Electrostatic Spray Delivery System Utilizing Pneumatic Conveyance

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Problem Description:

- Our project focuses on the development of a proposed nutrient delivery system that will help produce fruits and vegetables in a microgravity environment in correspondence with NASA's FFARM (Fresh Food Augmentation Resource Machine) project .
- It is mentally and physical important for space crews in outer space for extended periods of time, to be able to grow, manage, and harvest foods on their own.
- Current space crews rely heavily on pre-packaged foods for their dietary needs.
- Pre-packaged foods not only become undesirable for long periods of time but they also take up valuable space and have high economical costs.
- By allowing space crews to interact with the growth of plants in space, their psychological perspective is greatly improved making an all around happier and more productive astronaut.

Project Reasoning:

- Current research on nutrient delivery in microgravity environments has focused on hydroponics, a process to grow plants in a nutrient rich solution with or without artificial growth media. Hydroponic systems within microgravity environments typically utilize varying aggregate media (i.e. nutrient baths, ceramic porous tubes, and other porous media).
- Aeroponic systems are very similar to hydroponics, except aeroponic systems utilize a nutrient rich air mist into a segregated root chamber to provide the plant with the necessary available nutrients. Aeroponics system have many advantages, such as quicker germination and flowering, increased harvest, limitation of disease transmission, and the capability of individual dosage treatment application.
- The concerns with conventional aeroponic systems in microgravity are related to the collection of excess solution within the segregated spray chamber and the ability to adequately apply nutrients.
- Our project focus is to implement the benefits of conventional aeroponic systems with the principles of electrostatic spraying, which will offset the present concerns with aeroponic systems in microgravity.

Objective:

1. Determine the feasibility of electrostatic spraying as a viable means of nutrient delivery in a microgravity environment.

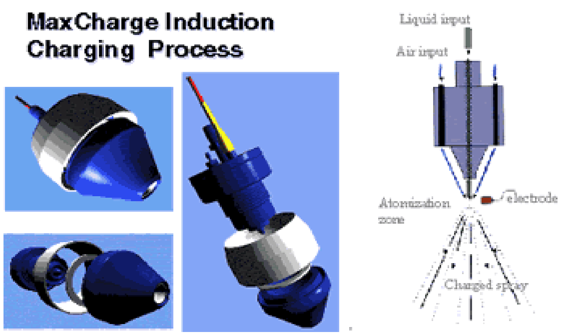
2. Design and construct a spray chamber simulator.

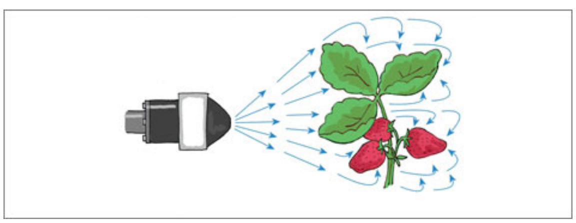
3. Integrate an electrostatic application system.

4. Evaluate the developed delivery system;

   a. Uniformity of spray applied using electrostatic application, charged vs. uncharged.

   b. Probe placement affects on spray application at 16, 20, 24, 28, and 32-inchs.





Max Charge Electrostatic Spray nozzle assembly (Top Left), Electrostatic nozzle operations (Top Right).

Plant being sprayed in electrostatic droplets (Bottom).

Pictures from: http://www.maxcharge.com/home/default.asp

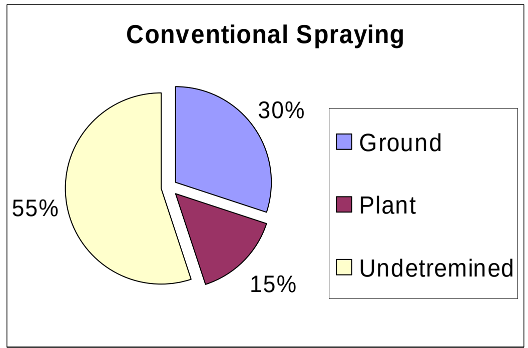
How it works:

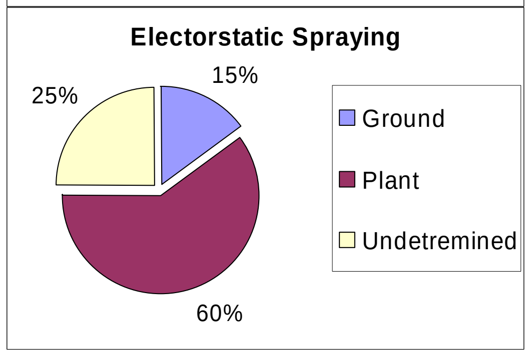
The liquid is pumped from the liquid container with a peristaltic pump to the solenoid, which regulates the flow to the nozzle.

The air coming from the air compressor is regulated by a pressure regulator and directed to the nozzle.

ESS Max Spray Electrostatic nozzle mounted within center of chamber mixes and charges the air and liquid coming from separate lines.

Charged particles leave the nozzle and are attracted to the grounded probe, covering the surface space equally.





The graphs above were made from information retrieved from:
http://www.maxcharge.com/home/default.asp

The benefits of air-assisted electrostatic spraying:

Air-assisted electrostatic sprayers produce electrically charged spray droplets which are carried to the target in an air stream.

Electrostatic spraying takes advantage of Coulomb's laws of physics to allow spray applicators to do a more complete job.

Air-assistance is necessary in electrostatic spraying to allow spray to penetrate deeper into the plant canopy or root mass.

The droplets have a force of attraction that is 75 times that of gravity. This means droplets will reverse direction and move upwards, against gravity, to coat normally hidden surfaces.

Finalized project

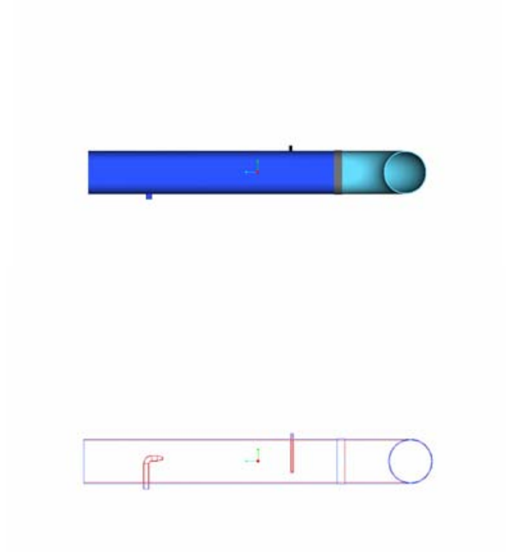


Figure 1- Pro E drawing of the proposed spray chambers

Design:

1. The ProE drawing (Figure 1) shows our tubular closed loop chamber that encloses the electrostatic spraying system.
   - The chamber is constructed of 6-inch PVC pipe approximately 5-foot in length.

2. The spray nozzle will be centered along the pipe and directed toward the rounded probe.
   - The assembly of the spraying system will be constructed of a PVC pipe that will run perpendicular to the top of the chamber.

Design:

1. The AutoCAD drawings (Figure 2) show the probe placement in regards to the nozzle placement.

2. The alignment of the tube.

3. Probe Placement used to determine accuracy of electrostatic nozzle at specified distances.

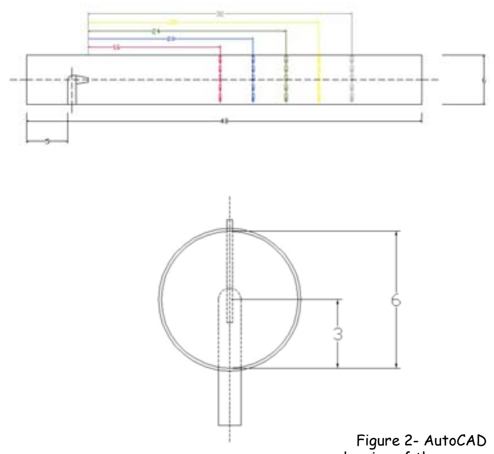


Figure 2- AutoCAD drawing of the proposed probe locations

Construction:

The pictures on the left are of chamber and spraying system construction.

Problem solving techniques and technical skills were essential in building and completeing the system.

Major obsticals that occurred during construction dealt with the possibility of the charge passing from spray to the chamber and not reaching the probe.

A possible solution to this problem is to coat the inside of the tube with a rubber liner, that will offset any possibility of charge transferring from the spray to the chamber.