Design and Manufacturing of Pneumatic Crop Uprooting Machine

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Abstract - Pneumatic crop plucking machine is basically a machine which is used to pluck the crops of various varieties for an example a cotton crop or a pigeon peas crop with the help of a crop holding jaw and a lifting lever operated by pneumatic actuators. In today's practice the crops are plucked either by hand itself by the daily paid workers or by a simple rod and a tool. So taking into considerations the difficulty coming into the work of plucking the crop continuously, we decided to automate the process by using mechanical and pneumatic means, the main advantage of our machine is that it is very simple to operate and it reduces the human fatigue and hectic to a greater extent. This is basically a new concept which is not in existence in the market. Looking to a long term investment this proves to be quite beneficial.

Keywords —Actuators, Control valves, Crop holding tool, FRL Unit.

I. INTRODUCTION

This machine is not in existence certainly now in market and hence this effort of ours is sincerely new on the basis of idea and application. This concept perhaps is further modified and brought into reality by work study and trial and error basis. This machine actually plucks the crops of cotton and pigeon peas from the ground. It can be also moved to desired place as it is equipped with the trolley member. The trolley has a ground clearance to suit farmland ground surface. This machine is operated by mechanical and pneumatic means. There are mechanical linkages between different parts connected to each other and the main action of holding and plucking the crop from the soil is actuated by pneumatic means. This machine uses the power from the compressed air and actuates the load by means of the pneumatic piston and cylinder. The crop holding jaw as-well-as the main lifting cylinder, are operated by means of direction control valves. This machine needs a supply of compressed air at 5 bar from a compressor. The compressed air is supplied to the actuators by means of hoses which are specified by the DCV's and the actuator dimensions. The actuators are so selected that it may satisfy the act of plucking the crops from the soil and shall also withstand the load firmly without failure. The machine is portable and can pluck any crop which needs to be plucked from the ground but whose stem dimensions must suit the dimensions of the holding jaw.

II. NEED OF PROJECT

Improving the lifestyle in day to day routine is very important task, as by improving the lifestyle we provide a lot of human comfort and also reduce the human fatigue and human hectic to a greater extent. Now-a-days reducing the time required for a certain job is very important as time is considered to be a very important factor when we have to pay for any work depending upon the time required for the completion of work. Indian agricultural sector is a very fast growing sector and many advances are been made in that field. Farmers are also experimenting new techniques in order to increase their production. This was the basic boosting idea behind the concept of our project. There are many farmers who grow the crops like the cotton crop or that of pigeon peas in their farm. However when the yield from these crops is taken then these crops are needed to be plucked from the ground completely as for the next crop to be grown in the farm it is very essential that the roots of the previous crop should be completely removed from the ground as it adversely affects the growth of the next crop. And now to pluck the crop from the ground workers are hired on daily wages basis and the workers pluck those crops by hand itself or at some places they use a simple tool which has a hook at the face. This seems to be a very simple process but when a worker needs to pluck lots of crops in the farm which are spread through the entire farm in Acres, then it gives rise to great amount of physical fatigue and hectic to worker. And the approximate wages for this job given now is 1000 rupees per day for an Acre land. Looking at the farm and the farmer's financial condition these wages prove to be out of affordability if a large land is considered. And even due to physical fatigue the workers purposely try to extend there working days in order to work comfortably and to earn more wages. Taking into account all these factors we decided to automate this activity of plucking the crops by using mechanical and pneumatic means. So we decided to launch a pneumatic crop plucking machine that would perform the function of plucking the crops as per requires schedule and also with very less hectic and human fatigue.

III. SCENARIO OF THE CROPS IN THE FARM

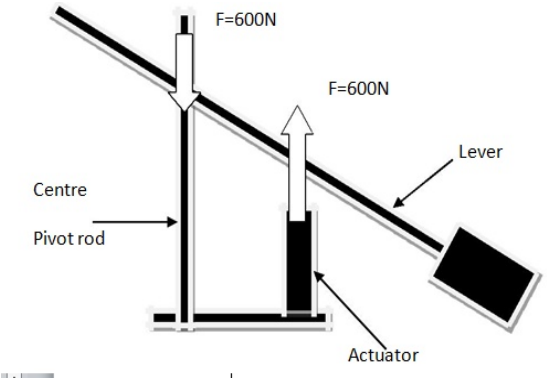
Cotton crops in the farm

Pigeon pea crop

IV. DESIGN CALCULATIONS

The elements need to be designed according to the type of force that will be applied on a certain object. Taking into considerations all the forces the elements are to be selected on the basis of material available. Then we also have to determine the failure of the components when they are subjected to various forces.

a) Design of main Cylinder



The approximate force applied by the human muscular force is taken into consideration and the force required in order to uproot the crops from the soil is determined. Hence the force assumed and the further calculations is as follows:-

Force = 400N to 600N

Cylinders available:

1) 25 x 25 mm 2) 50 x 100 mm 3) 50 x 200 mm

Cylinder no. 3 is selected as stroke length required was more because root of pigeon peas crops are upto 15 to 17 cm under ground

$$P = \frac{F}{A}$$

$$= \frac{600}{\frac{\pi}{4}(0.025)^2}$$

$$P = \frac{600}{1.9634\times10^{-3}}$$

$$P = 3.05592 \text{ X } 10^5 \, {}^{N}/_{m^2} \quad \text{i.e. P = 3.05592 bar}$$

Generally 3 bar pressure is required to uproot a crop according to the force considered to uproot the crops.

b) Bearing Selection

Calculation of Equivalent load , p .

$$\text{Pressure} = \frac{Force}{Area}$$

$$= \frac{F}{A}$$

$$= P \text{ x } A$$

$$= 5 \text{ x } 10^5 \text{ x } \frac{\pi}{4}(0.05)^2$$

$$F = 981.741 \text{ N}$$

This will be considered as Fr (Radial Force).

Fr = 981.747 N .

Now , P = (X × Fr. + Y × Fa) S

Where,

X = radial factor = 1 ……(DDB-4.4)

Y = axial factor ……(here neglected)

Hence the formula becomes,

Equivalent load ,

P = (Xx Fr)S = (1x 981.747) x 1.5

P = 1472.6215 N.

V. PROJECT SPECIFICATION

A. Pneumatic Cylinder: - Pneumatic cylinders or air cylinders are mechanical devices used to impart a force from a fluid, typically compressed air. A typical pneumatic cylinder consists of a piston, piston rod, and a body or tube. Compressed air enters at one end of the tube, imparting force on the piston, which is then displaced (moves) in order to balance the force exerted on the

piston. Air cylinders, or actuators as they are also called, are available in a variety of sizes, shapes, and have varying strokes. Typical cylinder sizes range from a small 2.5mm air cylinder, which might be used for picking up a small transistor or other electronic component, to 400mm diameter air cylinders which would impart enough force to lift a car even. Here they are basically linear actuators and are connected to the load that they are going to actuate.

1) Lever Cylinder

Category: - Linear Actuator

Dimensions: - 50mm X 200mm

Stroke Length: - 200mm

Ultimate Pressure Handling Capacity: - 10 Bar

Working Pressure Subjected to: - 5 Bar

2) Tool Cylinder

Category:- Linear Actuator

Dimensions: - 25mm X 100mm

Stroke Length: - 25mm

Ultimate Pressure Handling Capacity: - 10 Bar

Working Pressure Subjected to: - 5 Bar

Specification Table:-

Sr. no.	Part Name	Material	Part No.	Qty.
1	Round pipe	Aluminium	FMK-100-01	1
2	Top Cover	Aluminium	FMK-100-02	1
3	Bottom Cover	Aluminium	FMK-100-03	1
4	Piston Rod	EN 8	FMK-100-04	1
5	Piton A-B	Aluminium	FMK-100-05	2
6	O-Ring For Shaft	NBR	FMK-100-06	1
7	O-Ring For Piston	NBR	FMK-100-07	1
8	Delrin Coller	Delrin A-B	FMK-100-08	2
9	Delrin O-Ring	Delrin	FMK-100-09	1
10	Piston Lock Nut	M.S.	FMK-100-10	1
11	V-Seal For Piston A-B	P.U.	FMK-100-11	2
12	Diameter O-Ring	NBR	FMK-100-12	2
13	Cushion Seal A-B	NBR	FMK-100-13	1
14	Shaft For V-Seal A-B	NBR	FMK-100-14	1
15	Duster V-Seal A-B	NBR	FMK-100-15	2
16	Stud	M.S.	FMK-100-16	4
17	Spring Washer	M.S.	FMK-100-17	8
18	Nut For Stud	M.S.	FMK-100-18	8
19	Nut For Shaft	M.S.	FMK-100-19	1
20	Cushion Pin	Brass	FMK-100-20	2
21	O-Ring For Cushion Pin	M.S.	FMK-100-21	2
22	Bush For Cushion Pin	Nylon	FMK-100-22	2

B.Direction Control valve:- The hand lever operated direction control valve is basically a 5/3 dcv. It has 5 ports and three positions (forward, neutral and return) for controlling the flow of the fluid. The hoses are connected to the DCV by means of connectors. These are the devices which actually govern the direction to which the flow has to be sent. It has a spool inside it which reciprocates inside a finely finished bore. It opens and closes the ports by sliding action. To control the to and fro motion of a pneumatic cylinder, the air energy has to be regulated, controlled, and reversed with a predetermined sequence in a pneumatic system. Similarly one has to control the quantity of pressure and flow rate to generate desired level of force and speed of actuation.

To achieve these functions, valves are used to-

1. Start and stop pneumatic energy
2. Control the direction of flow of compressed air
3. Control the flow rate of the compressed air.

4. Control the pressure rating of the compressed air

Direction Control Valve:-

Category: - Hand Lever Operated Spool Type

Model: - 3ARMHLV-5-DHL-502

Body: - Aluminium Positions: - 3

Ports: - 5 Quantity: - 2

Specification Table:-

Sr. no.	Part Name	Material	Part No.	Qty.
1	Screw	Steel plated	3RMHLV5-01	1
2	Knob	Nylon	3RMHLV5-02	1
3	Bellows	Nylon	3RMHLV5-03	1
4	Handle	M.S.	3RMHLV5-04	1
5	Screw	Steel plated	3RMHLV5-05	4
6	Top cover	Al. press die cast	3RMHLV5-06	1
7	Cushioning pin	Brass	3RMHLV5-07	1
8	Delrin coller washer	Nylon	3RMHLV5-08	1
9	Body	Al. press die cast	3RMHLV5-09	1
10	T-Ring	NBR	3RMHLV5-10	6
11	Jali	Nylon	3RMHLV5-11	5
12	Spool	M.S.	3RMHLV5-12	1
13	Delrin coller	Nylon	3RMHLV5-13	1
14	End cover	Nylon	3RMHLV5-14	1
15	Screw	Steel plated	3RMHLV5-15	4

C. Pneumatic Fittings and Other Auxilliary Attachments: -

The compressed air is stored in an air receiver from which air is drawn out in to the consumer point by means of pipe line. While laying out the pipe line for the system, one should take sufficient care and pay attention to see that the pressure drop from the generating point to the point of consumption remains as low as possible. For economical reason, it is always better if the total drop of pressure is kept limited to a maximum value of 0.1 Bar or even less.

The following factors are taken into account while selecting 1. pneumatic pipeline and other air- line installations:-

2. Pressure of compressed air in the lines.

3. Total flow rate per unit time through the line.

4. Permissible pressure drop in the line.

5. Types of tube material and types of line fitting.

6. Length and diameter of tube or other pipelines.

7. Working environment.

PNEUMATIC FITTINGS:-

1) Connector: -

The connector is basically used in order to connect the pneumatic hose to the actuator or to direction control valves. It acts as a coupling between the pneumatic components and hoses. It is finely finished steel components and have external threads on them which fit into the internal threads of the other component. They are so designed that they provide and air tight sealed attachment along with the hose. The another face of the connector is a press fit connector into which the hose is to be fitted.

2) SPLITTER:-

The figure shows the splitter element which is used when we have to divide a single hose supply into two opposite

directions. This element is incorporated when we have to provide supply to two pneumatic components at the same time from single compressor outlet tubing. It is basically a T-shaped plastic component having one inlet and two outlet ports.

3) HOSES:-

The hoses or the PU-tubes are the air pipelines which actually carry the pressurized air from the source to the area of application. They are made of synthetic fibre and are completely air tight sealed. They are the main transmission lines in the pneumatic circuit. These are flexible and hence can suit any type of circuit construction. They can therefore be used to supply the air to long distances from the source and hence widens the area of application.

4) FRL UNIT:-

The FRL unit is basically a three way three component element which contains three very important elements that are Filter, Regulator and lubricator. This unit is very important in case of pneumatic circuit as it provides conditioned supply of air to the entire circuit. Pneumatic circuit is not a self-lubricating system as like the hydraulic one, due to which a certain external arrangement has to be made to carry out lubrication. In this unit the filter cleans and filters the air and makes it free from the impurities and any other foreign matter. The regulator is basically a pressure regulating device with which we can vary the pressure of the air to be supplied to the circuit inspite of the compressor pressure. The lubricator mixes the lubricating oil with the air by means of the venturi action. In the throat region due to a sudden pressure drop the oil is sucked by the air and hence a mist mixture of oil and air is thus formed.

5) WHEELS:-In order to suit the basic travelling conditions for the model, we have installed the wheels which would approximately lead to a better support to our model and would perform the function of taking the model from one place to another. The wheels are mounted on the axle and each wheel is independent to rotate to itself. However when we take into consideration the actual farm conditions then these wheels do not prove to be up to the mark and hence we are planning to install new wheels further in future scope which would be selected by noting all the parameters and ground clearance.

D) Trolley:-

A trolley is a member which acts as a foundation for the entire assembly. It is basically a frame along with wheels and other supports. The trolley is made by joining together the mild steel L - Brackets. The L-Brackets are welded together by arc welding. The supports for handle are made by mild steel square rod which is welded to basic frame. The motive behind choosing a heavy material for the frame was that it should not get damage or broken while the crop uprooting action. The trolley is designed on the basis of actual frame condition and the distance between the crops. The trolley holds all the components on its position. The trolley being simple in construction it also proves to be very robust in design and also supports the entire assembly firmly.

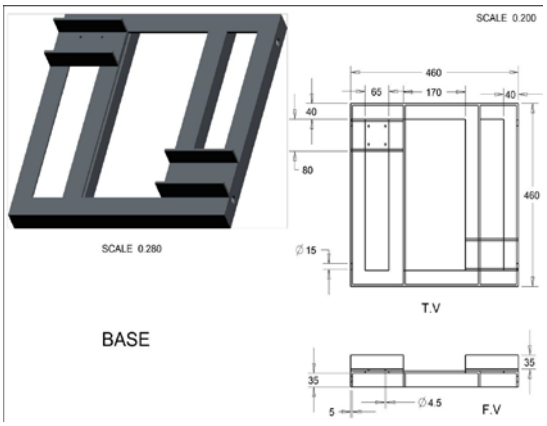
VI. MANUFACTURING PROCESS OF IMPORTANT COMPONENTS

Part Name: - Trolley

Raw Material: - Mild steel L- bracket & hollow square rod.

Quantity: - 01

Operation No.	Operation Description	Machine / Equipment	Tools	Time (min)
1	Measurement and Marking	Measuring Tape	---	15
2	Cutting	Cutter Machine	Wheel Cutter	20
3	Welding	Welding Machine	Welding Rod	20
4	Grinding	Grinding Machine	Grinding Wheel	05
5	Drilling	Drilling Machine	Drill bit	05

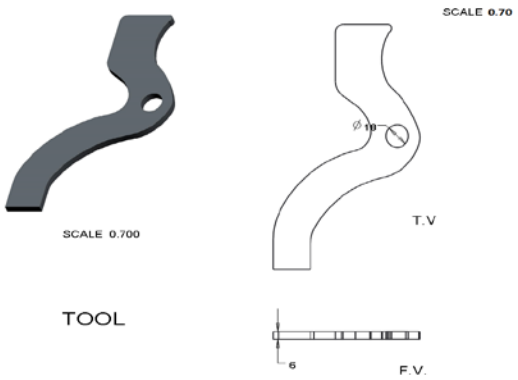


Part Name: - Crop holding tool

Raw Material: - Mild steel plate.

Quantity: - 01

Operation No.	Operation Description	Machine / Equipment	Tools	Time (min)
1	Marking of Profile	Marker	---	03
2	Pattern making	Sheet Metal cutting Scissor	Scissor blade	15
3	Gas cutting	Gas cutter machine	Oxy-Acetylene flame	15
4	Drilling	Drilling Machine	Drill bit	10
5	Grinding	Grinding Machine	Grinding wheel	05
6	Serration generating	Grinding machine	---	15



VII. WORKING OF MACHINE

The machine primarily runs on the compressor air supply. The compressor air supply can be controlled by means of flow control valve and regulator.

- First the compressor supplies the compressed air to the outlet hose. This pressure is then to be controlled by the flow control valve and the regulator in the FRL unit. The main hose is then divided into 2 supply lines by means of the splitter in order to give the supply to the main as well as the tool cylinder at the same time. Then the air reaches the cylinders accordingly by means of the hoses.

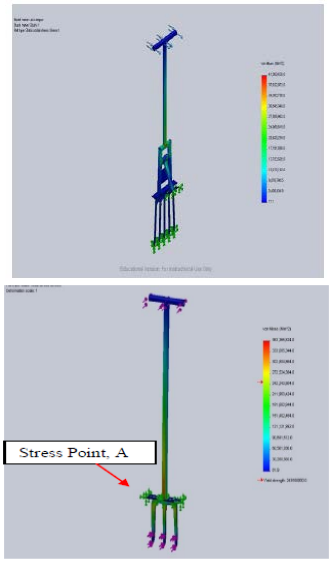
- The air when reaches the cylinders and then the further action are controlled by means of the direction control valves. The tool DCV is operated first. At this condition the lever is in lowered position. The tool is then opened by operating the DCV. After opening the tool, the machine is so adjusted that the stem of the crop comes in between the holding jaws of the tool. Then as the crop comes in the operating range then the tool is closed by engaging the next position of the DCV.

- After the tool is closed, then the lever cylinder is operated. The lever cylinder DCV is engaged at the first position and the forward stroke of the cylinder takes place due to which the lever connected to the cylinder piston is thus lifted up. And hence due to the force applied he crop held is uprooted.

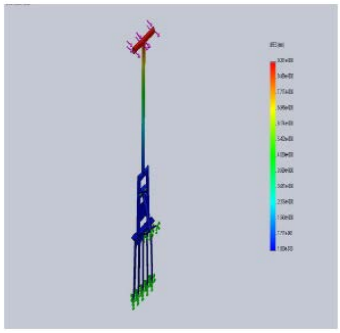
- As the crop after uprooting is still held in the tool, hence again the tool DCV is operated and another position is engaged and the tool is opened and the crop is released from the tool. Then the lever cylinder is subjected to the backward stroke and hence the lever is lowered.

VIII. SIMULATION AND ANALYSIS

Results of minimum and maximum stress, displacement and strain



a) straight b)Bend



c)Fulcrum

Type of Holding tool	Load	Stress		Displacement	
		Max	Min	Max	Min
Straight hold tool harvester	100	$1.02*10^8$	7852.28	37.9718	0
	150	$1.53*10^8$	12206.4	57.0185	0
	200	$2.03*10^8$	16305.4	76.0251	0
	250	$2.54*10^8$	20411.7	95.0154	0
	300	$3.04*10^8$	23662.3	113.993	0
	350	$3.54*10^8$	28794.7	132.914	0
	400	$4.04*10^8$	33012.6	151.8	0
	450	$4.54*10^8$	37337.7	170.634	0
	500	$5.03*10^8$	41664.8	189.403	0
	550	$5.52*10^8$	46081.3	208.103	0
	600	$6.00*10^8$	50561.8	226.717	0
Bend hold tool harvester	100	1.68E+08	764.509	34.2407	0
	150	2.54E+08	12206.4	52.0597	0
	200	3.39E+08	1220.01	69.6902	0
	250	4.24E+08	1530.44	87.440	0
	300	5.12E+08	1931.85	105.291	0
	350	5.98E+08	2299.15	123.23	0
	400	4.04E+08	33012.6	151.8	0
	450	4.54E+08	37337.7	170.634	0
	500	8.58E+08	3286.47	177.423	0
	550	9.44E+08	3621.72	195.558	0
	600	5.98E+08	2299.15	226.717	0
Fulcrum hold tool harvester	100	4.13E+07	71.1018	2.64591	0
	150	6.19E+07	105.897	3.96887	0
	200	8.25E+07	142.204	5.29182	0
	250	1.03E+08	194.832	6.61478	0
	300	1.24E+08	211.795	7.93773	0
	350	1.43E+08	290.573	9.2606	0
	400	1.65E+08	284.407	10.5832	0
	450	1.86E+08	342.811	11.9066	0
	500	2.06E+08	389.664	13.2296	0
	550	2.27E+08	391.414	14.5525	0
	600	2.48E+08	423.589	15.8755	0

IX. REVIEW FROM FARMERS ABOUT PROJECT

The experience of farmers who have seen the experiment of machine is excellent in their opinion.

"The machine comes to rescue of the farmers particularly at the time scarcity of farm labours." Said Mr. Sudhir Lahare, Rahata (Wakadi)

"Due the use of the machine, the work get completed quickly and economically compared with as completed by tedious manual efforts." Said Mr. Keshav Dandage, Ahmednagar.

"The machine is easy to operate and hence may be preferred by all the farmers." Said Mrs. Nimubai Fartale, Wadali (Nandgaon)

As there are various futuristic scopes for the same machine, according to the requirements, certain modifications can be introduced and hence it's a multipurpose machine.

X. CONCLUSION

We have tried our best to introduce a machine which would uproot the crops like pigeon peas, cotton crop and all other crops that may have the same stem size suitable for our tool, completely from the soil.This machine of ours proves to be very beneficial in the case when a farm worker has to uproot all the crops spread over acres of land. This machine does not bring any sort of fatigue to the worker. This machine was introduced on a trial and error basis. This is also a new idea of incorporating the power of pneumatics for the purpose of uprooting the crops. It has been a wonderful experience bringing our thoughts, ideas and concept into reality. We are looking forward to develop the concept to a larger extent and to overcome the certain disadvantages it has. Our project was a complete addition of pneumatic power and mechanical linkages to transmit the same. It also includes the proper selection of various dimensions of the components to be used. Our project is merely a basic model of what it can transform to after all the modifications that can be incorporated into it according the various applications. We came across many new concepts and got to learn really more of what we learned in our curriculum. It was really a challenging task and we were successful in overcoming all the hardships and problems we faced on the account of sincere team effort and co-ordination. This project of ours was an initiative in order to reduce the human effort to all possible ways by providing easier way. The reviews we got from farmers were really very encouraging and helpful. We really hope that this effort of ours surely proves to be a helping hand in every field of application it shall be incorporated.

XI. FUTURE SCOPE AND FURTHER MODIFICATION

As most of the processes on the farm are carried out manually, there is an extreme scope to automation in agriculture. This particular pneumatic crop plucking machine as, been made very first time, has many areas to develop. This machine we made plucks only one crop at a time in one complete cycle but more than one crop can also be plucked in one cycle if multiple actuators and tools used, leading to greater time saving. Also the very first step of grabbing the stem can be simplified by using certain mechanisms like star wheel mechanism which will eliminate the difficulty in grabbing the stem by providing the forward or backward movement of tool.

Also this machine can be used as multipurpose machine by simply changing the tool. This machine is now made to grab and pluck the crop but certain changes in the shape and design of the tool will allow the same for cutting purpose also, because there are many crops in agriculture which have to be cut rather to be plucked. This machine can be made more compact and lesser in weight by using comparatively compact portable compressor. Advance of

Machine on the irregular surface of farm can also be improved by using tougher, rigid & comparatively bigger wheels.

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