MOST EFFICIENT & DEPENDABLE CA CONTROL OF FRUITS & VEGETABLES UTILIZING PRESSURE SWING ADSORPTION WITH CARBON MOLECULAR SIEVE

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Abstract

Controlled Atmospheres (C.A.) for fruits and vegetables require careful control of oxygen O_2, carbon dioxide CO_2, and ethylene C_2H_4. This paper shall introduce a relatively new technology from Nitrotec Engineering Co. utilizing carbon molecular sieve (CMS) in a pressure swing adsorption system (PSA).

One of the major benefits of controlled atmospheres is the prevention or retardation of ripening and thus spoilage.

Basic C.A. Storage Requirements

1. The maturity of the harvest.
2. The internal condition of the harvest.
3. The speed at which storage atmospheres (O_2, CO_2) are established.
4. The speed at which core temperatures are reduced.
5. The level at which atmospheres and temperature remain during the storage period.
6. The length of the storage period.

Rapid C.A. Storage

1. Fruit (apples) storage is especially affected by the time it takes to lower the O_2 concentration in the room below 2%. Normally no longer than 3 days is desirable.

2. Carbon dioxide should not be allowed to rise above 3%.

3. Oxygen should be held at 1.5-2% for the entire period.

4. Hold CO_2 below 1-2% for the entire period.

5. Temperature should be held at approximately 31-32°F if the O_2 is held below 2%.

Ethylene, C_2H_4, production can be reduced as lower concentrations of O_2 are maintained. Thus, low O_2 retards fruit ripening by inhibiting both production and action of C_2H_4.

Nitrotec Carbon Technology

Nitrotec is a high-technology company formed for the commercialization of patented gas phase adsorption systems for the separation and recovery of nitrogen from atmospheric gas, developed by its licensor, Bergbau-Forschung GmbH, Essen, Germany. The systems preferentially remove nitrogen by means of patented special carbon molecular sieve adsorbents. The systems consist of carbon molecular sieve beds which are exposed to compressed air, the only feedstock. The systems are comprised of microprocessors, and sensing devices which monitor, regulate, and control the adsorption and desorption nitrogen production cycle.

Other patented gas phase adsorption systems commercialized by Nitrotec are for the separation and recovery of helium, CO_2, hydrogen and methane from gas mixtures.

Nitrotec's gas separation experience is in all industries using nitrogen, such as food, transportation, chemical, electronics, heat treating, and oil industries for which our nitrogen generating units are currently used.

Carbon technology brings to C.A. the opportunity to use an inexpensive (compared to cryogenic- liquid N_2) nitrogen gas generator which is extremely simple and dependable, producing N_2 on site on demand.

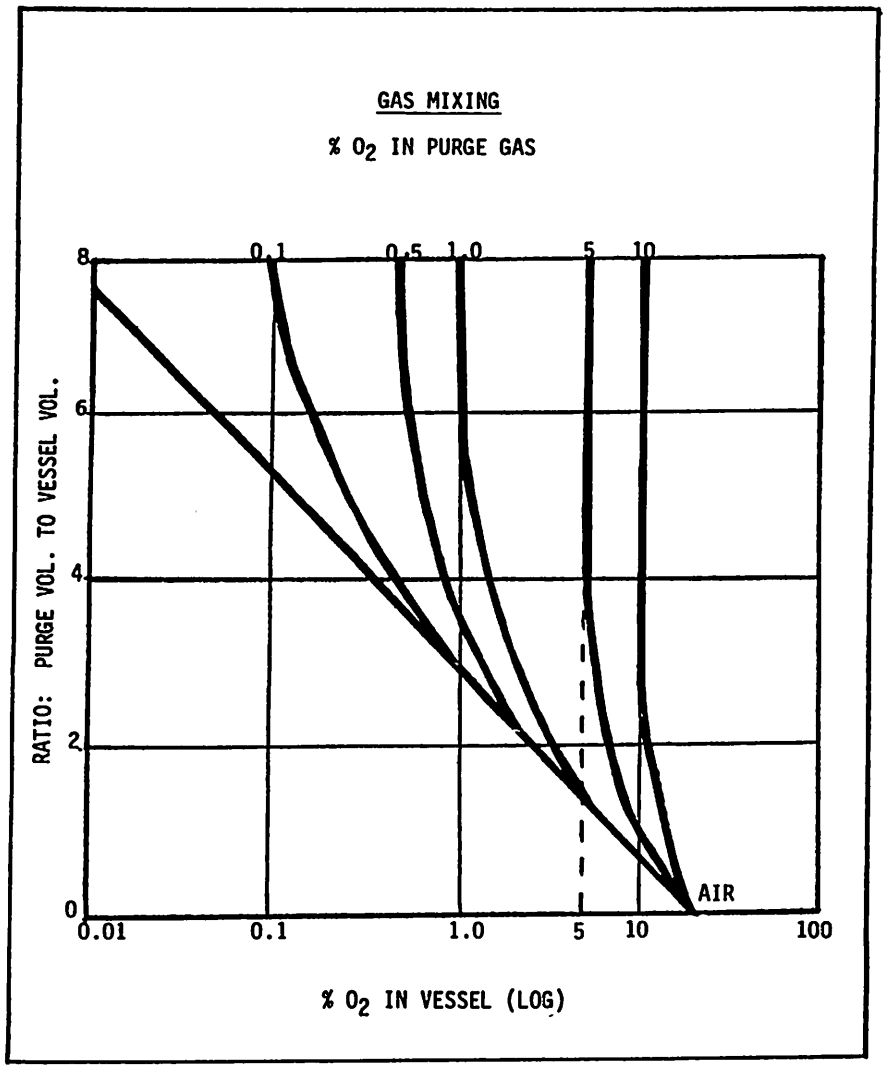
The waste product (30% O_2) can be used for water treatment systems as well and therefore be of double benefit for cogeneration.

Nitrotec's carbon technology can also be used for CO_2 and C_2H_4 removal.

N_2 Supply Purity

Due to the logarithmic equations dictating gas purging and mixing in an enclosure, Figure 1 shows that to achieve 2% O_2 after 4 volume changes a nitrogen supply concentration containing 1% O_2 would be sufficient.

FIGURE 1



PSA Nitrogen N_2 Generating System Description

Nitrogen gas generating system provides an air separation process which traps the oxygen molecules in compressed air by using special carbon molecular sieves and allows the nitrogen to pass through.

The process is quite simple in that alternating beds of these adsorbents are exposed to compressed air in a cyclic process of adsorption and desorption. Oxygen is rejected and vented into the atmosphere through a nitrogen purge containing 30% oxygen which could be utilized in other customer processes.

The system consists of three (3) basic modules.

A. An air compressor, along with its associated motor and controls.
B. A pulsation dampener, air cooled refrig dryer and filtration system are included on a common system skid.
C. A skid mounted Pressure Swing Adsorption unit (PSA) complete with a charge of carbon molecular sieve.

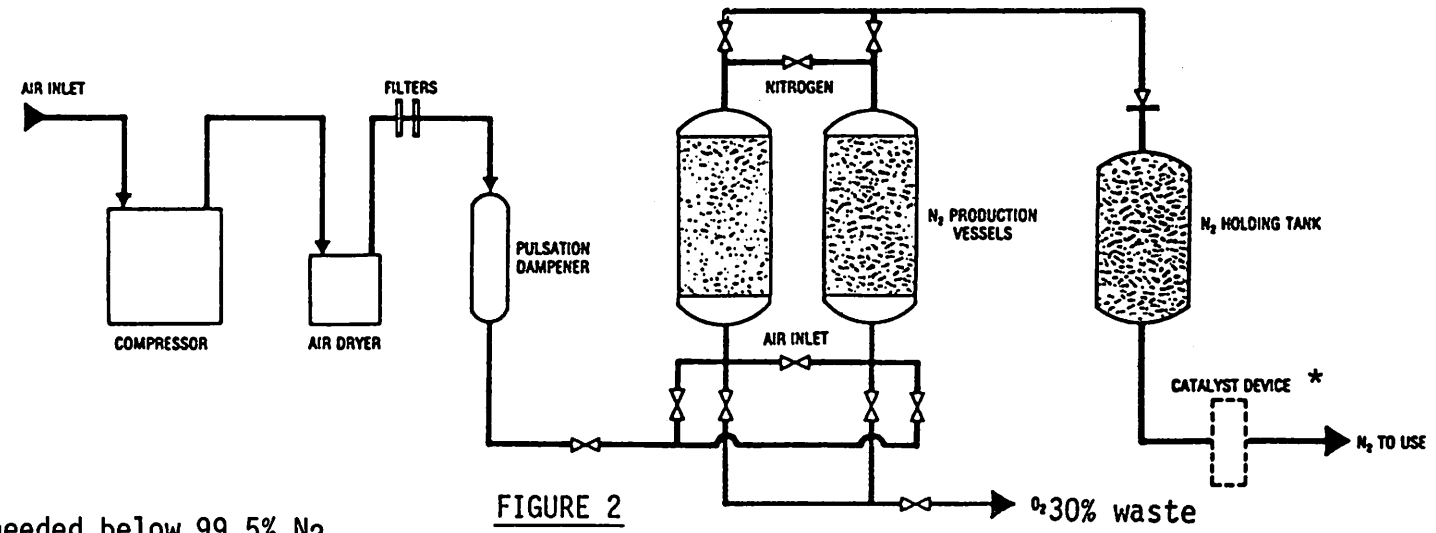


FIGURE 2

* Not needed below 99.5% N_2

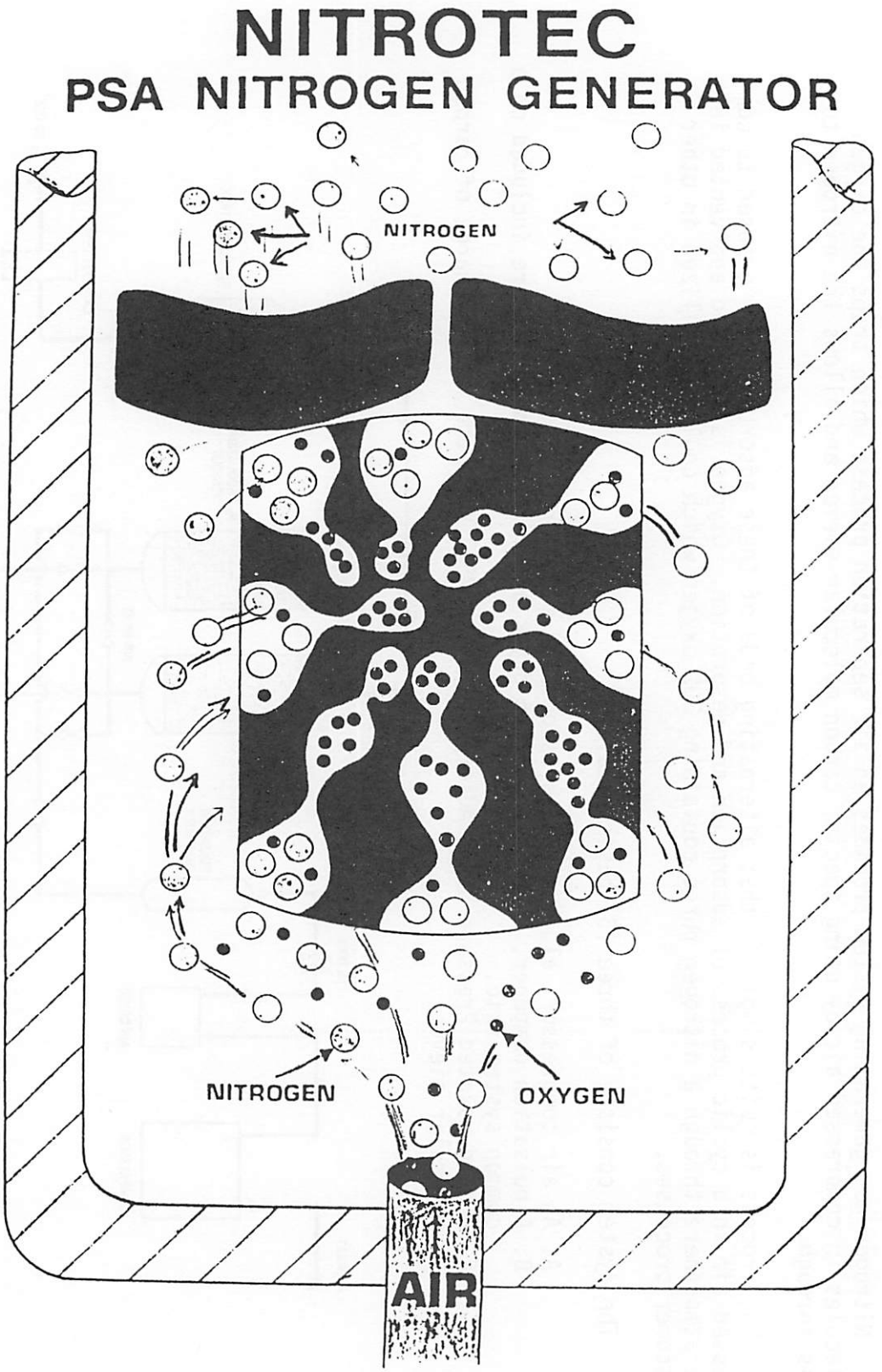

NITROTEC
PSA NITROGEN GENERATOR
NITROGEN
NITROGEN
OXYGEN
AIR

FIGURE 3

INERT-GAS PROTECTION - January 1983

J. D'Amico, Nitrogen Engineering Co.

Source	Description	Analysis	Capacity	Utilities	Cost/1000^3
Bottled N_2	High pressure bottles with cylinder gas regulators and pressure gages. Gas manifold for multiple cylinder arrangements	99.9% N_2 less than 0.1% O_2 less than -60°F D.P.	Up to 60 SCFH	None	$10-22
Liquid N_2	Liquid N_2 stored in on-site cryogenic tanks. Delivered by truck and referred to as "Merchant N_2"	99.995% N_2 less than 25 ppm O_2 less than -60°F D.P.	60-30,000 SCFH - Storage up to 15,000 gal of liquid N_2 (1,396,543 ft^3 gas) - Vaporizer may be required if demand exceeds boil-off rate	None, unless electric vaporizer needed	$5-9
Air Separation	A complete on-site air separation plant	99.995% N_2 less than 25 ppm O_2 less than -60°F D.P.	60,000 SCFH and up	Electricity water	$2-4
Pipeline N_2	Location close enough to major industrial air separation plant that cost to run pipe into customer's plant is feasible	99.995% N_2 less than 25 ppm O_2 less than -60°F D.P. - Oxygen attrition sometimes occurs after extended N_2 pipeline urns which result in O_2 levels of 0.2% which would then require a VAEI catalytic reactor to remove the excess O_2	Dependent on source ability	None	$.50-1.50
PSA N_2 (0.5% O_2)	Air separation via passing nonlubricated compressed air thru a dryer and then thru a bed of carbon molecular sieve	99.5% N_2 0.5% O_2 -40°F C.P.	500-30,000 SCFH 80 PSIG Multiple systems utilized for larger capacities	Electricity* water *Must compress 4 volumes of air to get 1 volume N_2 out	$1.00-1.30
PSA N_2 (0.5% H_2)	Same system as PSA N_2 (0.5% O_2) with the addition of a catalyst system to remove O_2 and a small dryer to remove H_2O residual	99.5% N_2 5 ppm O_2 0.5% H_2 -60°F D.P.	500-30,000 SCFH 70 PSIG Multiple systems utilized for larger capacities	Electricity* water, hydrogen *Must compress 4 volumes of air to get 1 volume N_2 out	$1.80-2.80

Conclusion

We have introduced PSA nitrogen gas generating technology to the food processing and food storage industry. Modification of that technology can be used to remove CO_2 and C_2H_4 by recirculation or utilization of a separate device with similar technology.

Nitrotec Engineering has other gas separation technologies which may better suit individual applications. Success in the Controlled Atmospheres industry will require utilization of state of the art technologies and close support to make them compatible to satisfy the market needs.