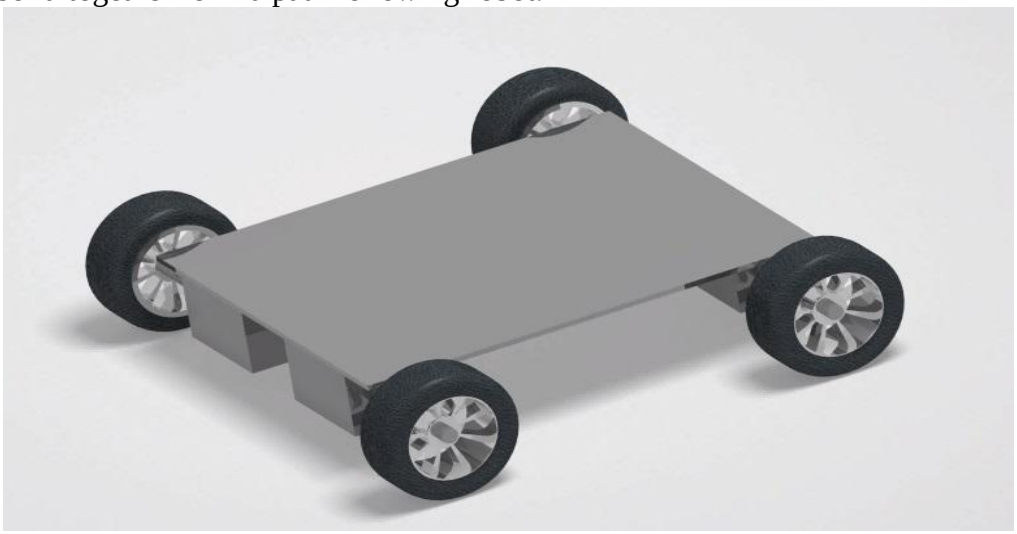

Fig.1. Arrangement of wheels of the machine

B. PATH OF THE ROBOT

For moving the machine around the trees automatically without any guidance, we need to create a path around them. The path is like a track to the machine with a track line. The track line must be as dark as possible for the sensor to detect it easily. The best choice is white in a black i.e. the track line must be white surrounded by dark color like black or brown. Choosing white helps the sensor to detect the path very easily even if the mud covers the dark surrounding. Thus, it helps the farmers clean the path rarely. The paths can be drawn in two ways as shown below.

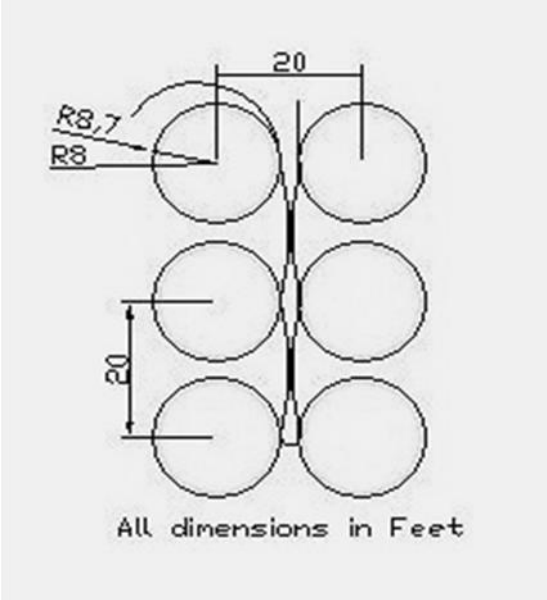

Fig.2. Path designed for the robot to follow

The creation of the path is the best choice for the robot to roam around in the farm, because the arrangement is easy and suits for all length of the trees. The thing we have to do is to choose the middle line whenever there are three lines i.e. at the intersections with the help of programming. This path is created with the help of the tape on a rope.

The maximum height that most of the lemon trees grow is 10 feet, after that their branches start to fall down. That is the reason why farmers place support to the trees at this stage itself. The maximum radius of the tree is 4 feet, after that farmers start cutting the branches. The best way of placing the track is, placing it when the trees are small enough (due to continuous rotation of the branches of the trees will be adjusted and will provide place for the machine to rotate).

C. CONTAINER

The container in this machine is designed in such way that the user can take the lemons easily, when the container is filled. The container is provided with an alarm which is in turn connected with a sensor that detects the level of lemons in the

container. Whenever, the container fills the sensor triggers the alarm to convey a message to the user that the container is filled. When the container is filled the machine stops automatically. A further advancement of automatic unloading can also be done to the machine but it shows its awful effect on the cost and balance of the machine. To collect the lemons easily from the container, a removable plate is placed in the front of the container.

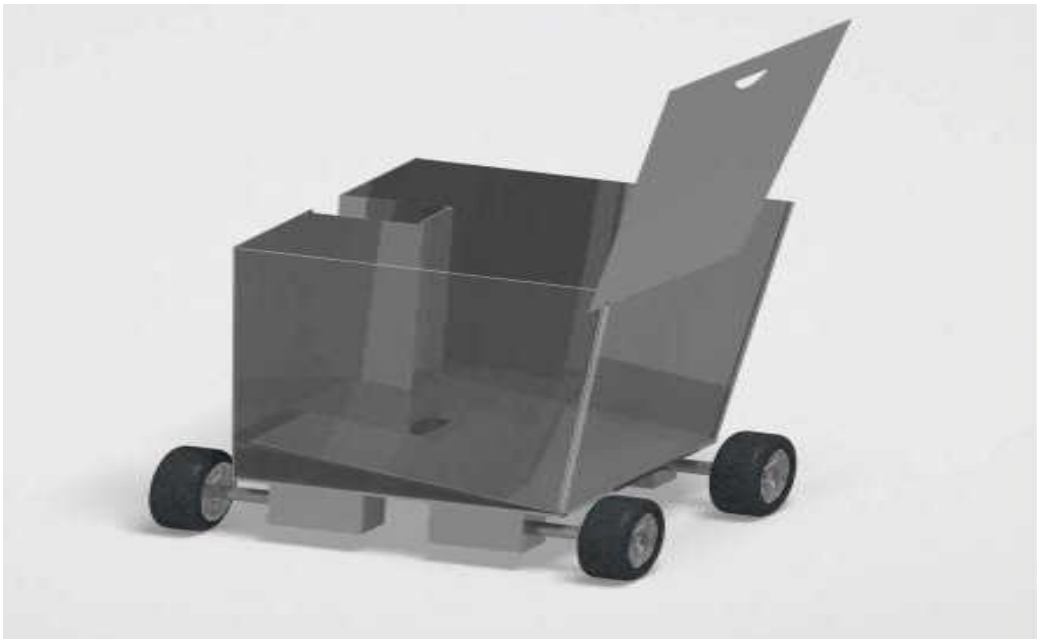

Fig.3. Container of the machine for lemons to be collected

The base of the container is designed flat and at an angle of $8\text{-}10^0$ with the horizontal and the inclination starts half feet from the front portion i.e. from the removable portion of the container.

Coming to the base dimensions of the container it must be 2 feet in length and 1.2 feet in width. The upper part of the container must be swollen for storing more lemons. It must have 2.5 feet length and 1.2-1.8 feet width.

D. ARM OF THE ROBOT

The arm of the machine plays an important role in the machine. The arm is controlled by a micro controller. The arm is divided into three components mainly. They are the rotary rod, the ladder and the cutter. In them, one will give the rotary mechanism; one will give reciprocating mechanism.

The rod of the arm can be rotated by using a stepper motor. This rod is programmed to rotate 60^0 from right to left. The height of the rod should not be more than 2 feet and the diameter must be at least 0.16 feet. Increasing the height of the rod may fail in balancing of the machine.

. Fig.4. Arm of the robot

The sensing capability of this machine to find the lemons, ripe lemons is provided by using a stereo camera. It can be connected to any part of the machine, but it has to take the picture of whole length of the tree. Sometimes it is difficult to take the picture which covers the whole length of the tree; at this place we better connect it to the pipe-1, so that it can take 3-4 pictures for every 3 feet of height. These images will command the robot recognize lemons to cut. We can choose the lemons either by color or size or even both.

Then, there will be a lifter that is attached to the rod and the ladder. This lifter lifts the ladder to the required position (angle) it at the required. The lifts can make a maximum angle of 130^0 and a minimum of 65^0 between the rod and the ladder. The lifter consists of two pipes and a chain. The lifter work is similar to the ladder. The design of ladder is similar to the fire engine ladder. The ladder must run as fast as the pneumatic system. It can also be moved by using gear and chain mechanism. The ladder is formed by four pipes one inside another and the lifter is connected to the rod

and the lifter. Every pipe consists of a bent plastic sheet connected to them. The length of these sheets is 1 or 2 inches long at both ends except the pipe-1. The sheet of the pipe one must be cut down a little bit to provide the lemons to fall in the bucket. The ladder has a chain welded to its inner most rod that is arranged inside all the cylindrical tubes. The chin is designed in a way that it has the same length as the pipe and the thickness is 3mm less than the diameter of the pipes. The chain shown in the figure is a set of three chains which can be welded to the pipe-4 (i.e. the inner most pipe here).

Fig.5. Ladder type arrangement for the robot arm to be extended

The chain will be passed over a gear which will be rotated with the help of the motor and the micro controller. The ladder moves forward when the gear rotates in anti-clock-wise direction and it will come to its original position when the gear rotates in clock-wise direction. For a proper balance of the machine the ladder must be made with a weight less material like aluminum. This part acts like a ladder for the lemons to roll into the container and hence we called it as the ladder.

E. GRIPPER

The gripper is placed just at the end of the ladder, so that the lemons fall directly into the ladder. Two types of cutters can be used in this gripper one is scissor type and another one is clamp type. The scissor type cutter contains a low range photo resistor or infrared sensor to scan the nearby lemons. The scissors in this cutter runs with the help of the motor and is operated by the micro controller. This cutter has a disadvantage of cutting the leaves along with the lemons.

The clamp type cutter contains two parts. They are the clamp and the blade. The clamp is used to hold the lemon, so that the lemon won't move while the blade tries to cut it. The clamp is provides with a touch sensor. The blade is arranged such that it can slides over the lemon without cutting it in the middle. This cutter is also provided with the short range photo resistor or infrared sensor. Instead of the cost and weight this cutter is best option compared with the scissor cutter. The clamp type cutter with its blade is shown below (for the purpose of celerity all the extra parts like ladder and the sensor are removed from the cutter).

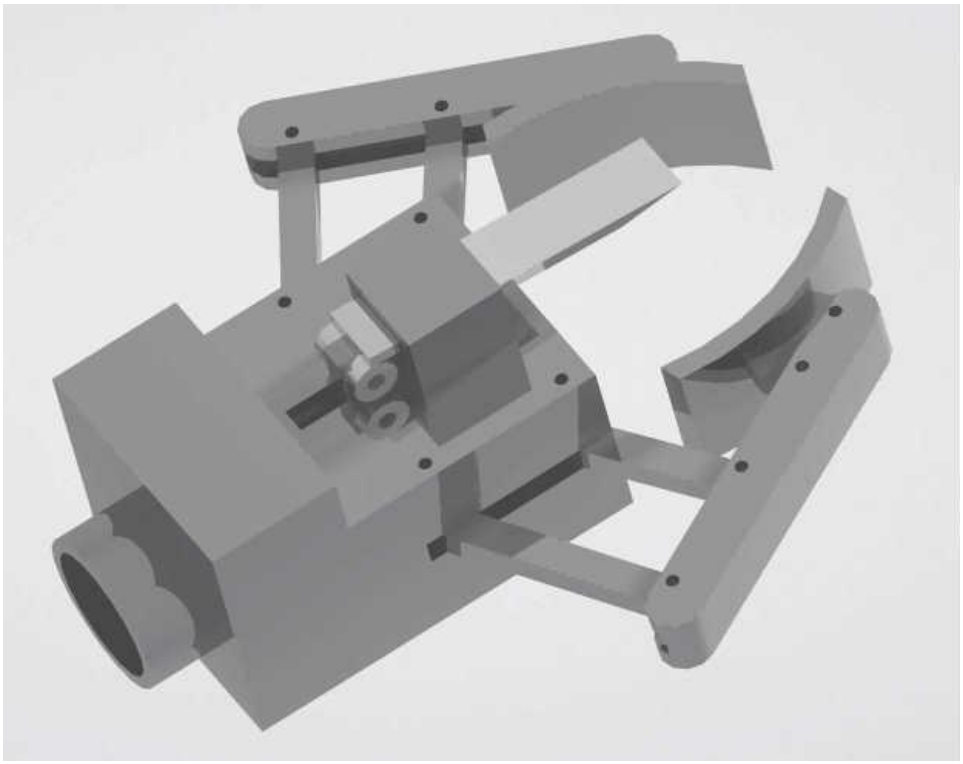

Fig.6. Design of gripper at the end of robot arm

Aluminum may be the best suggestion for the ladder. The clamp in the cutter first holds the lemon like a robotic arm and the blade slides over the lemon and moves back. Then the clamp releases the lemon into the ladder. Finally, the lemon rolls into the container over the ladder.

III. MECHANISM

When the robot is switched on it starts follow the track line, then it takes the pictures and starts recognizing the lemons to cut. Then, it calculates the angle and length to reach the lemon. Then, the ladder moves to the position of the lemon and then the cutter cuts it down. The arm always moves from bottom to top and right to left. When the angle between the pipe-1 and the rod is less than 90^0 it will moves to 100^o for every four lemons. If the all the lemons at this area are finished then the robot moves another 5 feet and starts to work again.

Operating the Lemon harvesting machine is very simple even for illiterates. The operation involves taking the machine to the track line and switching the power button. Then the machine automatically starts to collect the lemons. When the container is filled the alarm will be triggered and the machine will go off. The user has to unload the container just by pulling the container plate and has to flip the switch again. The user should not carry any ripe lemons when he is 20 feet around the machine. The picture of the robot is shown below.

Fig.7 Design of entire machine

IV. SELECTION OF MATERIALS USED

Different materials have been selected for the modeling of harvest robot so that the entire cost of the robot will be minimized. Bucket, rod and the motor cases of the machine are made of iron material so that the system base part will be having good stabilization and the material for pipes and chain has been selected as aluminum. The total weight of the machine is around 35kgs. The following table represents the stress in different materials when load is applied to them. Here we are considering three materials namely aluminum, iron and steel.

TABLE I STRESS IN DIFFERENT MATERIALS WHEN LOAD IS APPLIED

Load	Stress in aluminum	Stress in iron	Stress in steel
1	1.37e5	1.68e5	1.51e5
2	2.73e5	3.35e5	3.46e5
3	4.1e5	4.42e5	5.3e5
4	6.12e5	5.89e5	6.05e5
5	6.83e5	7.37e5	7.56e5
6	8.2e5	8.84e5	9.08e5
7	9.57e5	10.3e5	12.1e5
8	10.9e5	13.4e5	13.9e5
9	12.3e5	15.1e5	15.6e5
10	15.3e5	14.7e5	17.3e5

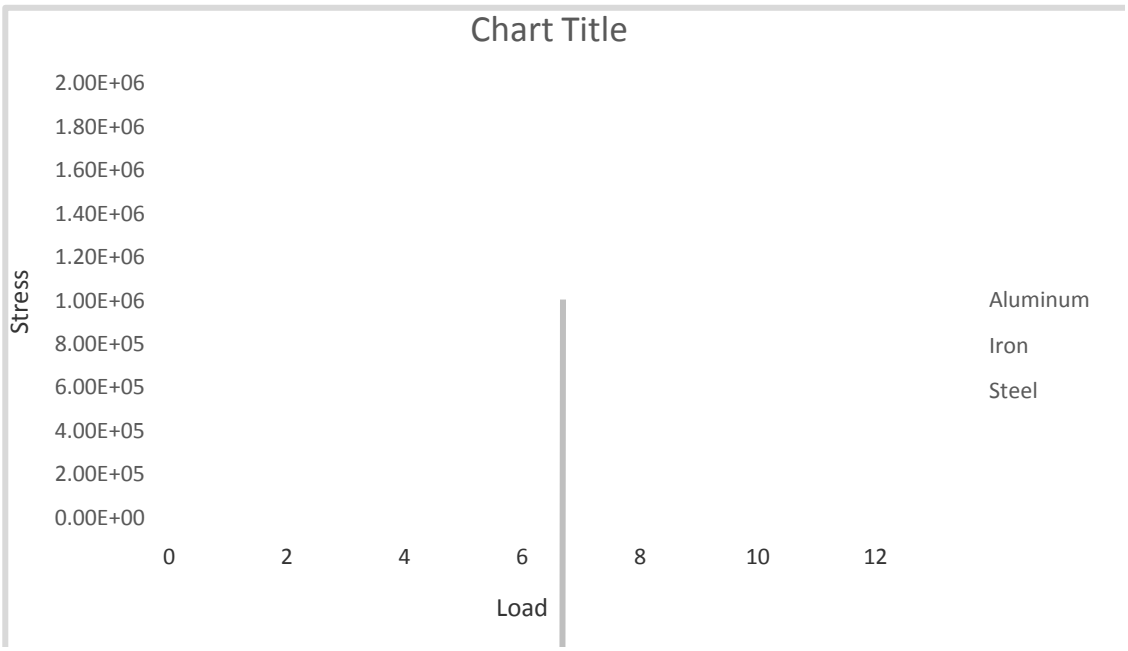

Fig.8. Sample graph representing stress in different materials when load is applied

Stress in different materials is considered for the applied load and the required materials have been selected for the modeling of lemon harvesting machine, the quantity and weights of the machine are tabulated in the following with the best considered design parameters.

TABLE II MATERIALS USED WITH WEIGHTS

S.no	Part	Material	Mass in kg
1	Pipes	Aluminum	4.38
2	Ladder sheets	Plastic	0.9
3	Rod	Iron	0.892
4	Bucket	Iron	11.11
5	Chain	Aluminum	3.8
6	Motor cases	Iron	0.816(each)
7	Axles	steel	0.1(each)
8	Lifter pipes	steel	0.376
Total mass of Robot (including motors & welded joints)			35.34

V. ANALYSIS

The different parts utilized in the modeling of machine have been noted and the safety load, bearable load and the failure load have been measured and noted for analyzing the machine parts.

TABLE III MATERIALS USED WITH SAFETY, BEARABLE, FAILURE LOADS

S.no	Part name	Safety load (N)	Bearable load (N)	Failure load (N)
1	Pipes set	5	16	7
2	Ladder sheet	2.5	5	4
3	Base	500	800	650
4	Rod	90	170	130

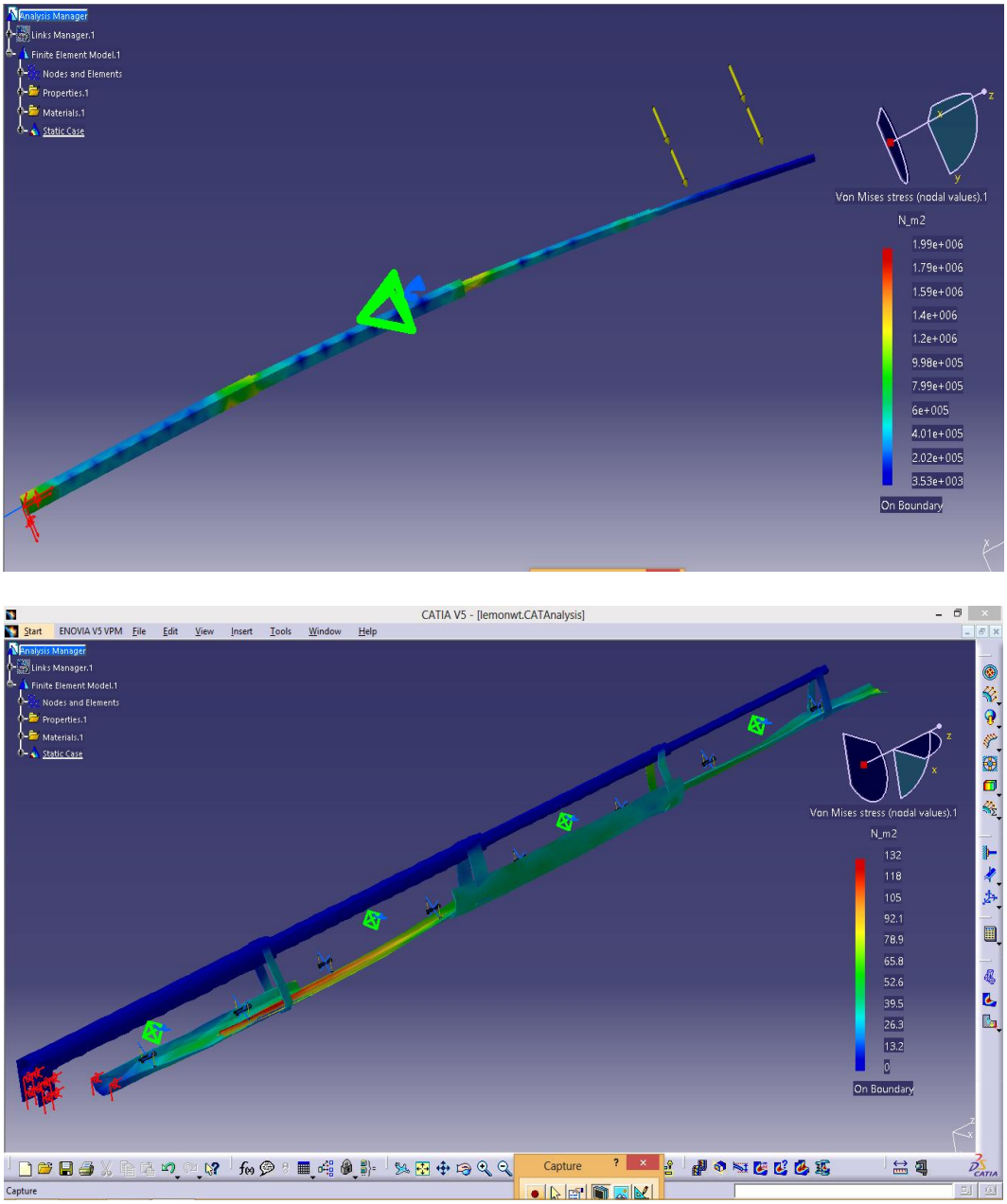

Fig.10. Analysis of applied loads

The bearable is the max load the part can with stand, the failure load is the load at which the robot fails to do its job. For example, when there is a load of 7N on the pipes they bend and the clamp will be at little lower than the lemon and it fails to cut it down.

The parts that fail mostly are tabulated and every other part depends on these parts. If these are safe the entire machine will be safe. The load on the rod is the weight of the pipes and the ladder sheets (approx. 5.4kg). But the safety load of the rod is 90N i.e. 9kg approximately

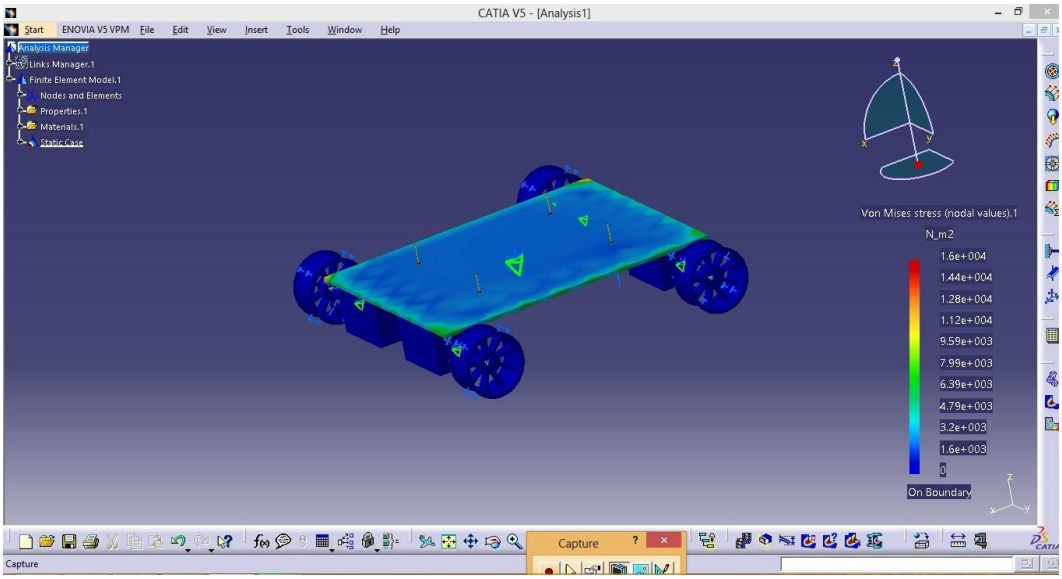

Fig.11. Analysis of bearable, failure loads

VI. COST OF THE ROBOT

The maximum cost of the machine including the track line (for one acres of land) is around RS: 60,000/- Now, let's compare the cost of the labor with the cost of the machine. The chat that is plotted below clearly shows that the machine cost will be recovered along with the interest within a year.

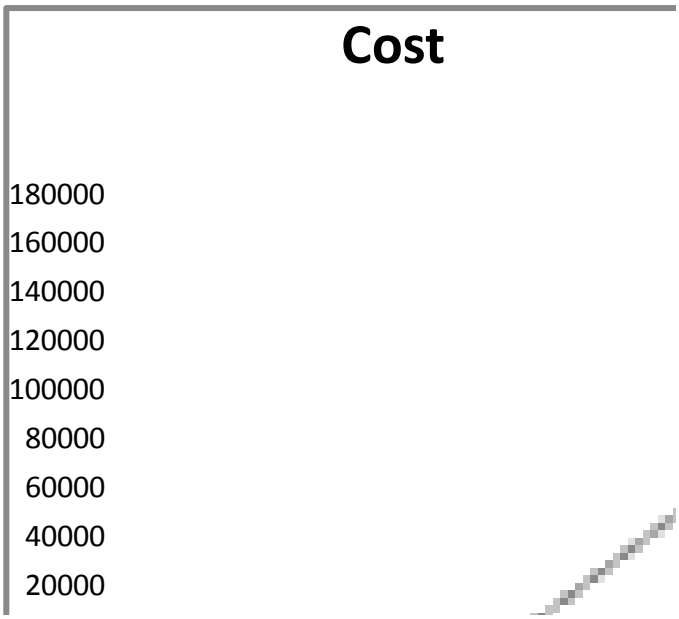

Fig.12. Sample graph representing the cost of the robot

The chat is plotted for an agricultural land of 10 acres for which at least 60 labors are required per crop. Each labor demands a minimum amount RS: 200/- at any area. So on an average labors cost 12000RS/- per crop. A worse crop can gives 15 crops per year where as a best one gives a crop for every 5 days. So, noticeably this machine can be implemented in the agriculture easily.

VII. CONCLUTION

This paper innovates a new machine which is cost effective and will reduce the effort of farmers in picking lemons. This machine also eradicates labor for harvesting the lemons. As this is very easy to operate anyone can handle this machine. This machine mechanism will be very useful in saving the time for harvesting the lemons.

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