EasyChair Preprint
№ 7238

A Review on Techno-Economical Polyhouse

Manisha Gurwani, Sachin Untawale, Santosh Jaju and
Arvind Bodhe

December 17, 2021

A REVIEW ON TECNO ECONOMICAL POLYHOUSE

Ms. Manisha Gurwani[#1]Dr.Sachin Untawale[#2],Dr.Santosh Jaju[#3],Dr.Arvind Bodhe[#4]

[1]*Student , Department of Mechanical Engineering ,G.H.R.C.E Nagpur,manishagurwani4@gmail.com*

[2]*Director Department of Mechanical Engineering ,G.H.R.C.E Nagpur,sachin.untawale@raisoni.net*

[3]*Dean ,Department of Mechanical Engineering ,G.H.R.C.E Nagpur,santosh.jaju@raisoni.net*

[4]*Dean,Department of Mechanical Engineering ,G.H.R.U Saikheda ,arvind.bodhe@ghru.edu.in*

ABSTRACT :

Considering the increasing demand for food, to meet with this demand, a better and developed farming culture, protected cultivation called as polyhouse farming has been used in recent times .Polyhouse is basically a house-type structure whose structure is made with G.I pipes and it is covered with polyethylene .In this paper, we have deliberated different structures of polyhouse according to different climatic conditions. Also, we have studied different materials alternatives for structure as well as cover. Different approaches for improving the efficiency of polyhouses have also been studied .In this paper, we have also studied the use of IoT in polyhouses. Here , we have also studied how to reduce the cost of polyhouse.

Keywords – Polyhouse, design , IoT , material , cost.

I. INTRODUCTION :

With the growing population, the need for food is increasing, which can only be fulfilled only by increasing the quantity as well as quality of crops. So, to overcome this problem, protected cultivation was used .The protected cultivation technology is known as polyhouse technology. It is a place where the environment is controlled according to the needs of the plants grown inside. Polyhouse is a frame structure of G.I or M.S pipe which is covered with a transparent material, i.e. Polyethene .Polyhouses helps to reduce the dependency on rainfall.

Considering the changing weather conditions, different facilities are needed to be provided. In summer season , due to increased temperature techniques for lowering the temperature should be used. Techniques for boosting temperature should be implemented throughout the winter season due to the low temperature. Moisture, soil and air temperature, conductivity, illumination, and carbon dioxide concentration are all elements that influence the growth of crops. So, to have control over these factors, different sensors , controllers, foggers , exhaust etc. can be used.

With the increasing advancements in technology, automated polyhouses can be designed . Polyhouse connected through internet can be developed. With the recent advancements, the Internet, the Wireless Sensor Network (WSN) and Geographic Information Systems (GIS), are new precision agriculture technologies being used . In which even in the absence of the human in polyhouse , everything can be controlled by using an app.

Fig 1. Polyhouse

II. POLYHOUSE BASED ON DIFFERENT FACTORS :

A. Design and structure :

Lovepreet Singh, Arun Kaushal and Amritpal Digra have published a paper [1] in which polyhouse stability designs are analyzed for different types of loads like dead, snow, live, wind and load combination. Loads were calculated by adopting different National Standards. Indore Navnath ,S. J. Kale ,Akoon A.B.,R .K .Singh and Harmehar Singh published a paper [2] in which different greenhouse designs, Quonset, walk-in tunnel, gothic and double-arc, single span and multi-span were analyzed for different types of loads like dead, live, wind and snow load. Rack-woo Kim, In-bok Lee, Uk-hyeon Yeo, Sang-yeon Lee [3] have studied procedures to determine the load of wind of greenhouse designs which may lead to establishing newly modified greenhouse design standards . Then, using experimental data, a structural analysis was performed, whose results led to the greenhouse's structural safety . S. Revathi , N. Sivakumaran, T.K. Radhakrishnan [4] proposed a study in which the system is designed to provide fresh air in consent with the standards of environment such that energy is used properly. The results of the trials demonstrate that the greenhouse meets the requirements of plants in terms where temperature balance. Also, energy is saved.

B. Materials of structure and cover :

V .K .Verma ,Tejkaran Singh Chawla ,Manas Adhikari, Rajat Sella published a study [5] in which Polyvinyl Chloride tubes are used as column .This supplies the structure with the necessary protection from various toxins found in the soil. Meng-Hao Tsai 1, Ying Chieh Lee[6] have completed a study in which they developed a composite plastic material (Nylon + recycled Polyethylene terephthalate (PET) + glass fiber reinforced Nylon). The greenhouse was built using composite plastic panels with a 5 mm wall thickness. The greenhouse made of composite plastic can have a damping ratio of 6.2 % while the traditional greenhouses which are made of galvanized steel have 2 % damping .D. Briassoulis , E. Schettini [7] has worked on a study in they investigated the mechanical properties of low-density polyethylene (LDPE) films under various pretension and uniform pressure schemes. The finite element analysis (FEA) was then used to investigate it both experimentally and numerically. In the linear elastic region, the testing were found in the favor of the selected ANSYS membrane element as well as the Reformulated Four Node Shell (RFNS) element. Within the linear elastic range, the mechanical behavior of both the films were reproduced satisfactorily.

C. Economy:

Prakash, Pramod Kumar, Prabhat Kishore, D. Jaganathan and Sheela Immanuel [8] have published papers in which the goal of the research was to find out the economic feasibility of polyhouse establishment with and without subsidy support. Gross and net returns were calculated to determine the profitability of gerbera grown under protected systems. The feasibility analysis showed that without subsidy support, gerbera cultivation under polyhouse is sustainably feasible, but the payback period is longer compared to with subsidy support.R.K.Yadav, P.Kalia, H. Choudhary, Zakir Husain and BrihamaDev has published a paper [9] in which off-season nursery production was proven to be lucrative in a low cost polyhouse of 50 sq.m , and production of off seasonal vegetables which are high valued was discovered to be successful for effectively producing vegetables over the winter in low cost polyhouse.
G.Rajendra ,K.Sushanth ,K .Mithun ,B .Devender ,D .Raju ,K .Anoosha [10] has proposed a paper in which they have installed a low cost polyhouse. The cost of polyhouse was reduced by using nearby available locally casuarina wood, which was coated with coal tar so that wood doesn't get degraded, which was used as structural material in designing of polyhouse . Frame work was made using Bamboos and Outer cover was made of UV stabilized PVC transparent sheet for polyhouse. Shanhong Zhang, Yu Guo, Huajian Zhao ,Yang Wang, and David Chow [11] have published a paper in which the control strategies were used for improving energy

efficiency in agricultural greenhouses. The different types of control strategies have been used such as Controlled parameters, Control Components, Control mode, Controller, and Control algorithm. Different methodologies of control strategies applied are Mathematical modelling study, physical experimental study ,numerical simulations, Parametric sensitivity study, Control Performance.

D. *Energy generation and distribution* :

Mridul Khanna, Richa Patro, Sakshi Mahanoori, Saptarshi Roy Chowdhury, Vikramsinh Patil, Varun Miglani [12] have published paper , the paper identifies the factors affecting farm productivity. .Saud Ghani, Foteini Bakochristou, Esmail Mohamed Ali Ahmed ElBialy1, Seifelislam Mahmoud Ahmad Gamaledin, Mohammed Rashwan, Ayman Mohamed Abdelhalim, Salman Mohammad Ismail [13] proposed a study in which effective greenhouse systems, such as natural as well as forced ventilation, fogging systems and evaporative cooling were investigated in order to control climate conditions and temperature in hot and arid areas. It was also suggested that roof and side walls openings should be provided for natural ventilation; equipped nests should also be provided with that to provide protection from insects and additional shading mechanism should also be provided to maintain temperature. For countries where high summer temperatures are observed, greenhouse shading should be supplemented with white painted roofs . It is also supplemented with an external black shading net which reduces PAR. Internal aluminized screens are also provided to prevent insects from entering.

Itigi Prabhakar, K Vijayaragavan, Premlata Singh, Balraj Singh, Janakiram, B L Manjunatha, Seema Jaggi and I Sekar[14] has published a paper in which Environmental constraints, Labor related constraints, Marketing constraints, Strategies were used to expedite the rate of adoption of polyhouse technology were implemented . Hao Wanga, Maoyuan Zhanga, Ze Yanga, Zhaozheng Wanga, Xu Liua, Yijia Lua, Linhong Jia,, Zhong Lin Wangd, Jia Chenga [15] have presented a study in which different types of energies were generated by means of greenhouse film. CST-Greenhouse is an iconic arched shaped greenhouse which can vibrate symmetrically, constituting a contact separation mode TENG. When Greenhouse Energy is combined with greenhouses, a lower transmission loss is observed, which is a distributed energy source, which means it can be used in irrigation.

E. *Algorithms / apps to develop model :*

Andrea Costantino, Lorenzo Combac, Giacomo Sicardie, Mauro Barianie, Enrico Fabrizioa [16] has presented the model which is used in the operation of the systems . It is also used to determine the energy performance. Also, taking into account angular fans whose speeds are variable, they are becoming the new energy provider to the industries. Wentao Cai, Ruihua Wei, Lihong Xu, and Xiaotao Ding [17] studied LGBM algorithm which was used to model the structure of greenhouses. LGBM was compared with other four models like BP neural network, RNN, Xgboost and SGB . Then they were built and tested. After testing it was found that LGBM has better fitting performance, fast convergence speed, least error range and the time required to build the model is also less.

F. *Climatic conditions*

Farhat Mahmooda, Tareq A. Al-Ansari[18] have conducted studies in which the greenhouse utilizes the humidification as well as dehumidification process, in which saline groundwater is used. This phenomenon provides proper surviving conditions for the plants throughout any season which leads to self-sustaining agriculture possible in arid climates .Ahmad Banakara, Mehdi Montazeria, Barat Ghobadiana, Hadi Pasdarshahrib, Fatemeh Kamrania [19] has entitled the study in which they mentioned a technique, in which the thermal energy which is extracted from the greenhouse can be reused, which leads to the reduction in the overall thermal load. In Tehran, the thermal performance, heating and cooling demands of conventional greenhouses, semi-closed greenhouses, and closed greenhouses were shown with models created with TRNSYS software.

Homa Esmaeli, Ramin Roshandel [20] provided an optimization technique that allows you to determine the best solar greenhouse design for any climatic situation and anticipate how well it will perform. It's also a decision-making tool that determines the ideal growing kind based on energy efficiency. Chaoqing Feng , Lizhuang Zhang, Rui Wang, Hongbin Yang, Zhao Xu, Suying Yan[21] have presented a new kind of polyhouse in which optical software is employed to stimulate the cover plate's concentrating abilities. This recently developed cover can not only manage the amount of

light that enters the room, but it can also maximize the solar energy's thermal efficiency.

G. Automation and IOT

Snehal Karle, Darshana Ozarde, Piyusha Patil, Chitra Thange, Prof.Ganesh Fodase[22] has proposed a paper in which low cost automation for polyhouse is designed for controlling temperature and humidity. In the rainy season, controllers were used to remove moisture from the polyhouse and provide a certain amount of sunlight by opening the roof top in both the winter and rainy seasons. Kazuhisa Itoa , Tsubasa Tabeib [23] have proposed a control system in which temperature and humidity of greenhouses can be controlled using relatively humidifiers, inexpensive heaters and ventilation fans. The concept of model predictive control (MPC) was applied to a small greenhouse to minimize the sum of squared errors .

Raja.G.,Rajarathinam,D.R.P,Abhraj.R.Arunkrishnan ,Febin Malik, Jesu Jorof Divin. J presented a paper [24] in which sensors and IoT generate control signals for irrigation of farm. For farmers convenience, the structure of the GUI has been unified. Ajith G. Sa, Girija M Gb, Jinson Devisc [25] has studied wireless ZigBee methods which led to the formation of inexpensive, low power polyhouse monitoring systems.
Every equipment within the room was controlled with Galileo, over the internet. By utilizing a wireless sensor network, it improves efficiency and flexibility while lowering manpower costs. Aarti Kochhara, Naresh Kumara[26] has published a paper in which Integration of Wireless Sensor Networks (WSN) has been used in greenhouses to reduce human effort. Horizontal,vertical and various layout have been tried to place sensors in greenhouse.

Feiting Lin ,Yabin Weng, Huilin Chen, Peifen Zhuang [27] have concluded a study in which they have designed a smart , up-to-date greenhouse monitoring system which uses remote sensing images and machine learning. By using this we can find threats of pests to vegetable growth and reduce the influence of pests on vegetables .Gao Junxiang , Du Haiqingb [28] developed an embedded web server . The server collects greenhouse data and transmits it. The embedded web server Boa and the embedded database management system (DBMS) SQLite were chosen to build the web server software system.

III. FUTURE SCOPE
- These days we are experiencing the adverse changes in climate suddenly irrespective of the seasons . To

avail with such conditions, a single polyhouse should be designed which will sustain in summer , rainy as well as winter season.
- As most of the polyhouses can't sustain wind loads so, sometimes they get inclined . Even some polyhouses can't sustain the rain loads; the upper cover suffers damage due to which rain water starts falling inside the polyhouse leading to the destruction of crops .So, there is a need to find an alternative material for cover as well as structure.
- With increasing trends in technology, a low-cost, semi -automated Polyhouse should be developed which can be afforded by small scale farmers.
- A polyhouse having smart tools can be designed so that it will lead to less human effort.

IV. CONCLUSION:

Thus, in this paper we have looked for different designs of polyhouses and analyzed them considering different loads [1].Here we have also studied the design of low cost polyhouses using materials available in nature like wood and bamboo [11].Here, we have also discussed effective greenhouse cooling methodologies and operation strategies [13]. With recent advancements, the LGBM algorithm was used to model greenhouses [17] . Here, we have also studied a developed cover which can deduct light control function and also properly utilize thermal solar energy [21].A low cost automated polyhouse with different sensors and controllers is discussed [22].Polyhouse having control through IoT is also discussed here .

REFERENCES:

[1] Lovepreet Singh , Arun Kaushal ,Amritpal Digra , A Review On Stability Of Polyhouse Structures, International Journal Of Agricultural Sciences Vol -17 ,Pp.285-292 ,2021

[2] Indore Navnath,S.J.Kale,Akoon A.B.,R.K.Singh And Harmehar Singh,Structural Ana Lysis Of Common Existing Greenhouses Design In Different Agro Climatic Zones Of Ind , Iainternational Journal Of Agricultural Enginnering,Vol.13,Issue-1,Pp.80-89,2020

[3] Rack-Woo Kim,In-Bok Lee,Uk-Hyeonyeo,Sang Yeon Lee, Evaluation Of Various National Greenhouse Design Standards For Wind Loading, Elsevir,Pp.136-154,2019

[4] S. Revathi ,N. Sivakumaran, T .K .Radhakrishan ,Design Of Solar-Powered Forced Ventilation System And Energy-Efficient Thermal Comfort Operation Of Greenhouse ,Pp.1-8,2021

[5] V.K.Verma ,Tejkaran Singh Chawla ,Manas Adhikari, Rajat Sella, Use Of Concrete F Illed Unplasticised Polyvinyl Chloride Tubes As Column In Polyhouse,International Jour Nal Of Engineering Research And Technology,Vol.4,Issue-12,Pp.578-582,2015.

[6] Meng-Hao Tsai , Ying-Chieh Lee , Practical Structural Design And Construction Of An Innovative Composite Plastic Greenhouse , Agriculture , Pp. 1-14 ,2021

[7] D. Briassoulis , E. Schettini , Analysis And Design Of Low-Density Polyethylene Greenhouse Films, Biosystems Engineering , Vol. 84 , Issue -3 ,Pp.303–314,2003.

[8] Prakash P, Pramod Kumar, Prabhat Kishore, D. Jaganathan , Sheela Immanuel , Economic feasibility of polyhouse establishment with and without government subsidy support: A case of gerbera cultivation in Maharashtra, India

[9] R. K. Yadav, P .Kalia, H. Choudhary, Zakir Husainand Brihamadev, Low-Cost Polyhouse Technologies For Higher Income And Nutritional Security, International Journal Of Agriculture And Food Science Technology, Vol. 5, Issue- 3, Pp. 191-196,(2014)

[10] G. RAJENDER, K. SUSHANTH, K. MITHUN, B. DEVENDER, D. RAJU & K. ANOOSHA , DESIGN AND DEVELOPMENT OF LOW COST GREENHOUSE TO RAISE DIFFERENT CULTIVARS , International Journal Of Agricultural Science And Research, Vol. 7, Issue- 3, Pp. 29-36,2017

[11] Shanhong Zhang ,Yu Guo, Huajian Zhao, Yang Wang, David Chow, Yuan Fang ,Methodologies Of Control Strategies For Improving Energy Efficiency In Agricultural Greenhouses,Elsevir,Pp.274-290,2020

[12] Mridul Khanna, Richa Patro, Sakshi Mahanoori, Saptarshi Roy Chowdhury , Vikramsinh Patil , Varun Miglani , FACTORS AFFECTING FLORICULTURE FARMERS' PRODUCTIVITY: A CASE STUDY OF PUNE, International Journal Of Modern Agriculture, Vol. 10,Issue -2, Pp. 727 – 735,2021

[13] Saud Ghani, Foteini Bakochristou , Esmail Mohamed Ali Ahmed Elbialy , Seifelislam Mahmoud Ahmad Gamaledin , Mohammed Mohammed Rashwan , Ayman Mohamed Abdelhalim , Salman Mohammad Ismail , Design Challenges Of Agricultural Greenhouses In Hot And Arid Environments – A Review, , Elsevier, Pp. 1-23,2018

[14] Itigi Prabhakar, K Vijayaragavan, Premlata Singh, Balraj Singh, Janakiram, B L Manjunatha, Seema Jaggi And I Sekar, Constraints In Adoption And Strategies To Promote Polyhouse Technology Among Farmers: A Multi-Stakeholder And Multi-Dimensional Study, Indian Journal Of Agricultural Sciences,Vol.87,Issue -4,Pp.485-490,2017

[15] Hao Wang , Maoynan Zhang ,Ze Yang ,Zhaozheng Wang ,Xu Liu,Yijia Lu.Linhong Ji, Zhong Lin Wang,Jia Cheng ,Energy From Greenhouse Plastic Films,Elsevir,Pp.89-99,2021

[16] Andrea Costantino , Lorenzo Comba , Giacomo Sicardie , Mauro Barianie , Enrico Fabrizioa Energy performance and climate control in mechanically ventilated greenhouses: A dynamic modelling-based assessment and investigation, ,Elsevir,Pp.288-298,2021.

[17] Wentao Cai ,Ruihua Wei,Lihong Xu ,Xiaotao Ding , A Method For Modelling Greenhouse Temperature Using Gradient Boost Decision Tree,Information Processing In Agriculture ,Pp.1-12,2021.

[18] Farhat Mahmooda , Tareq A . Al-Ansaria , Design And Thermodynamic Analysis Of A Solar Powered Greenhouse For Arid Climates , Elsevier ,Pp 497-509(2020).

[19] Ahmad Banakara, Mehdi Montazeria, Barat Ghobadiana, Hadi Pasdarshahrib, Fatemeh Kamrania, Energy Analysis And Assessing Heating And Cooling Demands Of Closed Greenhouse In Iran,Pp.1-7,2021

[20] Homa Esmaeli, Ramin Roshandel , Optimal Design For Solar Greenhouses Based On Climate Conditions,Elsevier,Pp.1255-1265,2019

[21] Chaoqing Feng, Lizhuang Zhang ,Rui Wang ,Hongbin Yang ,Zhao Xu ,Suying Yan ,Greenhouse Cover Plate With

Dimming And Temperature Control Function ,Elsevier ,Pp 1-9,2021

[22]] Snehal Karle, Darshana Ozarde, Piyusha Patil, Chitra Thange, Prof.Ganesh Fodase, D Esign And Development Of Low Cost Automation For Polyhouse, International Research Journal Of Engineering And Technology,Vol.6,Issue-4,Pp.3926-3933,2019

[23] Kazuhisa Itoa , Tsubasa Tabeib , Model Predictive Temperature And Humidity Control Of Greenhouse With Ventilation, Elsevier,Pp. 212–221,2021

[24]] Raja.G. , Rajarathinam, D.R.P,Abhraj.R.Arunkrishnan ,Febin Malik, Jesu Jorof Divin. J, Smart Polyhouse Farming Using Iot Environment, International Journal Of Trend In Sc Ientific Research And Development,Vol.2,Issue-3,Pp.691-697,2018.

[25] Ajith G.S ,Girija Mg,Jinson Devis,Polyhouse Environment Monitoring System Using Intel Galileo And Sensor Network Based On IOT,Elsevier,Pp1898-1902,2021

[26] Aarti Kochhara, , Naresh Kumara, Wireless Sensor Networks For Greenhouses : An End-To-End Review,Elsevier,Pp.165 -180,2019

[27] Feiting Lin ,Yabin Weng,Huilin Chen, Peifen Zhuang , Intelligent Greenhouse System Based On Remote Sensing Images And Machine Learning Promotes The Efficiency Of Agricultural Economic Growth,Elsevir,Pp.24-40,2021

[28] Gao Junxiang , Du Haiqing , Design Of Greenhouse Surveillance System Based On Embedded Web Server Technology, Elsevier ,Pp. 374 – 379,2011