A Patented Atomizing Nozzle System Developed by the Naval Air Warfare Center at Lakehurst, NJ

Background

Scientific studies in the 1970's and 1980's strongly indicated that fluorinated compounds, such as freons and halons, contributed to the destruction of the UV light absorbing ozone layer in the upper atmosphere. Laws were then implemented (Montreal protocol and the US Clean Air Act) to curtail and eventually end the production of some of these materials. Due to the institution of a ban in the 1990's in using halons, the Navy established a program to replace the use of halon for fire suppression on aircraft and ships with a more benign fire extinguishing system. The preferred halon replacement system would utilize environmentally harmless and readily available extinguishing compounds for fire suppression without any loss in performance or protection of the existing system. One of the main criteria in developing an extinguishing system for use on an aircraft was that the system would need to be as small, lightweight and simple as possible. Joseph Wolfe, while at the Naval Air Warfare Center, Warminster, and now currently with Navy Lakehurst, developed a nozzle from this study that addressed each of these needs.

To effectively use a minimal amount of water to extinguish a fire, a method of delivering the water in a fine mist, with as low a gas pressure as possible, was the goal. The fine mist would accomplish two things. First it would effectively lower the temperature of the fire by the absorption of large amounts of heat through the latent heat of vaporization from the conversion of the water to steam. The fine mist would effectively achieve this by uniformly and broadly covering the fire and hot spots utilizing a minimal amount of water and maximizing the surface area. Second, the steam resulting from the vaporization of the mist would help to displace and thus remove the oxygen required to keep the fire burning. To further increase the effectiveness of extinguishing a fire, a non-oxidizing gas (such as carbon dioxide or nitrogen) can be used as the carrier gas for the water droplets. The gas efficiently atomizes the liquid and provides the energy to propel the small droplets a far distance onto the fire. Air was the carrier gas used with the liquid atomizing nozzle system that the navy designed and tested for use on aircraft. Additional research using the atomization concept and a chemical reaction of acetic acid and sodium or potassium bicarbonate in a hand held fire extinguisher configuration is also a promising alternative technology that has been patented. Both of these compounds, which are incorporated into the design of the system, are automatically combined together when the extinguisher is activated.

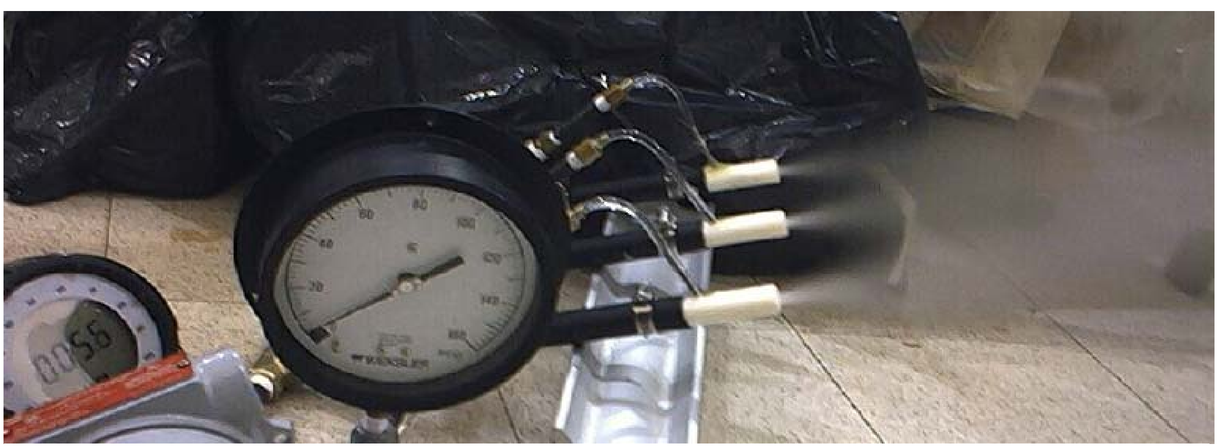

Figure 1. Three nozzles in parallel generating very fine mist with very low pressure gas.

A system incorporating this Navy patented atomizing nozzle has been successfully designed, developed and tested. As can be seen in the photograph in *Figure 1*, the nozzle can provide a very fine, high momentum mist at very low operating pressures.

Figure 2 is a picture of the system being tested and demonstrated within an aircraft cabin. To see a film clip of a demonstration of a fire being extinguished in the passenger quarters of an aircraft double click the icon below. This film clip illustrates the system's effectiveness in quickly extinguishing the fire and keeping smoke and fire contained within the area of the fire's origin.

To see film clip showing fire extinguishing demo Double Click Icon

Figure 2. Fire Extinguishing Test of Nozzle System in Aircraft Compartment

Significant Advantages Over Existing Fire Extinguishing Methods

Some of the significant advantages of using this nozzles for delivering water for extinguishing a fire as compared to the standard hose methods for supplying water to the fire are:

- Tremendous reduction in water damage due to lesser amount of water being utilized.
- Potential of using much smaller hoses, conceivably the size of garden hoses or smaller.
- Water mist generated can act as a smoke inhibitor / remover.
- Conservation of water.
- Potential of more effective fire extinguishing by using non-oxidizing carrier gas (N_2, CO_2, etc.)
- Capability may exist for injecting water mist into generally inaccessible areas such as
- between wall studs, roof joist, etc.
- Nozzle can be used to efficiently deliver other fire fighting agents such as foams, etc.

Benefits, Key Features, and Improvements Over Existing Nozzles and Atomizers

The features of this nozzle that make it very attractive are:

- It produces relatively small droplets within a rather narrow distribution range (droplets typically from 7 to 130 micrometers in diameter, and a mean diameter of around 50 micrometers). See ***Figure 3***.

- Very low pressures required for the carrier gas (typically on the order of 10 to 15 psi).

- High forward droplet momentum. Droplets have been shown to travel in a horizontal direction on the order of 30 feet from the nozzle when tested in an enclosed, wind-free environment. To see video clip demo that illustrates this high forward momentum Double Click Icon to the right.

- Non-clogging nozzle design.

- The nozzle's simple design enables it to be fabricated very inexpensively from cost effective materials such as plastics. For higher end, more demanding applications, the nozzle can just as easily be made using stainless steels, monels, inconels, ceramics, etc.

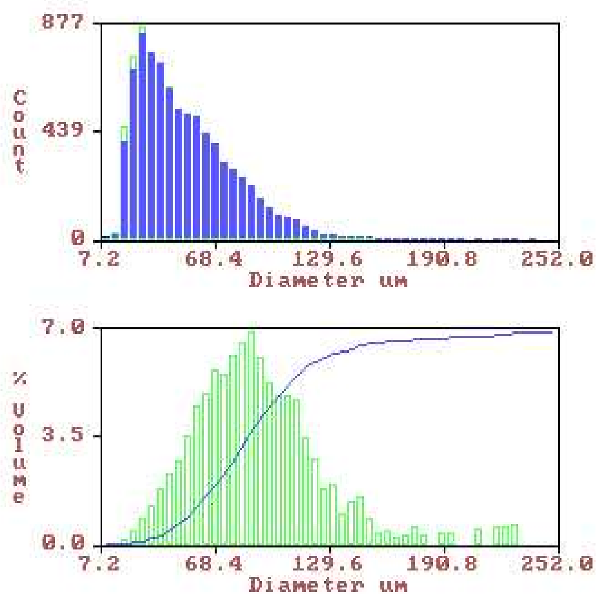

Figure 3 . Measured Droplet Distribution Plots as a Function of Droplet Diameter Size in Micrometers. For the Top Plot the Y Axis is the Number of Droplets for each Droplet Diameter and the Bottom Plot the Y Axis is the Per Cent Volume of overall liquid disperse that is in Each Droplet Diameter Size Range

Possible Nozzle Applications

The nozzle was designed specifically for creating very fine water mist for extinguishing fires on aircraft. The same features of this nozzle that make it ideal for extinguishing aircraft fires, also make it very attractive for other applications that utilize an atomization process. Some of these applications include:

- Portable, environmentally benign firefighting equipment
- Effective delivery of water for forest fire fighting
- Combustion of liquids or slurries
- Waste combustion and incineration
- Drying of materials
- Cooling of process gases
- Efficient airborne delivery of fluids for evaporative cooling
- Processing and/or mixing of materials
- Ice particle production
- Uniform, efficient application and distribution of materials on surfaces or in the air
- Deposition of materials and application of coatings
- Humidification
- Combustion nozzles; mixing fuel (oil, coal slurries, etc.) with oxidant; oxidant could be carrier gas that is air or pure oxygen
- Turbine fuel nozzles
- Fuel injection nozzles
- Smoke stack scrubbers, flue gas desulfurization (limestone solution mixed with flue gas)
- Eductors—nozzles that use high velocity air for mixing materials, powders, etc.
- Freeze drying
- CFC replacement cleaning systems such as the system developed by NASA Kennedy Space Center See website: http://technology.nasa.gov/Success_Story_Detail.cfm?PKEY=2038&category=Success%20Stories
- Uniform, efficient distribution of materials onto surfaces (I.e., pesticides, herbicides, fungicides, fertilizers, coolants, lubricants, cutting fluids, aromatics, disinfectants, flavorants, etc.)
- Uniform, efficient distribution of materials into the air (I.e., pharmaceuticals, aromatics, pesticides, smoke removal agents, etc)
- Deodorizers
- Aeration
- Animal cooling
- Special effects fog (theatrical, volcano and steam effects, theme parks, zoos, gardens, etc.)
- Dust suppression
- Industrial humidification (textiles, paper industry, furniture industry, chemical industry, etc.)
- Cosmetics
- Misting
- Washing
- Injecting liquids/solids
- Medical/medicine delivery

Figure 4 . Outdoor demonstration of nozzle system

Industries and Markets Where Nozzle Can Be Utilized

Because this nozzle can be easily adapted for many different applications, as seen above, this nozzle can be used in many different industries and markets. Some of these possible industries are:

- Firefighting
- Power generation
- Aeronautical and aerospace
- Food Processing
- Agricultural
- Medical
- Pharmaceuticals
- Detergents
- Paint and pigment
- Pollution control
- Chemical processing
- Ceramics
- Cosmetics
- Metal working and manufacturing
- Steel and metals
- Mining and minerals
- Recreational and entertainment

Nozzle Design and Patent Protection

The basic principle for this nozzle is the utilization of a convergent flow section for the gas and liquid injection which is immediately followed by a divergent flow section. The relative dimensions of the convergent and divergent sections along with the scheme for injecting the liquid into the gas stream is the key to obtaining small droplet sizes with high forward momentum and minimal applied gas pressure. **Figure 5** is a cross sectional drawing of the nozzle. The dimensions provided in the figure are only an example. For applications with lower or higher flow demands, the nozzle dimensions can be scaled down or up to accommodate the specific application requirements. This nozzle design is protected under patent 5,520,331. Patents 6,241,164 and 6,598,802 incorporate this nozzle design with a self contained carbon dioxide gas generating system. A number of other patents related to this nozzle technology have been submitted and are currently pending.

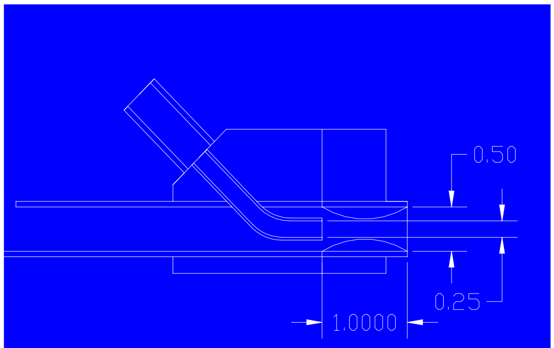

Figure 5 . Nozzle Drawing from Patent # 5,520,331

Companies Sought to Utilize the Nozzle Technology

The United States Navy is seeking companies and organizations that have an interest in incorporating this nozzle technology into their existing product lines or into new products. Exclusive, partially exclusive and non-exclusive licenses are available for U. S. based companies. In addition, a sub license is available through International Aero for some fields of fire protection. For the initial stages of involvement, a Cooperative Research and Development Agreement is one possible mechanism a company can use to become involved with the Navy and explore the potential for using the atomizing nozzle or related technologies for their specific application. A license for utilizing this patented technology can be obtained for specific market uses. There is also an interest in general nozzle manufacturing companies becoming involved. These nozzle manufacturers may have the opportunity to make and sell the nozzle to end user licensee companies. If you have an interest in this technology and would like to find out more please email Dr. Kevin Smith at ksmith@tech-scouts.net or call him at 724-539-8310.