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PLANT GROWTH CHAMBER CONTROLLER

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ABSTRACT

This dissertation is dedicated to a comprehensive study of Plant Growth Chamber (Phytotron Facility) systems utilizing Direct Digital Controllers (DDC). Among flexible controller system controllers, the DDC have shown feasibility in terms of cost effectiveness in a wide range of problem-solving abilities from industrial grade to good interface with user. DDC being core of Plant growth chamber controls all switching and data transfer functions of the plant growth chamber. Since it has in build relay card on same motherboard and logically connected with microprocessor chip, it is very easy to switch systems. Apart from switching capabilities DDC also performs the function of networking through RS-232 and TCP/IP communication over Ethernet. Also along with induction of DDC to plant growth chamber as controller there is another interface controller and interactive equipment called HMI, Human Machine Interface , which has most advanced touch screen and interactive capabilities and provides user a very simple and smooth way of running and maintaining its chamber. Also the HMI opens the gateway for networking and remote accessing feature to chamber. Advanced Plant Growth Chamber and Phytotron facility is develop with a objective to support Indian Agriculture in improving the crop productivity through better understanding of plant growth under precisely controlled environment conditions, aimed at the evolution of new varieties and technologies.The objective of thesis is to come out with a simulation model of Plant Growth Chamber based on Direct Digital controller and analyzes its operation. The general function of the DDC is to logically drive in parameters and on the basis of output parameter to controller all peripheral devices/equipments to maintain a desired level of temperature, humidity, Oxygen, light intensity and carbon dioxide level. An environmental test chamber artificially replicates the conditions under which machinery, materials, devices or components might be exposed. It is also used to accelerate the effects of exposure to the environment, sometimes at conditions not actually expected.

I. INTRODUCTION

1.1 General

Plant Growth Chambers –Phytotron Facility Systems

An **environmental chamber** is an enclosure used to test the effects of specified environmental conditions on biological items, industrial products, materials, and electronic devices and components.
Such a chamber can be used:

1. as a stand-alone test for environmental effects on test specimens
2. as preparation of test specimens for further physical tests or chemical tests
3. as environmental conditions for conducting testing of specimens

1.2 Overview

An environmental test chamber artificially replicates the conditions under which machinery, materials, devices or components might be exposed. It is also used to accelerate the effects of exposure to the environment, sometimes at conditions not actually expected.

These conditions may include:

- extreme temperatures
- sudden and extreme temperature variations
- moisture or relative humidity
- electrodynamics vibrations
- electromagnetic radiation
- salt spray
- rain
- weathering
- exposure to sun, causing UV degradation
- vacuum

Manufactured samples, specimens, or components are placed inside the chamber and subjected to one or more of these environmental parameters to determine reliability or measure after-effects such as corrosion. In the case of machinery such as internal combustion engines, byproducts such as emissions are monitored.An environmental chamber can be a small room used both to condition test specimens and to conduct the test. It can be a smaller unit that's used for conditioning test items. Also, some chambers are small enough to be placed onto a universal testing machine or other test apparatus.Many chambers are set at a certain set of conditions. Others can be programmed to cycle through specified sequences of conditions.As test requirements may be relatively simple or complex, environmental test chambers vary widely in size, ranging from small units designed for placement on bench tops to large walk-in chambers. Test chambers generally have viewports or video feeds to allow for visual inspection of the sample during the test. Reach-in chambers provide an opening that technicians may use to handle test samples. Chambers providing interior visual lighting must take into account the heat generated and compensate accordingly.

As with the wide variance in size, a number of user control options are available, ranging from simple analog indicators up to more modern digital readouts with LCD displays. Chambers may be computer programmable, and networked or Web-enabled test chambers are also available.

1.3 Equipment Testing

Examples of military equipment evaluated at the DCC include tents, parachutes, heaters, airbeams, medical devices and wild mills. The heat transfer properties of a wide range of new protective military clothing are tested at the DCC. Constant control of temperature (to within +/- 1°F) is possible with simultaneous control of both wind and humidity. (Other chambers in the world have only two-environmental-parameter capability, making the DCCs unique.) External observer and test monitoring areas have electronic data acquisition systems to record a variety of testing parameters and provide customized plotting, graphing and printouts.

1.4 Human Research

The DCCs are man rated for human safety. Human research in the DCC is aimed at the prevention of injuries and the minimizing of performance decrements in order to enhance overall operational effectiveness. The Chambers simulate types of environmental conditions that soldiers may encounter in the course of their real world duties. Soldier (and civilian) volunteers walk or run on treadmills to simulate a variety of work rates at different environmental extremes. Each chamber has two 5-person treadmills that can operate up to 15 mph (24 km/h) at a 12% grade. A facility kitchen prepares meals to test the effects of nutrition on physical performance. The DCCs include a dormitory facility for sleep studies as well as dressing rooms, showers and laundering facilities which support prolonged live-in studies.

Accelerated aging is testing that uses aggravated conditions of heat, oxygen, sunlight, vibration, etc. to speed up the normal aging processes of items. It is used to help determine the long term effects of expected levels of stress within a shorter time, usually in a laboratory by controlled standard test methods. It is used to estimate the useful lifespan of a product or its shelf life when actual lifespan data is unavailable. This occurs with products that have not existed long enough to have gone through their useful lifespan: for example, a new type of car engine or a new polymer for replacement joints.

Physical testing or chemical testing is carried out by subjecting the product to

- representative levels of stress for long time periods,
- unusually high levels of stress used to accelerate the effects of natural aging, or
- levels of stress that intentionally force failures (for further analysis).

Mechanical parts are run at very high speed, far in excess of what they would receive in normal usage. Polymers are often kept at elevated temperatures, in order to accelerate chemical breakdown. Environmental chambers are often used. Also, the device or material under test can be exposed to rapid (but controlled) changes in temperature, humidity, pressure, strain, etc. For example, cycles of heat and cold can simulate the effect of day and night for a few hours or minutes.

Weather testing of polymers is the controlled polymer degradation and polymer coating degradation under lab or natural conditions.

Just like erosion of rocks, natural phenomena can cause degradation in polymer systems. The elements of most concern to polymers are Ultraviolet radiation, moisture and humidity, high temperatures and temperature fluctuations. Polymers are used in everyday life, so it is important for scientists and polymer producers to understand durability and expected lifespan of polymer products. Paint, a common polymer coating, is used to change the colour, change the reflectance (gloss), as well as forming a protective coating. The structure of paint consists of pigments in a matrix of resin. A typical example is painted steel roofing and walling products, which are constantly exposed to harmful weathering conditions.

1.5 Gene Banks

Gene banks are a type of bio repository which preserves genetic material. For plants, this could be by freezing cuttings from the plant, or stocking the seeds (e.g. in aseed bank). For animals, this is the freezing of sperm and eggs in zoological freezers until further need. With corals, fragments are taken which are stored in water tanks under controlled conditions.[1]

Plant genetic material in a 'gene bank' is preserved at -196° Celsius in Liquid Nitrogen as mature seed (dry).In plants, it is possible to unfreeze the material and propagate it, however, in animals, a living female is required for artificial insemination. While it is often difficult to utilize frozen animal sperm and eggs, there are many examples of it being done successfully. In an effort to conserve agricultural biodiversity, gene banks are used to store and conserve the plant genetic resources of major crop plants and their crop wild relatives. There are many gene banks all over the world, with the Svalbard Global Seed Vault being probably the most famous one.

1.5.1 Seed Bank

A seedbank preserves dried seeds by storing them at a very low temperature. Spores and pteridophytes are conserved in seed banks, but other seedless plants, such as tuber crops cannot be preserved this way. The largest seed bank in world is the Millennium Seed Bank housed at the Trust Millennium Building (WTMB), located in the grounds of Lakehurst Place in West Sussex, near London.[2]

1.5.2 Tissue Bank

In this technique buds, protocorm and meristematic cells are conserved through particular light and temperature arrangements in a nutrient medium. This technique is used to preserve seedless plants and plants which reproduce asexually.

1.5.3 Cry Bank

In this technique, a seed or embryo is preserved at very low temperatures. It is usually preserved in liquid nitrogen at -196°C. This is helpful for the conservation of species facing extinction.[3]

1.5.4 Pollen Bank

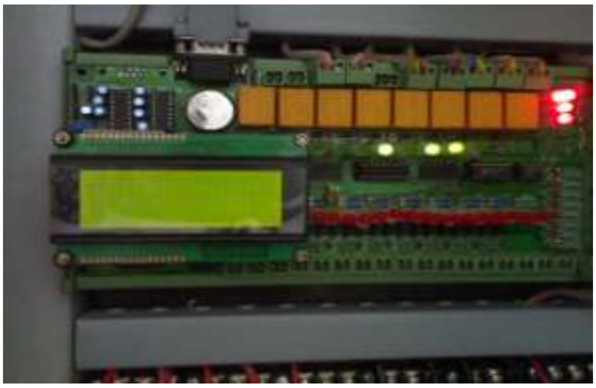
This is a method in which pollen grains are stored. We can make plants which are facing extinction in the present world. Using this technique, we can make plants with one set chromosome.

1.5.5 Field Gene Bank

This is a method of planting plants for the conservation of genes. For this purpose we construct ecosystem artificially. Through this method one can compare the difference among plants of different species and can study it in detail. It needs more land, adequate soil, weather, etc.. Germ plasma of important crops are conserved through this method. 42,000 varieties of rice are conserved in the Central Rice Research Institute in Orissa.

II. RESULTS AND DISCUSSION

Integrating Digital Direct Controller, Human Machine Interface and Networking brought a new technical dimension to Plant Growth Chamber. DDC was a very successful and encouraging step in development of plant growth chamber due to its high Industrial standards and robust nature . As to operate and maintain a Plant Growth Chamber the load connected in form of Air-conditioner , Heater , Humidifier and Lights is very high and their switching operation through relay brings Spikes and noise to system which hinder operation of any microprocessor. The problems of DDC Hang and restart were common but, addition of Snubbers and onboard relay system captured these spike and maintained a distance between microprocessor and noises. DDC was assigned a responsibility of switching of loads accurately as per values set in HMI. HMI was installed with a purpose of smooth and easy operation and to facilitate networking to the machines and connect them to network from where they can accessed any where across globe. Not only they can be accessed in terms of observation they can be monitored and parameters can be changed as per requirement. The Alarm System generated alarms about any alarming situation inside chamber about CO2 level or intensity of light.



A Snapshot of DDC Controller in Operation with Relay on Board

Trends on HMI Screen

In HMI graphical representation of data and logs through trends was a comprehensive demand of all research scholars, as it is very easy to understand and diagnose behavior of chamber at a glance.

Most of all the question of stability and life of chamber, controller and network was very well addressed and during on field operation in extreme conditions ranging from 4 DegC to 52 DegC the processor and HMI interface performed well without any sign of hindrance any these factors.

In two point control mechanism the parameter to controlled between the defined upper and lower limits. The band between the upper and lower limits is the hysteresis band. When even the parameter crosses the upper limit or the lower limit, a control action is initiated to bring the parameter within the range. These limits are defined through the configuration screen. The parameter is sensed as an analog signal and is converted to digital value by the controller. The digital value of the parameter is then compared with the upper and lower limit and actions are taken to maintain the value within the limits. If the value is within the limits then no action is taken. The control action is in the form of switching ON/OFF of a control. (e.g. the contactor of the heater turned ON/OFF to keep the temperature within range).A variant if it can allow a better control by providing stepped control. This is the case where the control can be set in multiple steps (e.g. Fan speed control in steps, using multiple heating coils connected to separate ON/OFF control, turning ON/OFF segments of light).

PID Control: If the system has the capability of continuous control of the parameter the PID control loop provides a precise control of the parameter (e.g. flow control through Variable Frequency Drive). An analog control signal defines the speed of the VFD is continuously modulated to maintain the flow rate.

The Proportional (P) control changes the control signal by a amount which is proportional to the difference between the set point and the parameter value. Proportional control always need a difference signal to control the parameter, hence the parameter can never reach the set point with only proportional control. Integral (I) control allows the system to follow a slowly varying signal where P parameter tends to negligible and maintains the parameter under control at the set point value. Differential (D) control provides response to ramp change in the parameter. However this kind of change is not applicable for parameters like temperature and humidity as they vary gradually. Time based pulse control: This type of control allows the controlled equipment to be turned

ON/OFF for a specific duration using timed pulses (e.g. releasing CO2 from cylinder using control valve for limited time).Specific Analog output value: This type of control sets an output value for a specific duration of the time to allow control of a parameter at a specific value. The analog output channel is set at a particular value for the planned duration (e.g. light intensity control through dimmer).

III. CONCLUSION AND FUTURE SCOPE OF WORK

It can be very well concluded that incorporation PID and DDC controllers in operation and maintenance of factors for plant are on very high standards. Especially switching of loads by DDC with such a ease and withstanding in such a disturbing voltage environment is outstanding. Since the Controller design, logic was simple it was easy to understand and install on Panel. Use of Industrial grade HMI result in extended life of Growth Chamber as they are the gateway to chamber , so it was ensure that HMI to bet of best standard.

Due to above mentioned qualities of DDC and HMI the cost of plant growth chamber was significantly brought down , being completely indigenously developed the cost was very well regulated and it can be afforded to by customers of various market segments and farmers for Agricultural Purpose.

Further Scope in this field to bring cutting edge indigenously developed technology to a market where economy is controlled by Agricultural productions, this product was developed with an objective to increase research works and cut down time to acquire any results desired by scholars. Instead there are vast voids in field of Agricultural Technology waiting to get filled. Some of these are mentioned below.

1. Nutri-Furtigation System

Nowadays, many vegetables are grown inside greenhouses in which environment is controlled and nutrition can be supplied through water supply using electrical pump, namely fertigation. Dosage of nutrition in water for many vegetable plants is also known so that by controlling water supply all the needs for the plants to grow are available. Furthermore, water supply can be controlled using electrical pump which is activated according to the plants condition in relation with water supply. In order to supply water and nutrition in the right amount and time, plants condition can be observed using a CCD camera attached to image processing facilities to develop a speaking plant approach.

2. Irrigation System For Dry Areas

Improving irrigation efficiency can contribute greatly to reducing production costs of vegetables, making the industry more competitive and sustainable. Through proper irrigation, average vegetable yields can be maintained (or increased) while minimizing environmental impacts caused by excess applied water and subsequent agrichemical leaching. Recent technological advances have made soil water sensors available for efficient and automatic operation of irrigation systems. Automatic soil water sensor-based irrigation seeks to maintain a desired soil water range in the root zone that is optimal for plant growth. The target soil water status is usually set in terms of soil tension or matric potential (expressed in kPa or cbar, 1 kPa=1 cbar), or volumetric moisture (expressed in percent of water volume in a volume of undisturbed soil).

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