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BASICS OF SHOT PEENING AND IMPORTANT DESIGN FEATURES OF A CENTRIFUGAL PEENING MACHINE

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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 components tremendously. The maximum residual compressive stress produced on the surface is atleast half the ultimate tensile stress of material.

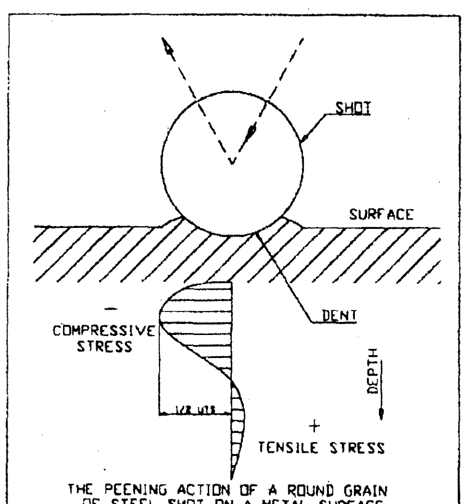
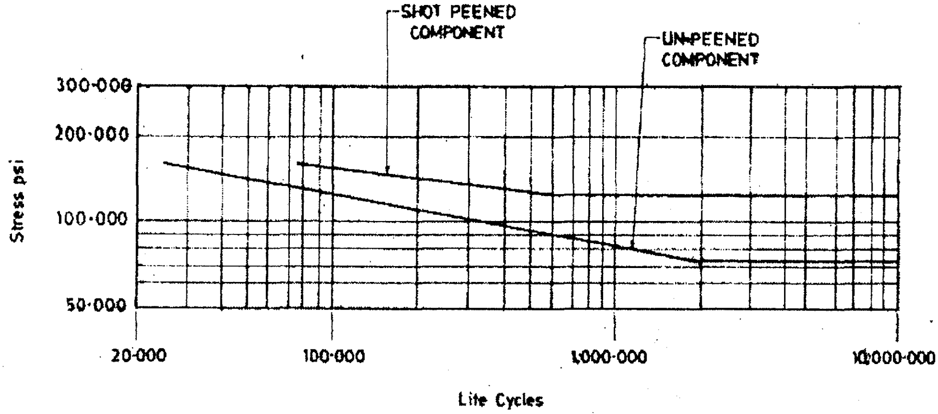


Figure - 1

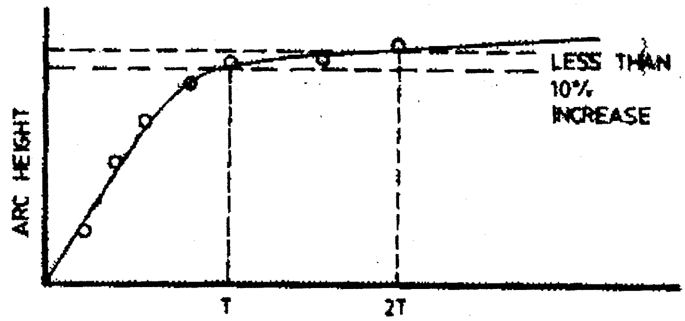
Shot peening is today an established process and has proven its value in over hundred of applications. Some of the important applications are to increase the fatigue life, to prevent the stress corrosion cracking; to form or correct the shape of sheet metal and other components, to over-come the porosity, 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 failure of existing designs, permit use of higher stress levels (Ref. Fig.2), permit use of inexpensive carbon steels in lieu of costly alloys steels, permit complete / partial elimination of costly manufacturing process like grinding and permit weight reduction for new designs. Thus for large volume of production, there will be tremendous saving in material and manufacturing costs.



Influence of Conventional Shot Peening on Fatigue Strength of Spring Steel using Production Conditions

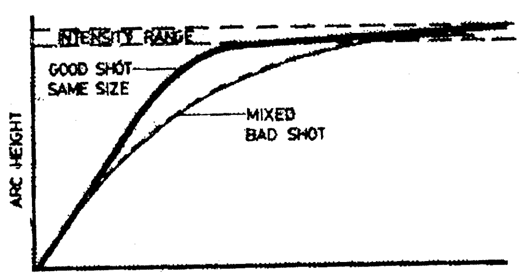
FIGURE-2

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(Ref. Fig.3). 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.



EXPOSURE TIME

SATURATION CURVE



EXPOSURE TIME

SATURATION CURVE FOR GOOD AND BAD SHOT

FIGURE-3

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, pipes, low production and for R & D applications. While the airless shot peening operations are some times 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.

All types of Airless Shot Peening Machines are provided with a mechanical handling system for effectively exposing the work to blast stream. One or more blast wheel units are utilized for propelling desired quantity of shots at adequate velocity. An efficient shot cycling system for continuous feeding of shots to wheel, a separator for efficiently removing the broken shots from the system, an automatic shot replenishing system for addition of shots to compensate for the broken shots removed by separator and a suitable ventilating system for extracting any dust created during peening operation are essential parts of a shot peening machine.

For consistent results and economical operation a production peening machine should be equipped with separator which is capable of continuously removing broken shots 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 repeatative 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 shots are not removed, they will continue to fracture in to 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 shots 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. A shot adding device should be provided with a shot peening machine and only full size shots should be filled in it. This shots adding device or automatic shot replenishing system depicted in Fig.-4 senses the level of shots 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 stabilized 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 stabilized condition. The CFS separator is standard on all shot peening machines and offers the following outstanding features that are essential for separator efficiency.

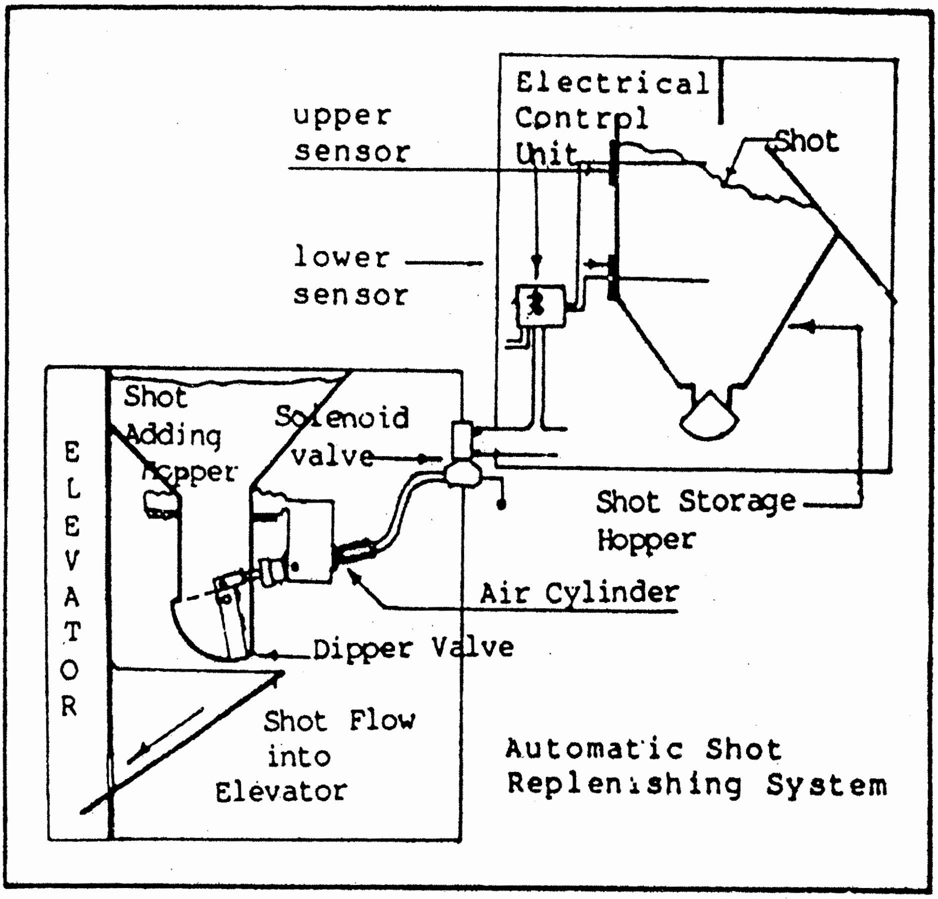
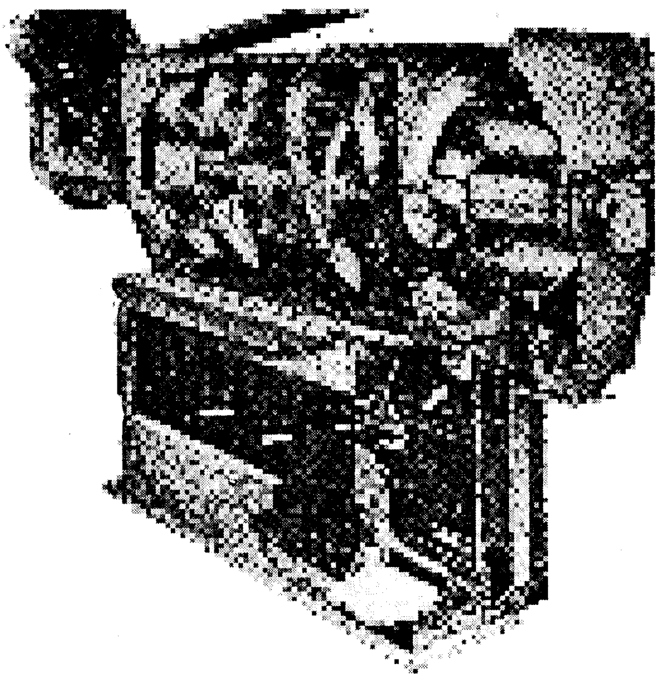


FIGURE- 4

1. The CFS is designed to utilize compensating flow to present a full length curtain of shots to the air washing currents.
2. 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.
3. Eliminates Wear : CFS is designed so that shots move on shots, not on separator parts.
4. Rotary Screen : The rotary screen removes any foreign material from the shot and discharge it through a refuse spout to a floor level container.

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.



ROTARY SCREEN SEPARATOR

FIGURE-5

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.-2.

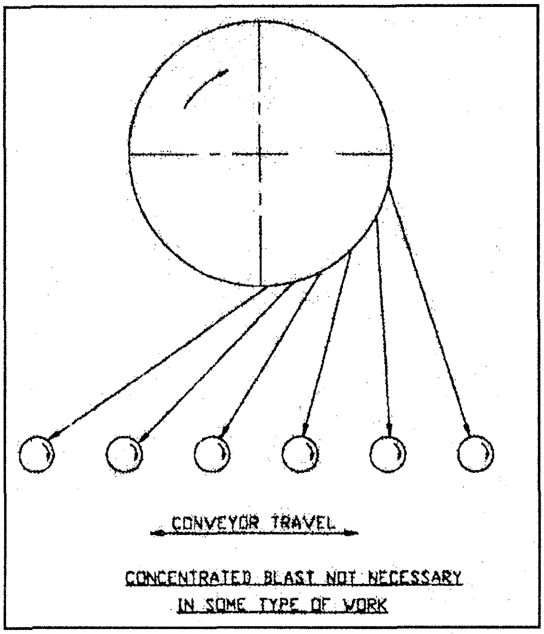
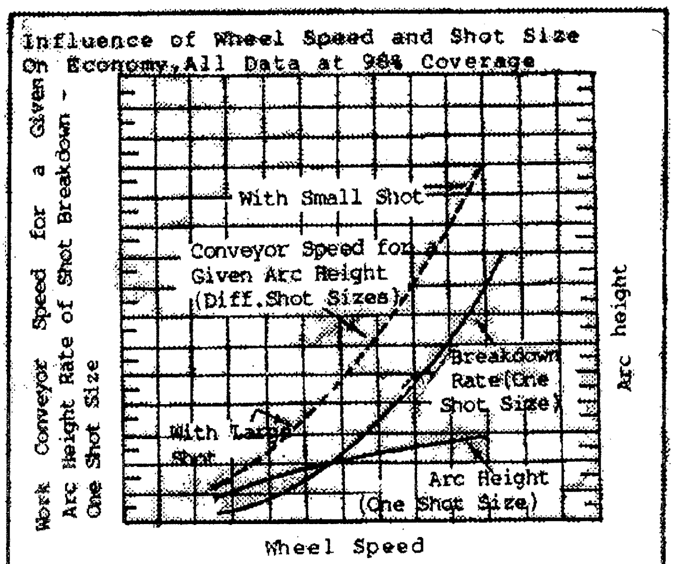


FIGURE - 6

In this particular application cylinders are being shot peened in such a way that as they advance they rotate on an axis parallel to the wheel axis. In this case the shots strikes the cylinder at right angles regardless of its position in the blast. For such applications spread blast pattern is just as effective as concentrated blast pattern. However, in cases where spread 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 induced 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 application.

The fact is that there is no known method of inspecting the quality of peening imposed on a machine part without running the part to destruction. The only control of the process is by inspection of the blast by means of an Almen Test Strip. But that measurement is true only for that particular interval. With high broken shots in the machine, the peening intensity might reduce drastically in a few seconds. It is thus obvious that in a production peening operation, the blast must be uniform at all times. Increased quality of peening does not imply increased cost of operation. If the peening machine is stabilized with high percentage of full size shots the overall cost of operation will be lower than what it would be with a high percentage of broken shots in the machine assuming equal increase in the fatigue strength.

The economy of a shot peening operation is a function of shot size, velocity of shots, shot breakdown rate and rate at which coverage is obtained. Tests conducted on actual peening machines indicate that with increasing shot velocity, shot breakdown rate increases for more rapidly than does the shot peening intensity. (This is illustrated by solid lines in Fig.-7). However, since the weight of a shot varies directly as the cube of its diameter, the number of shots per kg. of



Importance of Wheel Speed and Shot Size in an Airless Peening Machine

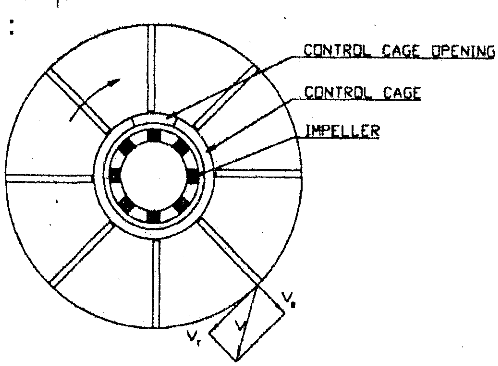
FIGURE - 7

shots varies as the cube of diameter of the shot. Hence, coverage is obtained much faster by smaller shots but it is necessary to increase the velocity of shots to obtain same Arc height. The dotted line of figure 4 indicates that as the wheel speed is increased to accommodate smaller shot size for a given arc height, the conveyor speed for 98% coverage increases very rapidly and the same characteristics as the curve for breakdown rate. In actual practice, it is observed that shot consumption per part peened is practically the same for small and big shots. Hence it is imperative that with small shot, the speed of production will be greatly increased, thereby reducing labour cost.

The factors affecting the peening intensities achieved by centrifugal wheel are :

1. Shot Velocity
2. Shot flow rate.
3. Shot distribution in the wheel pattern.
4. Angle of impact of shots on components.
5. Size, shape and hardness of shots.

To meet the varied requirement, there has been proliferation of centrifugal wheels in types as well as sizes. These include the old standard wheels 495mm (19½") in diameter, belt driven, operating at 2250 rpm and having flat blades. The tangential or vane tip velocity (V_T) of these wheels are calculated as under (Refer Figure.-8) :



CROSS SECTION OF A 495MM DIAMETER STANDARD CENTRIFUGAL BLAST WHEEL WITH STRAIGHT VANES SHOWING RADIAL TANGENTIAL & RESULTANT VELOCITY OF SHOTS

FIGURE - 8

$$V_T = 2\pi PRN$$
$$= 2\pi(.2475)\ [2250]\ /60$$
$$= 58.286 \text{ m/sec}$$

Where R is the radius of the Wheel, N is the angular velocity of the Wheel. The Radial Velocity V_R of the wheel is given by:

$$V_R = V_T\ (0.76)$$
$$= \underline{44.297 \text{ m/sec}}$$

Where 0.76 is an empirical factor derived from Velocity tests. Hence the resultant shot velocity V is obtained from V_T & V_R as under:

$$V = \sqrt{V^2_T + V^2_R} = \sqrt{(58.286)^2 + (44.297)^2}$$
$$V = \sqrt{5359.53}$$
$$V = 73.2 \text{ mtr./sec.}$$

Test results on different size of wheels show that the average shot flow rate is 1035 kg/hr/KW net.

$$\text{where } KW_{(net)} = (KW_{(motor)} - KW_{(idle)})$$

In addition to standard wheels, other wheel configuration being used for shot peening are curved vane and direct drive wheels. The curved vane wheels give same velocity (73 m/sec) at a lower speed of 2100 RPM and permits reduction in noise level as compared to flat blade wheels because of lower speeds. Inspite of this, conventional flat blade wheels are more popular in India. The flow rate of shots is a factor of wheel speed. At high speed less quantity of abrasive are propelled as compared to low speeds when powered by same HP motor. For peening the shots should be substantially round and free from voids or blow holes. The fatigue life of good quality shots would be more and greater economy would result in the use of more durable shots even if the cost per ton is considerably higher. It is thus imperative that properly heat treated steel shots or rounded cut-wire shots will be ultimately more economical not only in terms of shot consumption but in terms of consistent peening intensities and wear and tear of the peening machine.

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