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Covering and Uncovering Mechanisms for Polyhouse Roof Using Arduino

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Abstract – Polyhouse used to take crop production under protected cultivation or protected farming. Polyhouse partially allows sun rays reach to crop taken in polyhouse. It also increases production by creating Green House effect using the carbon dioxide release by crop during night. After every season end farmers need to remove shade of polyhouse for soil conditioning manually this required a lot of skilled labor's also this method is time consuming and costly at it have to pay labor's every time the shade removed and installed, it's highly dependable on availability of skilled labor's and the height on which labor are working to remove the shade at the end of every crop season. This affect the planting period of next crop to take in polyhouse by delaying it. The same problem is also faced during reinstallation of polyhouse roof after soil conditioning. The aim of this research is to prepare feasible polyhouse which can utilized to take every crop in it by adjusting it's roof.

Key Words: polyhouse, retractable roof, Arduino, roll-up mechanism, sliding mechanism. Folding mechanism.

1. INTRODUCTION

Precision farming is generally defined as information and technology based farm management system to detect analysis and achieve changeability within fields for optimum profitability, sustainability and defense of the land resource. Precision farming is concerned more with handling small areas within fields rather than on the fields itself and believes that the farmer who efficiently uses information earns higher returns than those who do not. However in the Indian Context with its severe land fragmentation precision farming has to do more with the precise application of agricultural inputs based on, weather and crop requirement to maximize sustainable productivity, quality and profitability.

Polyhouse is one technique of precision farming on a minor scale where plant safeguard and fertigation are accurate at the root area and plants are grown in defined conditions of temperature and humidity for consistency and maximization of yield.

Fig -1: Polyhouse

2. CLASSIFICATION OF POLYHOUSE

Polyhouse structure of various types is used for crop production. The different types of polyhouses based on shape, utility, material and construction are briefly given below:

2.1 Polyhouse Type Based On Shape:

Polyhouses can be classified based on their shape or style. For the purpose of classification, the uniqueness of the cross section of the polyhouses can be considered as a factor.

A. Lean-to type polyhouse

A lean-to design is used when a polyhouse is placed against the side of an existing building. It is built against a building, using the existing structure for one or more of its sides. It is usually attached to a house, but may be attached to other buildings. The roof of the building is extended with appropriate covering material and the area is properly enclosed. It is typically facing south side.

B. Even span type polyhouse

The even-span is the standard type and full-size structure, the two roof slopes are of equal pitch and width .This design is used for the polyhouse of small size, and it is constructed on l ground level. It is attached to a house at one gable end.

C. Uneven span type polyhouse

This type of polyhouse is constructed on hilly terrain. The roofs are of unequal width; make the structure adaptable to the side slopes of hill. This type of polyhouse is seldom used now-a-days as it is not adaptable for automation.

D. Ridge and furrow type polyhouse

Designs of this type use two or more A-frame polyhouses connected to one another along the length of the eave. The eave serves as furrow or gutter to carry rain and melted snow away. The side wall is eliminated between the polyhouse, which results in a structure with a single large interior.

E. Saw tooth type polyhouse

These are also similar to ridge and furrow type polyhouses accept that, there is provision for natural ventilation in this type. Specific natural ventilation flow path.

F. Quonset polyhouse

This is a polyhouse, where the pipe arches or trusses are supported by pipe purling running along the length of the polyhouse. In general, the covering material used for this type of polyhouses is polyethylene.

2.2 Polyhouse Type Based On Utility:

Classification of polyhouse can be made depending on the functions or utilities of the different utilities, artificial cooling and heating of the greenhouse are more expensive and elaborate. Hence based on the artificial cooling and heating, are classified as polyhouses for active heating and active cooling system.

A. Polyhouses for active heating

During the night time, air temperature inside polyhouse decreases. To avoid the cold bite to plants due to freezing, some amount of heat has to be supplied. The requirements for heating polyhouse depend on the rate at which the heat is lost to the outside environment. Various methods are adopted to reduce the heat losses, viz., using double layer polyethylene, thermo pane glasses (Two layers of factory sealed glass with dead air space) or to use heating systems, such as unit heaters, central heat, radiant heat and solar heating system.

B. Polyhouse for active cooling

During summer season, it is desirable to reduce the temperatures of polyhouse than the ambient temperatures, for effective crop growth. Hence suitable modifications are made in the polyhouse so that large volumes of cooled air is drawn into polyhouse, This type of polyhouse either consists of evaporative cooling pad with fan or fog cooling. This polyhouse is designed in such a way that it permits a roof opening of 40% and in some cases nearly 100%

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2.3 Polyhouse Type Based On Construction:

The type of construction is predominantly influenced by the structural material, though the covering material also influences the type. Span of the house inuring dictates the selection of structural members and their construction. Higher the span, stronger should be the material and more structural members are used to make sturdy truss type frames. For smaller spans, simpler designs like hoops can be followed. Therefore based on construction, polyhouses can be broadly classified as wooden framed, pipe framed and truss framed structures.

A. Wooden framed structures

In general, for the greenhouses with span less than 6 m, only wooden framed structures are used. Side posts and columns are constructed of wood without the use of a truss. Pine wood is commonly used as it is inexpensive and possesses the required strength. Timber locally available, with good strength, durability and machinability also can be used for the construction.

B. Pipe framed structures

Pipes are used for construction of greenhouses, when the clear span is around 12 m. In general, the side posts, columns, cross ties and purlins are constructed using pipes. In this type, the trusses are not used.

C. Truss framed structures

If the greenhouse span is greater than or equal to 15m, truss frames are used. Flat steel, tubular steel or angular iron is welded together to form a truss encompassing rafters, chords and struts. Struts are support members under compression and chords are support members under tension. Angle iron purlins running throughout the length of polyhouse are bolted to each truss. Columns are used only in very wide truss frame houses of 21.3 m or

more. Most of the glass houses are of truss frame type, as these frames are best suited for pre-fabrication.

D. Computerised Polyhouse

In general farmers prefer the manually Controlled System or Semi-Automatic Controlled System because of low investment. However, Manual systems require a lot of attention and care and are very difficult and cumbersome to maintain uniform environment inside the polyhouse. Ultimately this affects crop production and results in non-uniform growth and low quality of the crop. The Computerized Control System provides a faster and more precise operation in the polyhouse and also stores, displays and prints the polyhouse information as needed. In addition, computer can perform the required operations as per a pre-scheduled programme.

3. COMPONENTS AND MATERIAL

The following components are utilized in designing of mechanism for covering and uncovering of polyhouse roof.

3.1 High-density polyethylene (HDPE)

The high-density polyethylene (HDPE) is used to cover roof and walls of polyhouse. The HDPE have high yield strength, also it's not reactive to many chemicals used in agriculture land, it's partially allow sun rays, we used 250gause HDPE sheet. This provide protection from various insects and pest and hence the crop also get protection against insects and pests in polyhouse without using any chemical or spray.

Fig-2: High-Density polyethylene sheet

3.2 Low-density polyethylene (LDPE)

The Low-density polyethylene (LDPE) is used in polyhouse from the underground to the height of 1-1.5 meter according to the crops height. The LDPE helps to carbon dioxide (CO_2) to create greenhouse effect as carbon dioxide is released by plant at night and this can utilize by plant in daytime for photosynthesis process and hence the productivity increases in polyhouse.

Fig -3: Low-Density polyethylene sheet

3.3 Carpet net

The net provide extra protection to polyhouse from heavy rainfall, hailstorm, cyclone and heavy wind also it doesn't allow any insects or objects to damage the HDPE and LDPE. It's having good strength and durability to protect polyhouse.

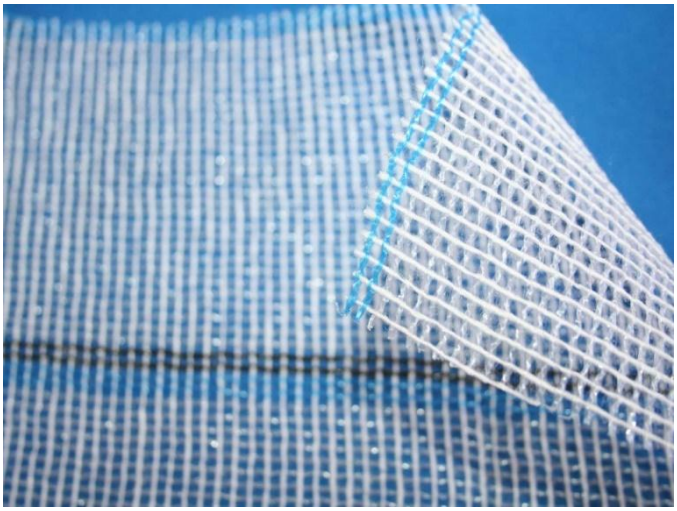


Fig-4: Carpet Net

3.4 G.I. Pipes

Galvanized Iron/Steel pipes are used in modern polyhouse to provide strength to polyhouse in extreme weather conditions like cyclone and heavy wind. The G.I. pipes are available in various diameter, thickness and length which can be utilized to construct polyhouse structure and also this pipes are durable for 20-30 years even in corrosive environment. We can choose standard pipe according to our polyhouse type, crop, geographical condition and government norms.

Fig-5: G. I. pipes

3.5 D.C. Motor

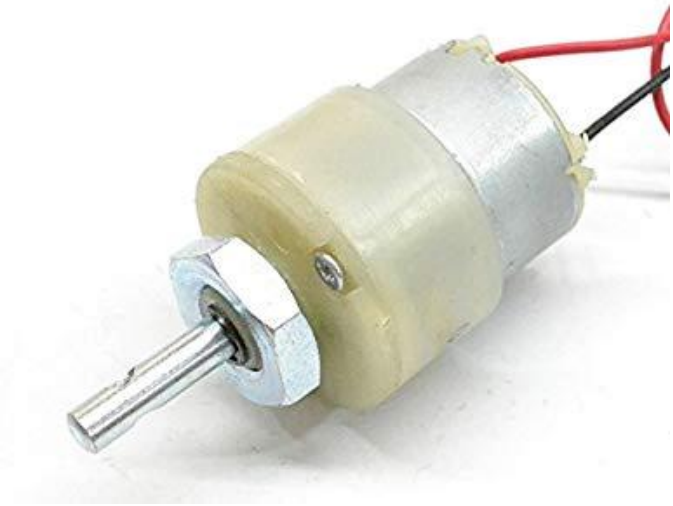


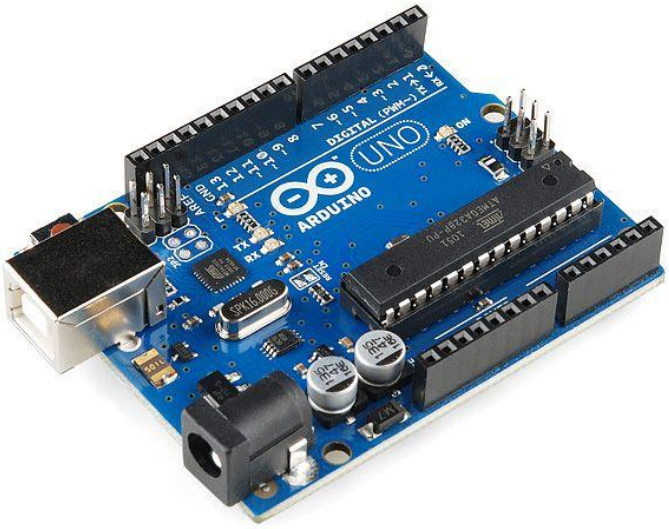
Fig-6: DC Motor

The D.C. geared motor runs on DC supply which insure safety of any living being from shock even if the current supply get damaged. The DC motors used here are low RPM high torque motors which provide moderate speed and high torque and power to upcoming the resistance or friction against the roof sheet and strips.

3.6 Arduino UNO

The Arduino UNO belongs to ATmega family and it's can be utilize for to control physical/mechanical objects. It's having features to reprogram it also it can be compiled with others hardware like RF module, SIM module, Bluetooth module and much more to operate it from distance.

Fig-7: Arduino UNO



4. MECHANISM

For covering and uncovering of polyhouse we designed and tried six different mechanism on the basis of reverse engineering, from that we decided to fabricate roll-up mechanism with two DC motor and different voltage input with a working prototype model.

4.1 Retractable Roof for polyhouse

A. Construction:

A pair of C-stud channel is fixed over the beam of polyhouse in such a way that the opening ends will be opposite to each other. A pair of bearing is also installed into the pair of C-stud and joined with a pipe

fixed at inner diameter of bearings. This arrangement helps the pipe to travel in a fixed path without creating any disturbance to the mechanism. Now, a pair of pipe is fixed perpendicularly over the bearing connecting pipe with the help of welding. The both pipe are separated with little distance such that another pipe can move freely from that space between them.

A small piece of pipe is added over diameter of connecting pipe such that it can rotate and move freely over it radially. This piece is added in between the gap of previous perpendicularly welded pipe and another pipe is fixed over the small piece of pipe with the help of welding. The small piece is lubricated so that it can rotate in different direction than connecting pipe freely.

The bearing distance covers the length of mechanism and the X number of perpendicular welded pipe covers the surface length of polyhouse when pin jointed.

Ex. - if the curved/surface length of polyhouse is 70 ft. and each pin jointed member covers 10 ft. of surface length then,

Number of member needed (X) = curved-surface length of polyhouse/ pin jointed member length

X= 70/10

X=7 pin jointed members are required to cover the entire surface of polyhouse.

B. Working

The last connecting pipe is fixed at the one end of polyhouse and having only two vertically welded pipe (i.e. single member is absent). Each conjugative connecting pipe members are connected to each other in such a way that, each pair of vertically welded pipe is pin jointed with another member vertically welded single pipe.

At the pin joint of member single pipe having a locking mechanism such that it lock the mechanism when it opened at certain angle (approx. 180 degree) this mechanism also contain a horizontally fixed pipe to support the roof of polyhouse over the entire length of polyhouse section, i.e. the connecting pipe and supporting pipes both are of same length.

The additional bearing (exceptionally small) attached over connecting pipe near to the C-stud and it having arrangement such that a rope/cable can be passed through it freely. Only the last connecting pipe at free end is having fixed position on rope/cable such that the knot is tie at both end of the connecting pipe.

A rope/cable is fixed with an electric motor and pulley over the breadth of polyhouse. When electric motor rotate in one direction the rope is pulled so the connecting pipe at free end also get polled with the rope/cable as I having fixed position over it and all other adjacent connecting pipe are also get pulled simultaneously with the help of pin joint member assembly and the roof is covered.

In the uncovering arrangement the rope pull the connecting pipe from the fixed end (i.e. electric motor rotating in opposite direction). The each connecting pipe get near to each other and the pin jointed member assembly contracts simultaneously so the entire roof get uncovered and collected at one end of polyhouse.

Length required to collect roof in its uncovering position,

L=XDB

Where,

L= compact length of roof,

X= number of pin jointed member and

DB= outer diameter of bearing.

4.2 Roman Shade - Roof For Polyhouse

A. Construction

A C-Stud cannel is fixed over the beam of polyhouse facing away from ground. A pipe strip connected with bearing added to this channel such that the channel works as a guideway for a bearing. The curtain/polythene of roof is folded such a way that it from a fixed breath in stair types of fold. A small ring is connected at each down end so that the rope can pass through it and support the mechanism. A pulley is attached at the one end and electric motor on another end. The rope is tied at the strip/pipe connected with bearing and rope/ cable is also passing through each ring connected to roof polythene.

B. Working

When the electric motor revolve in one direction the rope pulls the strip/pipe and the mechanism covers the polyhouse and when electrical motor revolve in another direction the rope pulls the strip form fixed end and hence the roof is uncovered and the mechanism is connected at one end of polyhouse. This mechanism is useful when polyhouse in opening in small sections the polythene of roof is fixed at the fix end of polyhouse.

Length required to collect roof in uncovering position

L = x*W+Ls

Where,

L= Compact length of roof

x= No of folds

W= Width of polythene

Ls = Length of strip

If the roof is 72ft & our mechanism having each fold of 15cm (i.e. 0.5ft) so number of folds required,

X= 140 folds are required to cover the roof.

4.3 Roll-Up Shade Using Rotating Drum For Polyhouse

A. construction

A cylindrical rotating drum is fixed at the one end of polythene end of polyhouse the drum having threading at both end to fix a rope/cable over it. The drum is used to roll-up the polythene of polyhouse roof. The polythene is roll-up over drum and one end is fixed over it and another is fixed over a strip. The strip having a bearing attached to it which travelling through a channel made of C-Stud which is fixed over the beam and tie with rope/cable. A pulley is attached at one end and electric motor to another end.

B. Working

When electric motor rotate it pull the rope and hence it pull the strip and also rotate the drum and the polythene get covered over the roof. when electric motor rotate in reverse direction the rope/cable pull the strip from drum side and rotate the drum in opposite direction and hence the roof polythene get rolled-up over the drum hence uncovering the polyhouse roof. This mechanism is only useful for small length of polyhouse as the rolling up increase the diameter of drum with wrapping polythene around it and the rope do not have such phenomenon so when it applied for large length area it may create some disturbance to mechanism.

4.4 Roll-Up Shade Using Torsional Spring For Polyhouse

A. Construction

A C-Stud Channel is fixed over the beam of polyhouse and a pair of a bearing is connected with the pipe into its inner diameter. A special purpose design torsional spring is connected at one end in a rigid shaft the spring is fixed over the shaft at one end. Another end is connected to a metallic plate which is connected to the hexagonal drum around the shaft. The drum is fixed with ball bearing so it can rotate around the spring and with each rotation it apply pressure over the spring.

According the spring it can have two types

a) Compressing spring type

b) Expanding spring type

The both are having same effect over the rotation of drum. The polythene of polyhouse is either roll-up over the drum with torsional spring or it may roll-up over the drum connected with electrical motor. Another drum having rope/cable roll-up over it. The roll/cable is connected to strip/pipe and hence to the polythene as the polythene cannot take a load of the torsional spring the polythene is joined with rope/cable so the entire load will be on the rope and not on the polythene sheet.

B. Working

When the high torque electrical motor rotate the rope will get rolling up over the drum and hence it apply pull force over the strip and hence the rope/cable and polythene as the pull force is greater than the spring resistance force the pull force rotate the drum with torsional spring and hence the potential energy is stored into the spring and the polyhouse get

covered and when the high torque electrical motor rotates opposite direction i.e. to uncover the polyhouse the release of potential energy from spring started which rotate the spring drum in opposite direction and the roof is uncovered.

4.5 Roll-Up Mechanism Using Stepper Motor

A Stepper motor is utilized to provide precision rotational angle to the mechanism both motors connected to the drum one containing the rope/cable rolled-up over it which another contain the polyhouse roof sheet. The strip with two ball bearing travelling through the C-Stud channel which is fixed over the beam of polyhouse is attached to the rope and polythene sheet also the sheet is joined with rope to sustain the load of the electric motor. The both motors are controlled with the microcomputer respectively its Arduino UNO R3 both stepper motor having different programmer installed to microcomputers for covering and uncovering mechanism the one having incremental programming which covering is having decremented programming while uncovering and vice -versa for another stepper motor.

4.6 Roll-Up Mechanism Using DC Motor and Different Voltage Input

A. Construction

A DC motor works of DC input. The difference in potential difference/ voltage can affect the speed of DC motor. Using this phenomenon we constructed a mechanism for covering and uncovering of polyhouse roof. The basic design was same the roof sheet is rolled over a drum from one side and from another side the strips attached to polyhouse roof sheet and drum. A stabilizer is needed for constant current supply so that we can vary the potential difference and hence the speed of DC motors for that we can use Microcomputers like Arduino UNO R3 and the constant current supply.

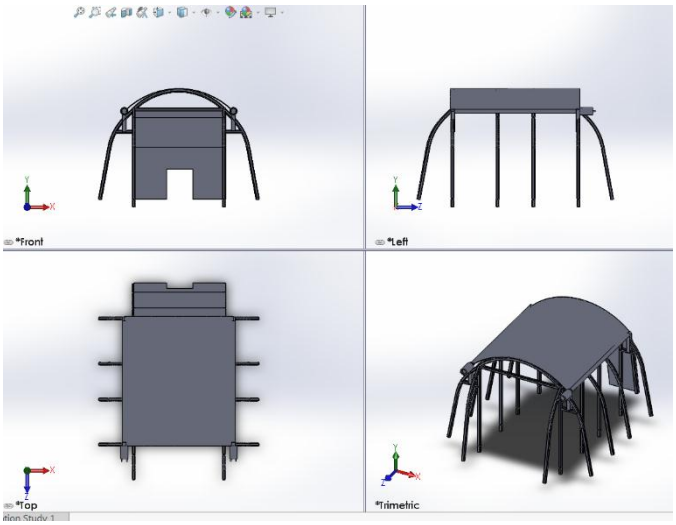
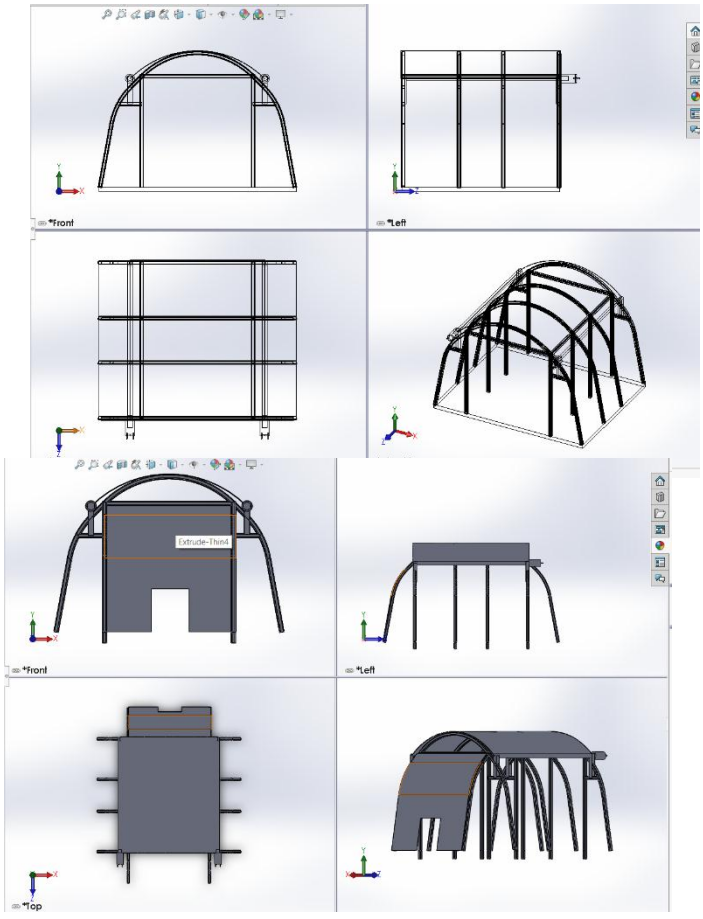
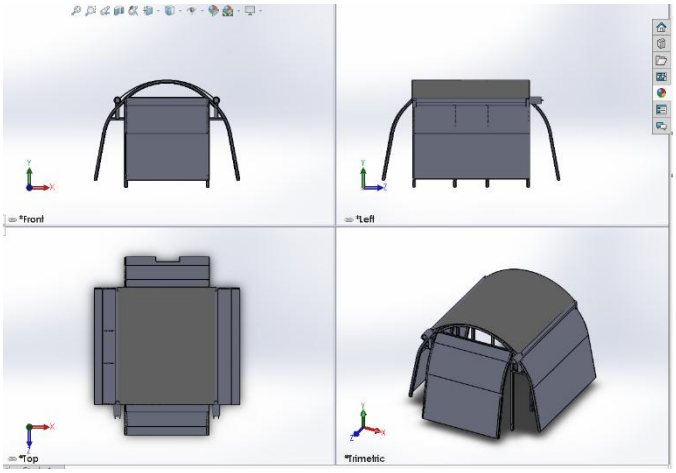


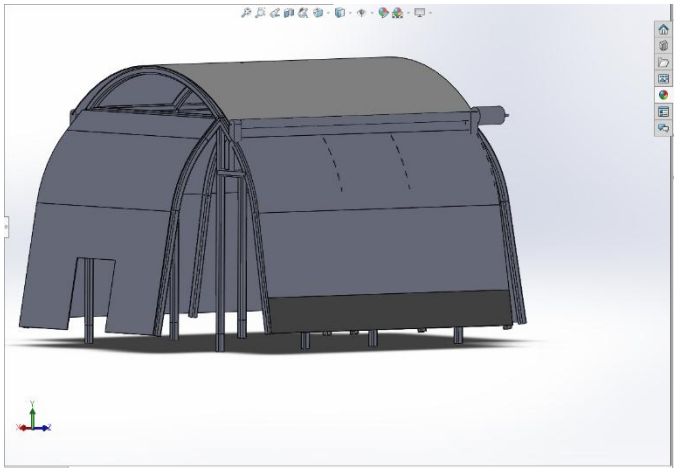
Fig-8: Different Views of Prototype's Frame Structure



(a) Installation of Roof



(b) Installation of wall with door of polyhouse



(c) Installation of side wall covering

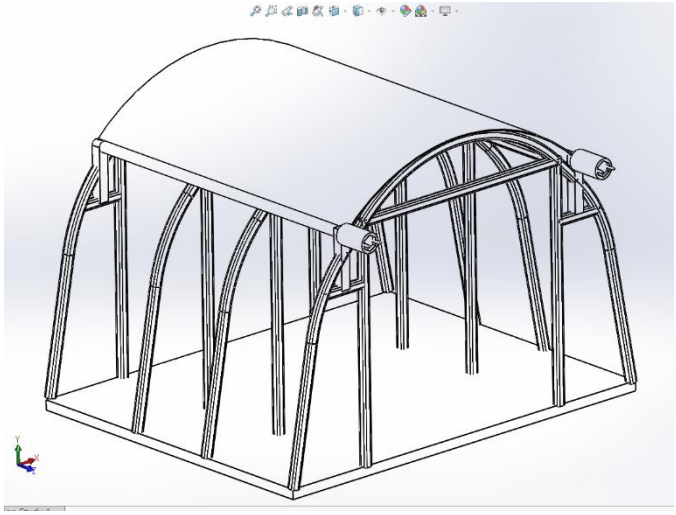


Fig-9: Different steps of constructing prototype in CAD software

(a) With Side Covering and Roof

(b) With Only Roll-Up Shade Mechanism

Fig-10: Trimetric View of Prototype in CAD software

B. Working

The DC motor having the more RPM if potential difference/voltage is more and the RPM is less when potential difference/voltage is less. If we providing a constant power supply to both DC motors the both revolve with same speed but if we change in millivolts the speed also varies i.e. increase or decrease with increase and decrease of voltage in millivolts. For short distance it's not necessary to provide any difference in voltage but if we need to cover larger area we must go for the difference in voltage so that the sheet covers the roof in proper manner and also it get rolled without any wearing and tearing. The difference in speed is important to avoid any damage to roof sheet because of continues change in diameter of rolling drum with roof sheet and strips while covering and uncovering of shade. A strips/rope can be chosen according to the gauge of roof sheet which provide proper strength to the roof sheet.

5. ADVANTAGES

•The resulted polyhouse can be utilized to take alternate crops to insure soil maintain it's fertility.

•The resulted polyhouse can be utilized to take polyhouse crops and non-polyhouse crops both using this uncovering mechanism.

•The sun rays can reach to the soil and helps in soil conditioning and hence no need to change the soil of polyhouse after certain duration.

•This mechanism save time by opening and closing polyhouse shade mechanically traditionally it is done by manual way need more time.

•It reduces worker life risk in manual way they need to work at height of polyhouse that is too risky

•Easy to operate whole system can be operated by remote that enable to operate it from distance too

•Automation made work too easy and fast

•It doesn't required skilled labour to operate it is too simple

•Higher productivity resulting in increased yield and provides the better growing environment for plants.

•Minimum labor requirement and hence labor cost is reduced.

•This mechanism is design to allow growers in warm and hot climates to have the best of both the open field and the closed greenhouse.

•When growing in the open field with no roof the yield, quality and timing is reduced.

•Agricultural and horticultural crop production schedules can be follow to take advantage of the market needs without delay.

6. DISADVANTAGES

•The initial cost of this system is high compare to traditional polyhouse.

•It required regular inspection.

7. RESULT AND DISCUSSION

In This project we added mechanism of covering and uncovering of polyhouse roof by rolling mechanism. We created prototype of original polyhouse and it is satisfying the aim of project to roll up cover of polyhouse. It is completely remotely operated by radio frequency using Arduino Uno. The project work shows good and expected result.

Even if this project work showing expected result to cover and uncover of polyhouse in prototype for large structure we required high power motor and it is discuss to make structure more flexible and automated and provide external power supply with help of solar energy .

Fig-11: Method of Installation and removing of roof of polyhouse using labours

8. CONCLUSIONS

It is more sophisticated method to cover and uncover shade of polyhouse manually. This project with help of mechanism covering and uncovering of roof sheet is done mechanically. Which reduces time required for shade covering and uncovering .This project work thus fabricated displays good and expected result. . After working on few future modifications this project could do good performance. This project will save time and increase profit in production.

9. FUTURE SCOPE

Fig-12: Polytunnel

The global market for smart polyhouse is foreseen to observe promising development all through the coming years. The rising ubiquity of the technology is anticipated to support market development in the coming years. Additionally, the utilization of smart polyhouse innovation helps essentially in expanding the yield and productivity of solar and floating controlled polyhouse.

9.1 Futuristic Modifications:

The project can be modified further on following points
•By use of solar panel we can generate electricity required for the working of the polyhouse.
•Height of polyhouse can be adjusted according to height of plants by using hydraulics operated cylinder.

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