Spanish Journal of Innovation and INTEGRITY
ISSN: 2792-8268
Volume: 42, May-2025
http://sjii.indexedresearch.org

Innovation of the Process of Automating Temperature Regulation in Vegetable Storage Stores

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Abstract: *Proper temperature control is essential for effective vegetable storage. Maintaining optimal storage temperatures, along with appropriate humidity levels and ventilation, can significantly extend the freshness, nutritional value, and marketability of vegetables. Advanced storage technologies, including automated temperature control systems, play a critical role in consistently achieving these conditions, reducing spoilage, and ensuring consumers receive high-quality produce.*

Keywords: *Automating temperature, agricultural, automation, sensors, SMS, cuts down, fluctuations, programmable logic controllers (PLCs), devices.*

Introduction

Understanding the specific needs of each type of vegetable and implementing best practices in storage can be of great benefit to farmers, distributors, and consumers.[8]

Different vegetables require a specific temperature range to ensure freshness and non-spoiling. An effective climate control system is the use of free cooling, active ventilation using the influx of cold street air. The air flow dries the food containers and helps maintain the temperature required for the treatment regime. Supply air heaters, regenerators, coolers, humidifiers, dehumidifiers, and ventilation dampers are controlled from the central console, both manually and using microcontrollers. The power supply of the electrical equipment of the climate system requires the presence of an autonomous backup source. Cooling and heating devices play a vital role in these automated systems. Modern cooling systems are energy-efficient and offer precise control, lowering the temperature when necessary. Automated heating systems can raise the temperature to prevent freezing or damage to certain vegetables. Additionally, air circulation systems—including automated fans and ventilation—ensure even distribution of temperature and humidity, preventing hot spots and maintaining a uniform environment throughout the storage area.

There are numerous advantages to automating temperature control in vegetable storage warehouses. One of the key benefits is the consistency and precision offered by automated systems. By eliminating the variability associated with manual adjustments, these systems reduce the risk of spoilage and waste, ensuring vegetables are always kept in ideal conditions. This results in higher quality produce that retains its nutritional value, flavor, and appearance for a longer time.

Energy efficiency is another major advantage. Automated systems optimize the use of heating and cooling resources, reducing energy consumption and lowering operational costs. This not only

enhances the sustainability of vegetable storage but also improves the profitability of agricultural operations. Furthermore, labor efficiency is significantly increased, as automation reduces the need for constant human intervention, allowing labor to be redirected to other critical tasks and minimizing the risk of human error.

If the temperature or humidity significantly deviates from the set points, or if a system malfunction occurs, the system is programmed to send alerts. These alerts are delivered to warehouse managers via SMS, email, or a dedicated application.

The system also issues notifications for preventive maintenance, ensuring the efficient operation of cooling, heating, and ventilation equipment and reducing the risk of unexpected failures.

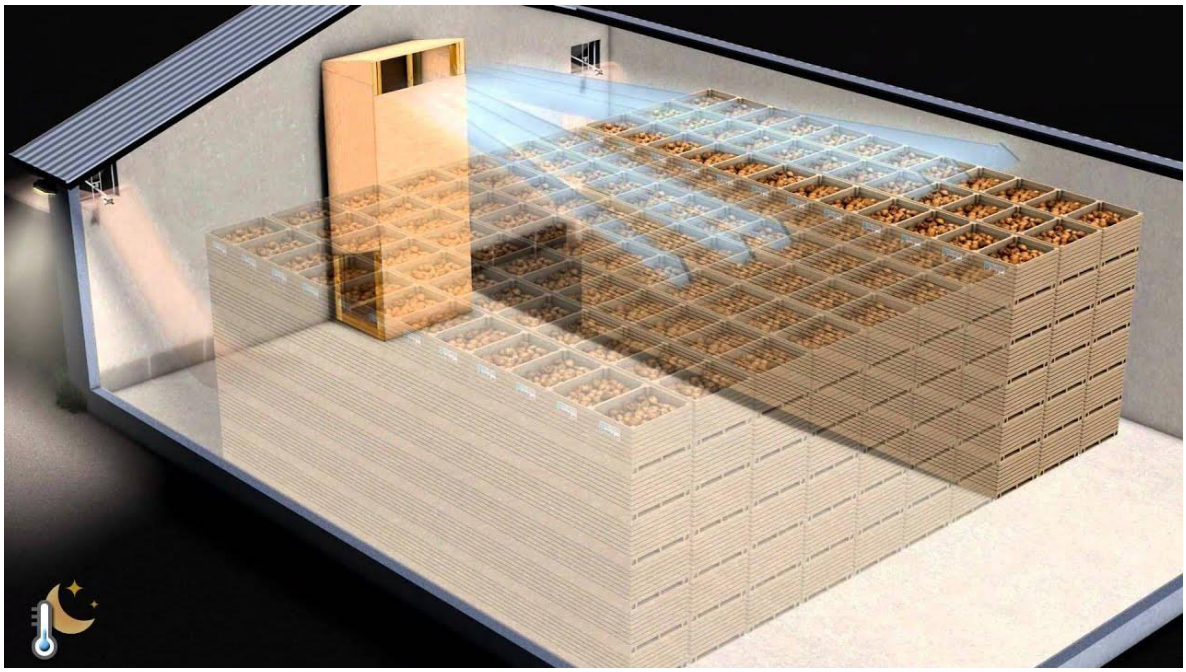

Figure 1. Vegetable Storage Warehouse

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Figure 2. Vegetable storage automation warehouse

This type of storage is the most common in Russia. It allows for storing a big amount of produce. It is suitable for storing onions, potatoes and beets.

The air preparation chamber in a vegetable storage under the bulk storage technique is important for maintaining climate index. It is better to locate the chamber along one of the outer walls of the vegetable storage building and to separate it from the inner wall of the storage room. Fresh air passes into the chamber through the intake valves, where it gets the required level of humidity and temperature. The recycle valves, heaters, humidifiers and coolers located in a chamber are used for maintaining the air that comes into the chamber.

Bulk storage with underfloor ducts entails the supply of air prepared with the help of high-pressure fans, where the air runs through the special cement underfloor ducts. Fans can be installed into the hollow floor of the air preparation chamber or into ducts. The air passes through the ducts and into the storage where it ventilates, heats or cools the vegetables. It also adjusts humidity. After that, the waste air mixes with the fresh air through the recycle valves or through the open intake valves. In order to avoid the formation of condensate, the storage rooms are equipped with special fans, which can be fitted with heating elements.

The automatic control system is used in a storage for maintaining the required microclimate parameters; it is operated with a computer with the aid of produce temperature sensors and ducts, inner and outer humidity sensors, and controls the microclimate inside the storage building.

Bulk storage with perforated air circuits is necessary if installing underfloor ducts for airflow is not an option. For example, if you're trying to equip a ready-built storage facility. A perforated metal air circuit is installed on the level floor. The prepared air moves away from the chamber through the air circuits and then comes out through the slots in the ducts and passes through the produce.

Underfloor ducts can be installed in any existing vegetable storage if minor modifications are made. This vegetable storage option is the fastest and the cheapest. At the same time, it means losing a certain percentage of storage capacity. Our specialists have estimated that perforated air circuits take up approximately 7% of total room space. Another disadvantage is the inconvenience of cargo operations by electric lift trucks and the other equipment typically used in a storage. Ducts can get damaged by such equipment, meaning that they will have to be replaced from time to time. On average, about 10%

of air circuits are replaced every year. At the same time, storage quality with perforated air circuits is similar to the quality provided by underfloor ducts.

Container storage: Container storage guarantees a high level of crop safekeeping. The process of maintaining produce quality is convenient and allows for the prompt removal of spoiled vegetables, provides for the convenient loading and unloading of produce and a high degree of process mechanization, and makes it possible to store different types of vegetables in a single storage or room and unload some of the produce without disrupting temperature conditions.

In containers, you can store vegetables that do not call for special care such as cabbage and carrots. Using this method, you can reach the required and stable humidity, temperature and air-exchange values in the storage room. In recent times, container storage has been used for potatoes, onions and garlic.

The disadvantage of container storage is the price of the containers themselves, which must be purchased for this storage type.

There are several distinct types of container storage technology:

1. Aspiration system assumes that vegetables are stored in containers in framed storehouses with the use of suction fans. The system is suitable for potatoes. beets, onions sand garlic. It allows for automating the process of storage control and monitoring humidity level, and can be supplied with heating and cooling systems depending on the type of produce and storage period.

Outside, parallel to the outer wall, a storage room wall with vertical openings is built, behind which the air preparation chamber is located. The chamber is equipped with high-pressure fans. These fans suck the waste air from the passages between the containers through the wall openings or discharge the waste air through the intake valves outside; they can also mix the waste air with the fresh air and let it back into storage. The air temperature is maintained with intake and emission valves.

In the storage, there are markings along the wall along where the containers should be placed. The space between each container should be 50cm. They are put into a pile 6-7 meters high. Above and opposite the abutting end wall, the passages between the containers are covered with metal-clad aspiration covers.

The ventilation system is fundamental and is used for drying, curing, decreasing and maintaining the temperature of produce. A refrigeration system is used at high temperatures (in May, June) or when the produce temperature needs to be decreased in a short period of time. Aspiration system - ensures a high degree of produce safekeeping with moderate time inputs for startup.

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