BASIC ASPECTS OF SHOT PEENING AND CONVERSION OF CENTRIFUGAL BLAST CLEANING MACHINE TO A PEENING MACHINE

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ABSTRACT

Shot Peening process relies on multiple impacts of spherical media to a surface to achieve residual compressive stresses. This results in improved material characteristic. Out of the two methods of propelling shots for peening viz. Airless Shot Peening and Pneumatic Shot Peening this paper deals with essentials of centrifugal Blasting Machine and converting a centrifugal Airless Blast Machine to a Shot Peening Machine.

KEY WORDS

Arc Height, Almen Gauge, Magna Valve, Rotary Screen Separator and Shot Classifier.

1. INTRODUCTION

Shot Peening is a cold working process in which the surface of finished part is bombarded with shots in special machine under fully controlled conditions. Each shot acts as a tiny peening hammer, making a small dent on the outer surface of the metal. This impact causes a plastic flow of the surface fibres to a depth depending on the angle of impact, size of shots and physical properties of material. The resultant residually stressed surface layer, which is in compression prevents formation of cracks, thus increasing the life of component tremendously. The maximum residual compressive stress produced on the surface is at least half the ultimate tensile stress of material.

Shot Peening is today an established process and has proven its value in over hundred of applications. Some of the important applications are to increase the fatigue life, to prevent the stress corrosion cracking; to form or correct the shape of sheet metal and other components, to overcome porosity, to work harden the surface and to permit use of very hard metals subject to fatigue and impact loads etc. The benefits of Shot Peening are to eliminate failures of existing designs, permit use of higher stress levels, permit use of inexpensive carbon steels in lieu of costly alloy steels, permit complete/partial elimination of costly manufacturing process like grinding and permit weight reduction for new design. Thus for large volume of production, there will be tremendous saving.
in material & manufacturing costs.

Arc Height is the measurement of Shot Peening intensity in terms of curvature of an almen test strip peened on one side and measured on Almen Gauge. The time necessary to produce saturation on a test strip is defined as the time required to achieve specific arc height which will not increase over 10% if the exposure time is doubled. An arc height is not termed as intensity unless saturation is achieved. When peening for fatigue and stress corrosion cracking, all the critical areas should be fully shot peened. Coverage is defined as the uniform and complete denting of the original surface of the work piece determined visually using a 10 power magnifying glass or peenscan.

The two methods of propelling shots for peening are Airless Shot Peening and Pneumatic Shot Peening. The choice of method of shot propulsion is done by considering the size design and quantity of parts to be peened. In production peening, the airless method is usually preferred and the use of Pneumatic Peening is confined to a limited number of jobs viz. peening in holes, inside pipes, for low production requirement like Aircraft industries and for R & D applications. The Airless Shot Peening operations are sometimes handled in the same type of equipment as general purpose machines designed to blast clean. It is often advantageous to provide a machine of special design to suit a particular job.

2. CENTRIFUGAL BLAST CLEANING MACHINES

Blast cleaning is a process where abrasive particles are propelled at high velocity to impact the surface to be cleaned and forcefully remove surface contaminants. This process is often used to provide a uniform cosmetic finish or etched surface in addition to merely cleaning the work piece.

Centrifugal wheels are the most widely used method because of their ability to propel large volumes of abrasive efficiently. For example, a 75 hp centrifugal wheel can accelerate to a velocity of 7.5 m/sec at a flow rate of 56000 kg./h. To do the same with 13mm diameter nozzle would require 20 nozzles and an air compressor driven by a 940hp electric motor. It's obvious from an energy viewpoint a centrifugal wheel machine should be used whenever possible.

Every centrifugal shot blast wheel machine has the following components:

* One or more centrifugal wheel
* Work handling system
* Abrasive handling system
* Abrasive cabinet
* Dust collector

Centrifugal wheels are commonly used in diameters ranging from 12" to 19 1/2". There are a number of differently shaped blades or vanes used, depending on the work being cleaned. Most wheels incorporate an impeller and control cage to feed the abrasive media on to the wheel of the vanes. The abrasive
stream can be targeted by simply rotating the control cage.

There are five factors that affect cleaning rates by centrifugal wheels;

* Abrasive Velocity
* Abrasive flow rate
* Abrasive distribution
* Angle of impact to the work
* Size, shape and hardness of the abrasive.

Any abrasive velocity can be achieved by sizing the diameter of the wheel and RPM of the wheel.

Abrasive flow rate is important to the cleaning process because it is abrasive particles impacting the work piece that performs the cleaning. More impact means faster cleaning. The total horsepower required depends on the optimum abrasive velocity to be used and the amount of abrasive per hour needed to cover the work being cleaned. At standard speed wheels can propel 1035 kg of abrasive per kilowatt per hour.

There are a number of methods used to achieve proper abrasive distribution for a specific application. The first is simply choosing the wheel diameter that comes close to producing the optimum abrasive stream. The abrasive stream can then be refined to satisfy the requirements through the use of special control cage opening.

The work handling systems simply deliver the work pieces to the abrasive stream and carry the piece to the next operation after cleaning is completed. The example of such work handling systems are Swing Table, Rubber belt Tumbler, a rubber belt or chain conveyor etc.

A typical abrasive handling system includes a screw conveyor that will deliver abrasive thrown by the centrifugal wheel to a bucket elevator. The bucket elevator lifts the contaminated abrasive and delivered it to a gravity type air wash separator. Abrasive handling system are designed to meet the requirements of a specific machine application.

The shot blast cabinet serves two purposes, it supports the centrifugal wheels and contains the high velocity abrasive particles preventing these particles from entering the work area around the machine. The cabinets are normally fabricated from mild steel plate and covered with replaceable wear plates in the direct impact zone. The other part of the cabinet are lined with resisting rubber sheets.

The use of manganese steel plates as replaceable wear element has gained popularity in recent years. The manganese steel work hardens from impacting steel shot. This mode of manufacturing blast cabinets reduces the initial cost of the manganese cabinet vs. mild steel. It's cost effective once installed because of extra wear plates do not have to be maintained.
The other important feature incorporated into the blast cabinet is the work opening-sealing device. This can be a simple manual door, or a series of flexible finger seals that conform the contour of the workpiece passing through the cabinet. It’s important to remember that centrifugal whel machines propel thousands of kg. of steel shots per hour at a very high velocity. The abrasive particles must be contained within the cabinet to prevent injury to employees working near the machine.

An important consideration is the dust collection system. Every blast cleaning machine generates dust of some type. Rust pulverised mill scale, paint and other contaminants are removed from the surface of the part being cleaned. Air flow through the air wash separator is initiated by the dust collector. The blast cabinet usually requires six air changes per minute to remove the dust generated by the blast action.

3. CONVERSION OF SHOT BLASTING MACHINE TO SHOT PEENING

Converting a Shot Blasting Machine to a Shot Peening Machine necessitates following improvement, since Shot Peening Process is a controlled blasting operation.

Following factors should be closely controlled:
* Distribution & Angle of impact.
* Size of shots
* Regular supply of shots to the blast wheel

To control aforesaid factor, following attraction should be incorporated.

3.1. Shot Distribution and Angle of Impact

![Diagram of conveyor travel]

Fig. 1. Conveyor travel
Concentrated blast not necessary in some type of work

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One of the most important qualities of a good peening wheel is a concentrated blast and a provision for locating this concentrated blast properly in relation to the work. Almost any centrifugal blast wheel designed for projecting shots can be expected to do a good peening job but if the blast is inefficient the cost of peening operation will be excessive for a given life increase.

In peening machines, normally concentrated blast patterns are preferred but there are certain applications where long spread is equally more effective. Example of the same is depicted in Fig. 1.

In this particular application cylinders are being shot peened in such a way that as they advance they rotate on an axis. In this case the shots strikes the cylinder at right angles regardless of its position in the blast. For such applications concentrated blast pattern is just as effective as spread blast pattern. However, in case where concentrated blast is important for peening it is equally important to ensure that the control cage is adjusted in such a way that the blast is directed at right angles to the work. Lower compressive stresses would be inducted if the shots strike the components at large angles from vertical. It is thus important to carefully study the shot distribution pattern of the blast wheel for various shot peening applications.

Fig. 2. Plots of shot distribution produced by typical centrifugal wheels patterns at 7 1/2 degree increments of wheel. The axis of wheel is located 762 mm (30") from the sample sheet. Typical patterns are obtained by varying the control cages, triangular or modified triangular (A) rectangular (B) and patented impeller and blade configuration.
Fig. 2 depicts some typical wheel stream patterns that show the percentage of shot distribution every 7 1/2 segment of wheel stream: curve "C" has much more of its shots in the hot spot zone than does the long pattern curve "A".

Knowing this distribution enables the manufacturers to apply the centrifugal blast stream more optimally on the work to be peened. Pattern "B" in Fig. 2 can be considered a standard pattern which is achieved by using a control cage with rectangular opening. Pattern "A" can be achieved by use of a triangular or modified triangular opening in the control cage.

3.2. Size of Shots

Fig. 3. Rotary Screen Separator

For consistent results and economical operation a production peening machine should be equipped with separator which is capable of continuously removing broken shot from the machine at the same rate at which they are broken. The breaking of shots in a peening machine is fatigue fracture, i.e. the type of failure which occurs after a number of repetitive application of load or stress. The number of applications of stress before failure occurs is commonly referred to as "fatigue life". The result of this phenomenon is that, when a peening machine is loaded with new shots and put into operation, little or no breakage of shot
will be encountered until its average fatigue life is approached, at that point the quantity of new shots with which the machine was started will breakdown rapidly.

If these broken shot are not removed, they will continue to fracture into smaller particles, leaving only a small percentage of full size shot in the machine. Obviously, in an efficient shot peening machine, they are replaced by full size shots no sooner they disintegrate. However, if their removal is delayed, fluctuation in the shot size will be reflected in the fatigue life of the peened parts. Thus it becomes evident that in a continuous shot peening machine the failure of shots as well as the removal and replacement of broken shots should be continuous. Hence, an efficient and properly adjusted separator plays a vital role in maintaining uniform intensity on the peened components. Refer Fig. 3.

The CFS separator is standard on all shot peening machines and offers the following outstanding features that are essential for separator efficiency.

* The CFS is designed to utilize compensating flow to present a full length curtain of shots to the air washing currents.

* Low shot velocity: The shots begins to fall from zero velocity, the uniform low velocity curtain permits a more thorough “air Washing” of the shots.

* Eliminates Wear: CFS is designed so that shots move on shots, not on separator parts.

* Rotary Screen: The Rotary Screen removes any foreign material from the shot and discharges it through a refuse spout to a floor level container.

3.3. Regular Supply of Shots to the Blast Wheel

Fig. 4. Automatic Shot Replenishing System

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As has been discussed earlier that an efficient separator will remove the broken or under sized shots from a shot peening machine at the same rate at which they are generated. This in a continuous shot peening machine will reduce the level of shots in the feed hopper and stage will come when the storage hopper will not be in a position to supply adequate quantity of shots to the blast wheel. This will result in reducing the peening intensity.

Thus shot adding device should be provided with a shot peening machine and only round and uniform size shots should be filled in it. This shot adding device or automatic shot replenishing system depicted in Fig. 4 senses the level of shot in the storage hopper with sensing probes and no sooner the level comes down to a predetermined level i.e. lower sensor, the dipper valve of shot adding device is automatically opened.

The full size shots are added to the storage hopper through the bucket elevator till the level of shots in the storage hopper reaches to the upper sensor. In a continuous shot peening machine, for uniformity in peening and economy of peening operation the shot peening machine must be operated under a stabilised condition. It is that condition of a shot peening machine in which the rate of breakdown of shot is constant, the rate of removal of broken shots is equal to the rate of breakdown and new shots are added into the machine at the same rate. It implies that a minimum of broken shots remain in the machine during stabilised condition.

The addition of the features as discussed above will convert Shot Blasting Machine into a Shot Peening Machine, however, the efficiency and controls of a shot peening machine can be further improved by incorporating Magna Valve and Shot Classifier

3.4 Magna Valve

Wheel peening machine historically have relied upon wheel motor load current as a measure of flow rate. In some application this may be acceptable but active flow rate sensing device provide more advantages. Since wheel running at a higher speed and throwing same quantity of shots will draw more current than a wheel running at a normal speed and giving same flow rate. An ammeter reading will be deceptive to the user in terms of shot flow rate. For such applications magna valve will give absolute indication of flow rate.

3.5 Shots Classifier

Since any kind of shots impurity directly results the peening intensity so to get genuine shots, shot classifier is very useful. Shot classifier retains all kinds of impurities like irregular shaped shots, grits, foreign materials and allow only spherical shape shots for blasting operation.

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