# Role of Pollution Control Equipment in Shot Peening Machines

Kailash Chaudhary
Assistant Professor
Department of Mechanical Engineering
MBM Engineering College, Jodhpur, Rajasthan, India

***Abstract*— Abrasive blasting can have minimal environmental impact if it is located in an appropriate area and sited, designed and operated properly. If proper care is not taken in addressing environmental issues, however, it has the potential to cause environmental harm. The necessity and importance of effective air and noise pollution equipment is evident in wake of prescribed environment and health or safety norms. The dust collector and air-wash separator are the "lungs" of a shot peening machine. The dust collector provides the necessary ventilation to remove dust from the blast cabinet. It also provides an air stream across the "air-wash" separator to clean the small fines and foreign contaminants from the shot before it is reused. All shot peening machines require good dust collection and air-wash separators for reliable and efficient long term operation. The average shot peening or blast cleaning machine can produce decibel levels between 85 and 125 dBA and experts agree that continued exposure to noise above 85 dBA over time will cause hearing loss. This paper covers the developments and applications of the pollution control equipments in surface finishing industry. It highlights the process characteristics, its operational features and its resulting influence over the control of environmental pollution. The process parameters are explained with a view to control the process in order to achieve the desired results.**

***Index Terms* — Shot peening, Environmental assessment, Pollution control**

## I. SHOT PEENING PROCESS

Shot peening is a process used to produce a compressive residual stress layer and modify mechanical properties of metals. Residual stresses are stresses that remain after the original cause of the stresses (external forces, heat gradient) has been removed. They remain along a cross section of the component, even without the external cause [1].

Shot peening is a cold working process in which the surface of the finished part is bombarded with shots under controlled conditions. Each shot acts as a tiny peening hammer; making a small dent in the outer surface of the metal (Fig. 1). This impact causes a plastic flow of the surface fibers to a depth depending on the angle of impact, size of shots and physical properties of the material [2]. The resultant residual stressed surface layer, which is in compression, prevents formation of cracks, thus increasing the life of the component (Fig. 2). The maximum residual compressive stress produced on the surface is at least half the ultimate tensile stress of material. Shot Peening serves to increase the fatigue strength of parts subjected to high alternating bending or torsional stresses. The process has very effectively replaced other time consuming and expensive processes of improving fatigue strength. It permits the design of less expensive and light weight components.

Conventionally, when a part is not able to withstand the stresses that it is required to, a lot of trial and error effort is put into design of the part. Its material may be changed, the part may be subjected to heat treatment process, attempt may be made to change its machining techniques, or the designer may even go to the extent of changing the design of the part. If analyzed properly, it may be found out that all the above exercises are totally uncalled for. What may have offered a better solution at a nominal cost could have been the shot peening of the part [3].

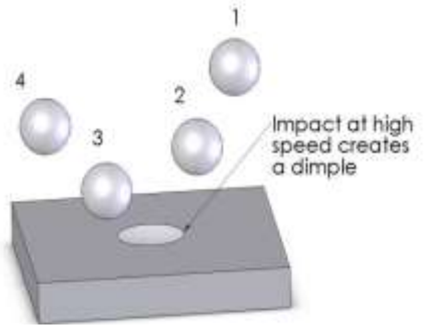



Fig. 1: Shot Peening Process

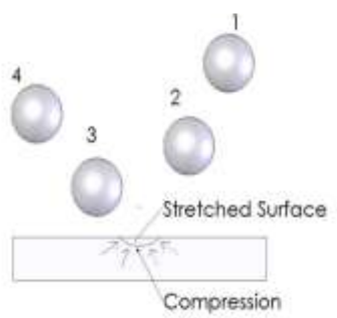



Fig. 2: Shot Peened Surface

## II. ENVIRONMENTAL ASSESSMENT FOR SHOT PEENING

Abrasive blasting can have minimal environmental impact if it is located in an appropriate area and sited, designed and operated properly. If proper care is not taken in addressing environmental issues, however, it has the potential to cause environmental harm. Key environmental issues are: air quality, noise, water quality and waste management. The environmental information required to undertake an adequate assessment is related to separation distances from residential or other sensitive receivers, air quality protection measures, noise mitigation measures and water demand and use. Water and soil protection measures including wastewater containment and disposal, chemical storage and work areas, storm water pollution prevention, solid waste storage and disposal.

*2.1 Air Quality*

All abrasive blasting must be carried out in a cabinet constructed to contain the emission of particulate matter (generally dust) from the blasting operation. The blast room or cabinet must be totally enclosed and vented to the atmosphere through an effective dust collector, preferably a fabric filter or paper cartridge. Filters must ensure that the maximum pollution level of solid particulates in each cubic metre of residual gases does not exceed 250 mg per cubic metre of exhaust air. For air quality purposes, the recommended minimum separation distance between the abrasive blasting room or cabinet and the nearest residential (or other sensitive land use) premises is 50 metres. All exhaust ducts should terminate at least 3 metres above the highest structure within a 30- metre radius of the exhaust. Discharge from the dust collector to the atmosphere must be vertical, at a minimum discharge velocity of 10 metres per second. All cabinets that have external exhaust ducts should meet the required separation distances.

*2.2 Noise*

The machine manufacturer and user should take all reasonable and practical measures to ensure that the activities on the whole site, including during construction, do not pollute the environment in a way which causes or may cause environmental harm. It must not exceed the relevant maximum noise levels. Note that operation outside usual business hours may well result in impact off-site, particularly at night time or early morning when background noise levels are usually lower [6].

*2.3 Water Quality*

Pollutants generated by abrasive blasting should be prevented from entering water bodies (including groundwater) through direct discharge, seepage or through contamination of storm water. Pollutants may include suspended solids, grease, lubricants, solvents, nutrients and oils.

*2.4 Wastewater Management*

Hazardous materials (fuels, oils, pesticides and other chemicals) must be stored in a bunded and preferably rainproof area to minimise the risk of surface/groundwater contamination.

*2.5 Storm Water Management*

Roof storm water should be collected for reuse and must be managed separately from potentially contaminated runoff (i.e. from car parking and other hard paved areas). The facility should incorporate a storm water management system for all areas where contaminated runoff may be generated (including car parks). Structural controls such as bunded storage areas, first flush diverters, gross pollutant traps, oil/water separators, hydrocarbon absorbers, in filtration basins (eg grassed or vegetated swales, garden strips or stone filled trenches), sediment traps or soluble pollutant removers are all acceptable methods. Storm water treatment specialists should be consulted to determine which management systems will be most effective.

*2.6 Water Conservation*

Abrasive blasting facilities should incorporate systems that enable the containment and reuse of water (including treated storm water and wastewater) to replace potable (mains) supplies for operations such as landscape irrigation, toilet flushing and process water (eg machine cooling and cleaning).

*2.7 Waste Management*

All used abrasive and waste products generated during abrasive blasting (i.e. surface coating, spent media, filter cartridges, personal protective clothing) must be contained and securely stored before disposal to a licensed waste depot. Abrasive waste that contains toxic heavy metals (e.g. lead) must be disposed of at a licensed hazardous waste facility approved to take heavy metals. Silica-free abrasives must be used.

## III. SOLUTION

The first step toward the solution is acknowledging the problem; and since everyone is part of the problem, we all must be part of the solution. We are moving in the right direction but it is a continuous process that takes great effort.

From the perspective of one whose life is devoted to an industrial process, air blasting, I know first-hand that it can be a dirty business. Without following the proper steps, blasting can definitely pollute the air, and the land, and also the water, depending upon waste disposal methods. However, with appropriate engineering controls in place, blasting need not offend in any category.

As a manufacturer, we respond to market needs, which are driven by people who respond to others. Besides our marketing responsibilities, we want to be good planet citizens as well. So, we engineer our products to help our customers be good planet citizens.

You wonder how this is so. Well, the blasting industry has many environmentally-friendly facets. Some examples follow.

• Blasting with plastic media came about in response to a need of the United States Air Force to eliminate or at least substantially reduce the use of caustic chemicals as stripping agents to remove paint from aircraft. Using plastic or other lightweight media indirectly reduces pollution by reducing the amount of waste that is stored in landfills or ends up in a waterway. Other lightweight media can be organic, such as starch, corncob, walnut shells, rice hulls, fruit pits or ground corn. These media decompose, further reducing landfill waste. Over the past 25 years, many thousands of aircraft have been stripped with plastic media.

• Dust collection protects air quality and helps prevent air pollution. Common to our industry is reverse-pulse dust collection, which when combined with HEPA (High Efficiency Particulate Air) filtration does an admirable job of reducing air pollution. HEPA filters can remove at least 99.97% airborne particles 0.3 micrometers (µm) in diameter.

• Blast rooms protect the environment by providing an enclosure for the blasting activity. Such enclosures are generally equipped with recovery systems that capture the media and contaminants removed from the object being blasted. Sophisticated recovery and cleaning equipment separates the dust and contamination from reusable media, allowing the media to be recycled sometimes hundreds of times. Recycling media conserves energy by reducing the media consumed. Less media means less fuel used to transport it.

• In blast cabinets or rooms, aluminium oxide media is used for industry or artistry for etching glass as an alternative to chemical etching methods. Glass bead media is used to blast medical parts, eliminating the need for toxic chemicals required for the passivation process.

• Shot peening improves fuel efficiency by reducing friction and increasing oil retention. It is used to improve permissible stress levels of components and therefore prolongs service life of automotive parts. Peening to strengthen parts can reduce vehicle weight, thereby reducing fuel consumption.

## IV. AIR POLLUTION CONTROL EQUIPMENTS

The necessity and importance of effective air pollution equipment is evident in wake of prescribed environment and health/safety norms which helps in reducing air pollution in work-areas. The various types of air pollution control equipment are:

1. Cartridge Filter Type Dust Collector
2. Fabric Bag Type Dust Collector
3. Cyclone Type Dust Collector

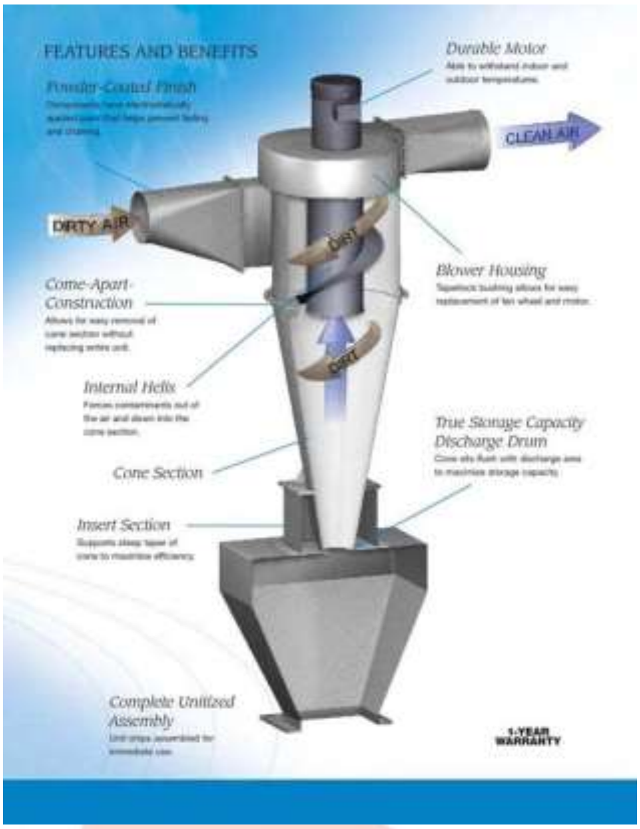
*4.1 Cartridge Filter Type Dust Collector*

Cartridge Filter Type Dust Collectors have a reinforced pleated paper filter element, these high efficiency filter elements have efficiency of about 99.99% to filter the air upto 3 microns . Modern type of cartridge filter dust collectors use reverse pulse jet to clean the filter periodically.

*4.2 Fabric Bag Type Dust Collector*

In Fabric bag dust collector, dust-laden air is drawn from the blast room into fabric bags of the dust collector with the help of exhaust fan. Dust is retained inside the bags and fresh air goes into atmosphere. The bags shaking mechanism shakes the bags periodically through timer controls to remove dust from bags.

*4.3 Cyclone Type Dust Collector*




In cyclone dust collector, dust-laden air is drawn from the blast room into dust collector with the help of exhaust fan. Due to cyclonic effect heavy particles are settled in the hopper and fine dust goes into atmosphere.

## V. NOISE CONTROL

First, we need to understand that sound or noise is created by vibration and measured in frequency or Hertz which are cycles per second. The typical hearing range of humans is from a low frequency of 20 Hz to a high frequency of 16,000 to 20,000 Hz. As we age, or as our hearing becomes damaged, we lose the ability to hear the higher frequency sounds.

As a machine builder, we need to assess the noise source and frequency in order to treat the overall machine noise level. There are three common methods we use to reduce the noise level and each works best with a certain range of frequencies.

The higher frequencies are better affected when the noise is absorbed; the mid-range frequencies are treated best by creating barriers and the lowest frequencies need to be isolated. A typical shot peening machine will have all cabinet inlet or outlets, such as air inlet stacks on the roof of the cabinet and dust collector fan discharge areas, lined with a fibre or foam material. Often, they are covered with a perforated sheet metal. Absorption materials act to dissipate noise and reduce the reflections of the noise waves.

The mid-range frequencies are treated with barriers. The peening cabinets are fabricated of 1 /2" thick sheet steel and all welds are solid seam welds. Any doors or windows are treated with a double skin or double glazing with a foam absorption material packed between the layers.

This method effectively blocks the transmission of the noise. Special care is taken to seal any areas where the blast hoses or robot enters the cabinet. The low frequency noises are treated by isolating the machine from the plant floor with engineered machine vibration isolation mounts or feet. This method decouples the source of the noise from any path that would allow further transmission; it’s very surprising to see how well the machine low frequency noise travels to the plant floor and is amplified. Additionally, we attach foam material to the underside of our machine hoppers to eliminate the noise from further reflections between the machine underside and the plant floor. After the noise sources are treated, we locate the operator in a position around the machine where the noise is well treated or will be at the lowest dBA point. Machine manufacturers should advise the customers on the best or better location in their facility to place the machinery. A location too close to a wall will actually amplify the machine noise.

The last consideration as a machine builder with regards to machine location should be the ambient noise that exists in the area; the ambient noise will affect and increase the noise level of the new machine. An example of this is a machine that operates with a noise level of 80 dBA is placed near another machine that operates at 80 dBA, the combination of the two machines will produce a noise level of 83 dBA.

## VI. THE INDUSTRIAL POLLUTION PREVENTION PROGRAM

Through proper management and operating practices, the industrial pollution can effectively be reduced significantly. The net effect of a pollution prevention program is to improve the economic worth of the industry by lowering expenditures on pollution control measures as well as minimizing regulatory burdens.

The industrial pollution prevention program can be conducted at a manufacturing facility that produces fabricated metal products for industrial use including structural steel members and plates, in addition to a wide variety of structural bolts, fasteners, and so on. During manufacturing, the facility performs many operations including electroplating, conversion coating, cleaning, machining, grinding, impact deformation, shearing, welding, sand blasting, hot-dip galvanizing, painting, assembly and testing. Many of these processes result in the production of hazardous pollutants that must be disposed of in some fashion. For example, the electroplating line results in the production of acids and rinse water containing zinc and chromium and the hot-dip galvanizing line results in the production of acids and rinse water containing zinc, lead and iron. The painting processes result in the production of used industrial acids, solvents, and chemicals used for cleaning and degreasing metal components.

By design, the initial recommended operational changes and process modifications to the plant to prevent or reduce waste are simple to implement, and their pay-back periods are fairly short. For example, modifications requiring minor structural changes in galvanizing resulted in reducing rinse water use by about 60 % thus leading to savings in water consumption and waste treatment. Additional modifications requiring larger investments can also be done for implementation by the facility after initial modifications were completed.

Pollution prevention encompasses all activities leading to the elimination of waste materials at the point of generation. Generally, within an industrial facility, pollution prevention programs constitute organized, comprehensive, and continual efforts to systematically reduce waste generation. By reducing the generation of wastes, industrial facilities can save money on raw material purchases, material handling fees, disposal fees, and other operating costs. In addition, potential environmental liabilities can be reduced and worker/public health and safety can be enhanced. Hazardous waste generators also can benefit from any improvements in the general quality of the environment as well as an enhanced public image resulting from their involvement in pollution prevention activities.

## VII. PROCEDURES AND METHODS

A work plan for the pollution prevention assessment program can be developed. The work plan consisted of several tasks which are summarized as follows:

1. A detailed assessment and evaluation of current practices in the areas identified above along with a detailed characterization of all wastes produced by the facility.
2. Identification and delineation of all possible pollution prevention and minimization opportunities.
3. Economic and technical evaluation of all waste prevention and minimization alternatives including short as well as long term impacts of these alternatives.
4. Recommendation to the management of the manufacturing facility for implementation based on economic priority in terms of greatest benefit and shortest pay-back periods.
5. Providing technical assistance, where appropriate, during the process of implementation of the recommended alternatives.
6. Review of the results and impacts on waste prevention after implementation of the alternatives.

In developing this program at the industrial facility, emphasis should be placed on areas where the impact on reducing the total pollutant load produced by this facility is greatest. In developing a work plan, a multi-media approach is emphasized in developing pollution prevention and minimization strategies affecting all operations and processes [5].

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