Contamination Control and Reduction Through Dry Ice Media Blast Cleaning

M.W. Lewis, Cold Jet, Inc., Loveland, OH

Keywords: CO2; Snow cleaning

ABSTRACT

Dry ice media blasting is a process that utilizes frozen carbon dioxide (CO_2) as a blast media.

Unlike sand, walnut shells, plastic beads or other grit media, dry ice has little molecular density and is therefore non-abrasive. Hence, the media virtually disintegrates upon impacting the area being cleaned. All that remains is the decontaminated surface which is residue free since the actual cleaning media vaporizes. Reclamation is limited to the removed contaminate.

This type cleaning/coatings removal offers the ability to clean production tools on-line during manufacturing without disassembly in many cases and with no abrasion.

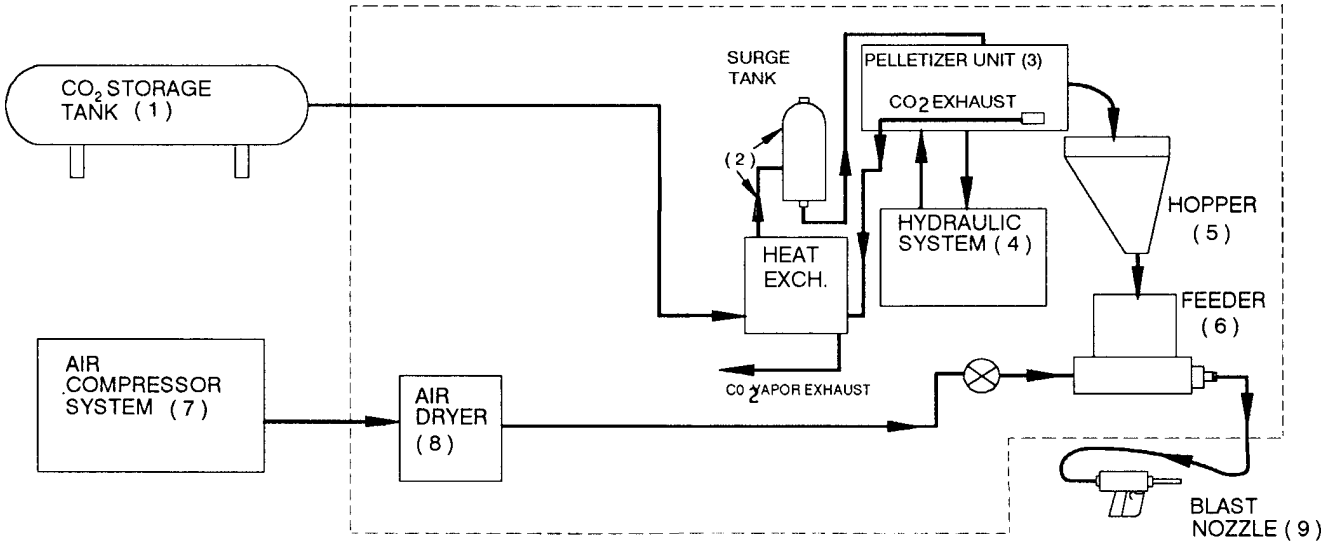
The dry ice media is produced by pelletizing liquid CO_2. It is then propelled at the contamination by compressed air via a specialized rectilinear blast nozzle which can be controlled either manually or robotically.

In general, a quick return on investment can be expected based on: no media reclamation or disposal, little or no tooling disassembly/assembly prior to and after cleaning, on-line cleaning capability during production, greatly reduced or eliminated surface degradation of tooling, and an increase in production part quality arising from the exceptionally clean operating environment.

DRY ICE MEDIA BLASTING

Dry ice media blasting is a process wherein pellets of solid CO_2 (dry ice) are propelled by a stream of compressed air or inert gas and directed at the surface which is to be cleaned or decontaminated.

Dry ice pellet media is produced by converting liquid carbon dioxide into a solid. This solid "ice cake" is then compressed through specially designed die plates to form pellets. The pellets are deposited into a hopper. On operator demand, the pellets are fed into a stream of compressed air and directed at the surface to be treated.



The Cold Jet system with its auxiliary equipment consists of the nine major sub-systems as shown in the above illustration.

Society of Vacuum Coaters 505/298-7624
35th Annual Technical Conference Proceedings (1992) 1-878068-11-3

The removal of contamination is accomplished by three primary factors: pellet velocity and mass (kinetic impact), pellet mass flow rate (number of pellets per unit of time in nozzle exit flow), and thermodynamic effects. Each one of these is controllable by the system and/or the operator to arrive at the optimum efficiency attainable for each application's usage.

Pellet impact energy is a product of pellet velocity and mass. Velocity is a function of pressure regulation through special nozzle assemblies. Velocities are matched in individual applications by controlling propellant pressure and/or choice of nozzles. The propellant stream, being either air or inert gas, may be subsonic, sonic, or supersonic when it comes into contact with any given surface. Pellet mass (and density) is mechanically adjustable so that the mass weight per cubic foot of pelletry can be changed.

Pellet mass flow rate is operationally controlled by regulating the dry ice feed rates into the propellant stream.

Other thermodynamically induced surface mechanisms are in effect to greater or lesser degrees, depending on the type of coating and the nature of the substrate. Because of the temperature differential between the dry ice pelletry and the surface being treated, a phenomenon known as "fracking" or thermal shock can occur. The scientific principle on which this process is based is that as a material gets colder, it becomes embrittled and may be broken up more easily. In fact, thermal shock can serve to break the bond between some contaminants/coatings and the substrate on which they are lodged. Since the process produces minimal kinetic and abrasive stress on the work piece being treated, damage to the substrate is virtually eliminated.

Another thermodynamic effect takes place as the solid CO_2 pellets impact the surface and instantaneously change phase to a vapor, absorbing the latent heat of sublimation and expanding rapidly at the point of impact. This gas expansion serves to increase impact pressure for efficient removal of the debonded contaminant particles.

ADVANTAGES OF DRY ICE BLASTING

Dry Ice pellet blasting offers a number of advantages to end users. The most important are outlined below:

Cost Reduction

The natural sublimation of dry ice particles eliminates the cost of cleaning media disposal; cleanup is reduced to the removed residues only. In addition, containment and collection costs associated with water and particle blasting procedures are also eliminated.

Improved Productivity

Because dry ice cleaning provides on-line maintenance capabilities for production equipment, timely and expensive detooling procedures are kept to a minimum. Dedicated cleaning cycles are no longer required, as preventative maintenance schedules may be adopted which allow for equipment maintenance during production periods. As a result, through put is increased without adding labor or capital equipment.

In addition, since the CO_2 pellets sublime upon impact and leave no residue, they do not harm hydraulics, machine bearings or other contaminant sensitive items. This makes it especially advantageous to use the CO_2 blast process on items which might normally require extensive disassembly, further cleaning for removal of the cleaning material, or masking to protect adjacent areas.

Extension of Equipment's Useful Life

The non-abrasive quality of dry ice pelletry means surface degradation of the part being cleaned is minimized, allowing it to wear more slowly. Dry ice blasting will neither create nor destroy the profile of a machined part. Furthermore, higher frequency cleaning shortens application time, further reducing the amount of cleaning related wear and tear on machinery and equipment.

Safety

Carbon dioxide is a non-toxic, non-polluting element which has been approved for industry use by the EPA, FDA, and USDA. By replacing toxic chemical processes with dry ice pellet blasting, employee exposure and corporate liability stemming from the use of chemical cleaning agents can be materially reduced or eliminated completely.

Non-corrosive, Dry Process

CO_2 pellet blasting is a non-corrosive dry process which can be used on chemically sensitive substrates and/or electrical components.

Environmentally Safe

Liquid CO_2 is obtained from other industrial processes, most frequently from ammonia and petrochemical plants, where it is an industrial by-product normally vented to the atmosphere; therefore, the use of dry ice blasting is not a net contributor of carbon dioxide to the atmosphere. The use of dry ice blasting is being studied by the Environmental Protection Agency, Risk Reduction Engineering Laboratory, Cincinnati, Ohio as an environmentally sound method of lead paint removal.

CAPITAL INVESTMENT

While liquid CO_2 is an inexpensive media, selling for approximately $.05 per pound with prices varying by quantity usage and geographic location; the price for a complete CO_2 blasting system is a fair size capital investment. However, a quick return on investment can be realized based on: No media reclamation, little or no tooling disassembly/assembly prior to and after cleaning, on-line cleaning capability during production, greatly reduced or eliminated surface degradation of tooling and increased production part quality due to an exceptionally clean environment around the production tooling.

CURRENT APPLICATIONS

While dry ice blasting is a relatively new technique, its acceptance has been wide spread. The United States Government has commended Warner Robins on their use of dry ice blasting for paint stripping and aircraft cleaning as a means of reducing environmental pollution and eliminating the health and safety hazards associated with aircraft maintenance.

In the molded products industry, dry ice is being used to clean release agents and residue build-up in molds This has proven to be an extremely successful application since the mold can almost always be cleaned on-line and the profile remains intact allowing for more frequent cleaning.

The automotive industry is using dry ice blasting to clean paint carriers, clean parts molds and deflashing.

FUTURE RESEARCH AND DEVELOPMENT

A recent study performed by the National Food Producers Association tested dry ice blasting as a means of destroying biofilms. The results of this study show that after dry ice blasting biofilm chips inoculated with either Salmonella enteriditis or Listeria monocytogenes, the chips tested negative for viable organisms.

Research is also underway to test the effectiveness of dry ice blasting for lead paint abatement, asbestos abatement and nuclear decontamination.