Development of CATTS Technology: A Controls Perspective

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Techni-Systems was asked to design and build the first Controlled Atmosphere Temperature Treatment System (CATTS) environmental chamber in 1994. It was a very challenging engineering task due to the many physical parameters that need to be tightly controlled. All the systems have to work simultaneously without adversely affecting each other. Also, the high humidity/temperature environment necessitates special considerations to deal with water condensation internally that could impair the instrumentation.

CATTS Intended Use

The CATTS chamber is designed to perform research with infested commodities using hot forced air or vapor heat in combination with controlled levels of oxygen and carbon dioxide. The goal of this research is to identify protocols that effectively kill insects without the use of methyl bromide or other hazardous chemicals.

The control features, including computer monitoring include temperature monitoring, temperature control, dew point monitoring, dew point control, oxygen monitoring, oxygen control, carbon dioxide monitoring and control, and air velocity monitoring and control.

The mechanical system, including fans, injectors, solenoid valves to obtain and maintain appropriate environmental conditions for both CATTS systems are described in detail.

The electrical system was designed not only to maintain the environmental conditions in the units, but to gather physical data on the operation of the unit and report important environmental conditions during operation. The system includes a power panel, a control panel, heater source, fan source, among other system in the unit.

The environmental chamber has precision thermistor temperature probes with an accuracy of ± .1°C. The probes measure 7 cm. in length and .16 cm in width for easy insertion into the commodity. One probe is located in the supply air stream at the entry of the bottom lug. Located in the duct immediately above the top lug, another probe measures the temperature of the return air. Each lug has six probes, which are connected to a 1/4-turn electrical connector. While the lug is outside the chamber, the thermistors are inserted under the skin of the commodity to measure the surface temperature or into the center to measure the core temperature. After the lug is placed in the chamber, the temperature probe cable is locked into the stationary half of

the connector mounted on the frame in front of the lug. The user selects from a graphic screen how each probe is used (surface, core, or unused).

A vacuum pump draws air out of the CATTS chamber, through oxygen and carbon dioxide analyzers, then back to the chamber. The dew point analyzer reads over the range of –40 to +60°C. The oxygen analyzer reads 0-25% O_2, and the carbon dioxide analyzer reads 0-80% CO_2.

The CATTS chamber is designed with flexible control algorithms in order to accommodate a variety of tests. Heating, dew point, oxygen, and carbon dioxide control can be individually enabled or disabled for a given test. Temperature, dew point, oxygen, and carbon dioxide parameters are each maintained using Proportional/Integral/Derivative (PID) control algorithms.

If heating is enabled, there are four separate sets of Ramp/Soak parameters that can be configured. At the beginning of a test the temperature setpoint starts at the current supply air temperature, then increments at the selected Ramp rate (degrees/hour). When the Supply Air temperature setpoint reaches the Soak Temperature setpoint, it levels off for the entered Soak Time period. Up to three subsequent Ramp/Soak configurations can be used if desired. Ramp Overrides can be configured to ensure that surface and core temperatures are increasing uniformly.

Dew point is controlled relative to a selectable offset from the Lowest Surface temperature, the Average Surface temperature, or the Return Air temperature. If Hot Forced Air heating is desired, the offset can be set to a negative number in order to maintain a dew point below the surface temperature of the commodity. If Vapor Heat is desired, the offset can be set to a positive number in order to maintain a dew point above the surface temperature.

Oxygen concentration is controlled by injection of nitrogen if above setpoint, and injection of air if below.

Carbon dioxide concentration is controlled by injection of nitrogen if above setpoint, and injection of carbon dioxide if below.

A test may be automatically terminated based on one of three selectable conditions. The system can be configured to wait until the lowest Core Temperature reaches an entered setpoint, then wait an additional user entered time period before terminating the test. This same scheme can be used with the Average Core Temperature. Finally, the test can be terminated as soon as the Final Soak time is complete.

Commercial Scale Application

Factors related to the development of a commercial-scale are discussed.