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26 April 1994

U.S. Department of Energy
Office of Scientific and Technical Information (OSTI)
P.O. Box 62
Oak Ridge, TN 37830

Re: Final Report (due 5/1/94) - Mobile Zone, spray booth ventilation system
Grant# DE-FG01-91CE15489

Summary

I wish to thank all who were associated with this research project, in particular, Bill Brown the principal investigator. I am grateful for the opportunity; it has been a valued learning experience for me. Mobile Zone Associates was unable to commercialize the Mobile Zone technology during the grant period, July 31st, 1991 through January 31st, 1994. Yet, the design, fabrication, installation and testing were successfully completed. However, there is no question that we will commercialize it. The Mobile Zone unit built under the DOE grant is fully functional, thoroughly tested and suitable for use in an industrial environment. Additional detail is presented in the attached, peer reviewed article which appeared in the Journal of the Air & Waste Management Association.

Background

Painting is an integral part of manufacturing and service work that takes place at tens of thousands of sites across the United States. A common result of this painting activity is air pollution in the form of chemical gases categorized as Volatile Organic Compounds (VOC) and Hazardous Air Pollutants (HAP). Painting activity is also energy intensive. The Mobile Zone Associates have developed a unique technology which produces substantial benefits in terms of energy and pollution.

Many of the man made objects which we use each day have either decorative or protective coating. Most of these coating are applied as "paint" by means of a spray gun. Paint begins as a liquid mixture of resins and solvents. The primary function of all spray guns is to produce microscopic droplet from liquid paint. These droplets exit the spray gun nozzle and strike the workpiece. As the droplets land on the surface of the workpiece, they coalesce into a viscous liquid film which begins to polymerize as the solvent evaporates. Once the solvent evaporates it has no further use and becomes waste. Solvent typically makes up from thirty to seventy percent of the paint volume. Not all the droplets land on the work surface. The portion of the spray which does not become part of the surface coating is called overspray. Overspray has no use and becomes waste. During the painting process, overspray may

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account for ten to sixty percent of the paint which is sprayed. Needless to say, a substantial amount of waste is generated during the painting process.

This operation takes place in a ventilated work room called a spray booth. Functionally, it supports the painting process by removing the overspray and evaporated solvent wastes through its ventilating air exhaust system. These two wastes are quite different. The overspray is a visible, sticky dust. If exhausted to the atmosphere, it can cause local property damage which is easily traced back to the emission source. Fortunately, overspray can be easily and inexpensively captured by particulate filters installed in the exhaust system. The evaporated solvent is an invisible chemical gas. If exhausted to the atmosphere, it causes general personal and property damage. The damage is subtle and untraceable to its emission source. Unfortunately, it is difficult and expensive to capture since it is mixed into large volumes of exhaust air. For these reasons, overspray is popularly considered a pollutant which is captured and disposed of, while solvents (VOC) are not.

The perception of VOCs as a pollutant which must be reduced is slowly gaining a reluctant following as result of regulation. Complying with government regulation is often an unwelcome burden because it diverts a portion of our time and energy from serving our self-interests and can be very expensive. Whether the behavior change is active or reactive, we can take some solace and pride in the change. With the information currently available, the people who wrote the Clean Air Act believe it will establish a standard for indefinitely sustainable, environmentally sound economic activity. This Act will be fully implemented sometime after the year 2000. The 189 chemicals identified for control as pollutants include most of the current paint solvents.

The regulatory pressure has created movement in several areas. There is change in the materials; the coatings are more environmentally friendly with lower VOC content or none at all in the case of powder coatings. There is change in the application of coatings; the spray equipment has a higher transfer efficiency leading to a reduction of coating usage by reducing the waste. There is a change in the work room where the coatings are applied; the capture of the VOCs in the spray booth is more direct reducing the size and cost of abatement equipment.

This last change, the spray booth, is the work focus of Mobile Zone Associates. Mobile Zone Associates came to have an interest for two reasons; ventilation expertise and the opportunity to witness a very expensive abatement installation. In 1988, an aerospace defense contractor was required to install abatement equipment to eliminate VOC emissions from one of its paint booths. After only one pass through the spray booth, the ventilating air was sent to the abatement equipment. This caused the abatement to be commensurately large with matching capital and operating costs. The problem and the solution were obvious, the high cost could be dramatically reduced by reducing the quantity of air treated. The obviousness of the solution was the motivation for our efforts.

Eight years later, I have gained respect and certain wariness for the characteristic of obviousness. The initial approach to reducing the exhaust air from the spray turned out flawed and unusable. Dismayed but still enthusiastic, other technical solutions were considered at length and in detail. Finally, an approach was identified which met all performance, safety and cost requirements. This approach was initially developed to an engineering prototype stage with an U.S. Environmental Protection Agency small business innovation research grant. This approach found final refinement in the production prototype of the Mobile Zone funded with the Department of Energy grant. In retrospect, Mobile Zone Associates was somewhat lucky to identify a technical solution.

Mobile Zone Associates has not been so lucky in getting the technical solution into commercial use. The explanation is both simple and ironic; the demand is low. Low demand results from the high cost of treating the air pollution. In turn, low demand restricts the opportunities for new technology. There is a strong element of luck in introducing new technology, of being in the right place at the right time. It really helps if there plentiful opportunity. Lots of opportunities shorten the time required to match well a need with a technology. Few opportunities can mean years to make a good match.

I undertook the development of this technology with the enthusiasm born of the conviction that I would have a solution in short order. I was looking forward to the rewards for solving such a problem: the affection of family and friends, valued and compensated by society and enjoying work of my own making. Although I was certainly overconfident, at least I did not brag.

Evolution

The motivation for developing this technology sprang from the need of a customer to satisfy local air pollution requirements. The need was a one time need; in that once the regulation was satisfied that was it. However, the need was not insignificant; the price tag for satisfying it was close to one million dollars.

From the early 1980's to late 1980's, I worked in a company closely associated with capital improvements at Textron Aerostructures as a contractor. Textron was the subcontractor for several aerospace companies including Lockheed and Rockwell International. Textron built the wings for the B1B bomber. All the products produced by Textron required one or more coats of paint. Textron was one of the larger stationary sources of VOC in Nashville, TN. Since Nashville, like many cities, is an ozone non-attainment area, the air pollution regulatory agency took steps to reduce ozone levels by reducing VOC emissions. VOCs are an ozone precursor since VOCs photochemically react with nitrous oxide to form ozone. Textron's principal source of VOC emissions were the many paint spray booths it operated. The local air pollution regulatory agency required Textron to control VOC emissions on several paint booths at a cost of nearly one million dollars.

I was aware that the cost of treating VOC emissions from paint spray booths could be greatly reduced if the volume of contaminated air from the spray booths could be reduced. I was also aware that there were tens of thousands of paint spray booths which would potentially need treatment equipment. There appeared to be a significant need, a sizable market and product to satisfy the need. In short, everything to found and sustain a business.

Spray booths consume and contaminate large quantities of air because that is the way that they are designed. As designed they work well for their intended purpose in terms of performance and cost. However, if energy usage and air pollution treatment become factors, then the current design of spray booths do not work well.

My first solution concept was to localize the ventilation to where the painting activities was taking place within the spray booth. This operational feature will greatly reduce the volume of contaminated air which is exhausted. An array of exhaust damper would selectively operate responsive to the location of the painter. This idea turned out to be already well described in the prior art of patent literature. Unfortunately, it also had key operational deficiencies. The safety of the worker air supply was compromised and the spray booth had a large area of stagnant air which prohibited the establishment of laminar flow in the booth. It was clear that no workable concept had yet been put forth by anyone. After one and a half years of trying to improve this concept, I invented a new concept in 1986.

The new concept still localizes the ventilation to where the painting activity is taking place within the spray booth and greatly reduces the volume of exhaust air. Yet the new concept differs in that the machinery used to achieve this effect is located on the supply side of the spray booth rather than in the exhaust side. Most of the ventilation air is recycled through the booth to maintain a laminar flow across the entire booth cross section. Another difference is that the painter is carried in a cab within the booth. The cab also provides fresh air to the painter. This concept was developed and ultimately resulted in the U.S. Patent #4,926,746 issued May 22, 1990.

The physical embodiment of the concept was developed principally through first a U.S. Environmental Protection Agency SBIR research grant for \$50,000 and then a Dept. of Energy, Energy Related Inventions grant for \$73,950. The research work for both grants was carried out by Mobile Zone

Associates, the business name for William (Bill) E. Brown and Clyde Smith. It was my great good fortune to renew my association with Bill Brown through the work on the research grant. My initial association with Bill began as an employee of his company, Woods Metal Company, after I graduated from Georgia Institute of Technology with an engineering degree in 1974. I have benefitted from both my personal and professional relationship. Bill was a substantial contributor to the successful technical development of the Mobile Zone technology in his role as principal investigator.

The EPA grant began September 31, 1989 and finished March 31st, 1990. For a Phase I program, it was ambitious - to build a full scale machine incorporating the Mobile Zone technology. This was done as an engineering prototype and successfully tested. Ironically, Mobile Zone Associates's request for Phase II money was turned down with the explanation that we had developed the technology sufficiently for commercialization to occur. Essentially, we were victims of our own success to our dismay.

The Dept. of Energy grant began July 31, 1991 and finished on January 31st, 1994. Our research objects included the design and construction of a production prototype and two test installations. Mobile Zone Associates did built the production prototype and one test installation, at River Steel Co. in Nashville, TN.

Mobile Zone from the Product Viewpoint

Strengths

The present unit is relatively mature from a design viewpoint; any changes or improvements will be incremental and minor. Bill and I are not without talent and energy; we have been working on this for eight years. We have left nothing complicated in the design in terms of fabrication, installational, operation or maintenance. The Mobile Zone technology is still the only approach to minimizing energy usage and eliminating air pollution which provides safety and mobility to the worker. I am reproducing the design specifications which guided our work:

Mobile Zone Sample Specifications 2/22/91

A. Spray Booth Exhaust Reduction Subsystem

A Mobile Zone subsystem shall be added on or incorporated into the manual spray booth(s). A 60 to 95 percent reduction in the spray booth exhaust rate is expected. The owner intends to minimize the capital and operating costs of heating and cooling the spray booth ventilating air, as well as minimizing the capital and operating costs for treating VOC contaminated spray booth exhaust, as applicable. Other requirements follow:

1. subsystem shall have no negative impact on production rates or quality
2. subsystem shall have no negative impact on worker safety
3. booth shall retain laminar flow ventilation pattern with a nominal ventilation velocity of 100 fpm, adjustable up or down 20 percent
4. booth and subsystem shall incorporate multi-stage dry filtration
5. booth and subsystem shall meet current NFPA 33 standards without a variance
6. booth and subsystem shall meet current local, state and federal OHSA regulations without a variance
7. The mechanism shall be designed for longevity, reliability and maintainability including wherever possible stock materials and components.

B. Mobile Zone

To achieve the desired objectives, stated above, requires a machine having three principal functional features: a structure providing mobility to the worker, a locomotive and control system, and a mechanism capable of dividing and distributing the fresh and recirculated components of ventilation air. Since the Mobile Zone subsystem can achieve the objectives through a variety of forms, considerable latitude is available to accommodate owner preference.

1. Mobility and Structure

The first requirement is to define the access required by the worker or workers. Typically, this requirement will be expressed in degrees of freedom and travel limits. Subsequently, a structure can be designed to accommodate this movement.

2. Locomotion and Control

Although not necessary in every instance, movement should imitate the capabilities of the worker. Specifically, the worker should have proportional control including: the velocity of the movement (zero to 50 fpm), the rate of acceleration and deceleration. Additionally, limits, along with associated sensors, may be incorporated into the control system to minimize the possibility of inadvertent injury to the worker or work piece.

3. Ventilating Air Division and Distribution

Consistent with the structure, movement chosen and specific application parameters, various mechanisms may be suitable to establish and distribute the fresh and recirculated ventilation components. Cost, simplicity and space requirements are criteria by which a final selection may be made.

Weaknesses

The principal weakness is marketing. In retrospect, the number of people who expressed opinions on the necessity and desirable features of a Mobile Zone type product was too small. Too few had too much influence. My listening was also selectively biased. I do not consider this to be a big weakness, just a weakness. For the examples are countless where the opinions of a large number of people are just as foolish as those of a few. A slightly worse transgression is that the existing market for machine of the Mobile Zone type is small. We know that few commercial opportunities occur each year. Obviously, Mobile Zone Associates hears of only a fraction of those opportunities which occur each year. Although the perfect opportunity may occur next month, the statistical odds are that a long wait is likely. Our worst marketing transgression is the lack of a commercial champion. The group that should be most supportive of our efforts is the industries which use paint booths. Mobile Zone Associates can save these companies most of their expenditure for air pollution control equipment. Yet few must install equipment precisely because of its cost. If Mobile Zone Associates were to make air pollution control affordable then it would be self fulfilling. The regulatory agencies would require such equipment. Therefore, even when companies are under pressure to control their air pollution, these companies are reluctant to make Mobile Zone part of their response to their regulatory agency. This is not any conspiracy; yet it is the shared reaction to individual company encounters with the EPA.

Next Steps

There are avenues of action available. Mobile Zone Associates will promote its technology through both advertising and writing articles for trade journals. One peer reviewed article has already published and is attached as part of this report. At a minimum, we shall write two articles for Industrial Paint and Powder trade journal. Another avenue of action is to contact companies who have installed

air pollution control equipment on their paint booths. Provided their business grows, the Mobile Zone technology can greatly benefit them. Rather than installing new control equipment to allow expansion. These companies can retrofit their spray booths with Mobile Zone technology and generate smaller exhaust volumes. In such a way, the existing control equipment can be more efficiently used. This will be our focus.

Closure

This has been a learning experience, some of which I will now share. I would do it again if I had the chance to do it over. Yet, there is no doubt such a program takes a big commitment of time, money and energy. This time and energy should already be available to the researcher. If he or she is going to re-prioritize their life to make time, something or someone may lose out. At least short term, the re-prioritization will likely incur negative consequences and money will be chronically short.

I have been researching and studying the methods by which new products are successfully introduced into the marketplace. The method which I have selected after this review is Winning at New Products by Robert Cooper. Cooper's method is empirically based; he studied and compiled what successful product introductions had in common. He has even generated an empirical computer model (NewProd) to predict the probability of what new product ideas will succeed. I mention this because I have introduced it into the corporation where I work. What I have learned from the research grant, I will use my corporate effort. Additionally, what I learn from my corporate effort, I will use to commercialize the Mobile Zone technology.

Best Regards,

Clyde Smith

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