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SHOT PEENING PROCESS AND ITS APPLICATIONS

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ABSTRACT

Today when a part is not able to withstand the stresses that it is required to, a lot of trial and error effort is put over the part. Its material may be changed, the part may be subjected to heat treatment process or attempt may be made to change the machining techniques. Designer may even go to the extent of changing the design of the part. In many case if analysed properly it will be find out that all the above exercise is totally uncalled for. What may have offered a better solution at a nominal cost could have been the shot peening of the part.

Shot peening process increases fatigue life of the part. It toughens the outer surface of the part, it effectively increases the tensile strength of the part and eliminates cracks and other imperfections. This is made possible due to the even compressive stress patterns that are developed during shot peening and also the effective eliminations of microscopic defects in the thin surface shell of the shot peened part.

Shot peening is intended to reduce surface tensile stresses in metal parts which are subjected to repeated application of complex load patterns such as axles, springs, gears, shafting, aircraft alighting gear and structural parts for the purpose of improving resistance to fatigue and stress corrosion cracking. Shot peening is also used for application such as to close porosity in casting and to straighten or form the parts.

This paper describes the basics of shot peening process. Brief description of the effect of shot peening on the part is described. Various process variables involved in the shot peening process have been discussed. The factors that affect the shot peening process are the size of the shot, the type of the shot, the hardness of the shot, shot velocity and application angle. All these have been discussed in the paper.

Surface coverage, which is a measure of how completely an area has been covered by the indentation of the individual shots, has also been covered in the paper. The examination procedure for the surface coverage has also been discussed. Methods of propelling the shot as well as the shot peening intensity monitoring procedure have been discussed.

A brief mention of the shot peening equipments and its automation has been done in the paper. At the end paper covers various application of the shot peening process.

INTRODUCTION

Shot peening process is a process in which spherical shots made of metal or glass are blasted on to the surface of the metal part. As the shot hits the surface of the work piece it results in a mild depression due to the plastic flow and radial stretching of the metal at the surface of contact. As a result of the shot peening of the part by the stream of shots, a thin compressive stress layer is developed at the surface. Due to the development of this compressive stress the part will be able to withstand the tensile stresses till these compressive stresses are overcome. As a result a shot peened part has better ability to withstand the tensile stresses compared to the original part.

Another effect of the shot peening is the elimination of the microscopic defects on the surface of the part. This blends the surface imperfections and causes the formation of an integral surface layer at the top and hence this results in the elimination of the points that could act as stress concentration build up points.

SHOT PEENING PROCESS VARIABLES

There are number of parameters that may affect shot peening process. These are the material of shot, hardness of shot, size of shot, shot flow rate, impact angle, distance of the nozzle from the work piece, relative motion between the work piece and nozzle. These are being discussed in the subsequent write up.

SHOT MATERIAL AND ITS HARDNESS

The shot used for peening are usually of cast steel with the hardness of usually 40 to 50 on the Rockwell C scale. Cast iron can also be used as the material. However as it is brittle it breaks down quickly and so causes the difficulty in maintaining the process of peening.

Many times if the contamination of the metal part surface by the iron from the shot is not permitted then the material for the shot can be glass, ceramics or stainless steel. For the use on thin parts the glass beads are the best option.

SHAPE AND SIZE OF THE SHOTS

The shots or beads that are being used should be free from sharp edges and deformed shapes. For ideal peening application it is preferable that all shots be of perfectly round shape and of same size and material properties. The size of the shot will be dependent on the thickness of the work. Small shots will give better coverage while a large size shot will give smoother finish.

Since the shots break down due to the repeated use, there is the need for the maintenance of the shots. It has to be ensured that the shots used should not contain more than 20 % of the shot size that is not desired. The metallic shots should be checked once in an eight hour operation, glass beads once in two hour operation to ensure that not more than 10 % shots or beads are deformed. In case of the wet glass peening, the entire slurry charge should be changed at least every two hours.

SHOT VELOCITY AND IMPACT ANGLE

The shot velocity is very important parameter in the shot peening process. The kinetic energy of the shot is proportional to square of the velocity and hence higher the shot velocity more will be the work done and hence more will be the effect of the shot peening process resulting in the development of higher compressive stresses in the part. High shot velocities can be obtained by the use of air nozzle and centrifugal wheel system.

In case of air blast method, the shot is introduced in to the stream of compressed air (by use of suction or gravity) and then this stream is directed by the nozzle on to the work piece. Due to the direction of the compressed air in to the nozzle, a low-pressure high velocity airflow is obtained in the suction line that conveys the shots.

As there is no need to raise the shots, this system is less expensive and is suitable for low intensity peening applications. For the high intensity pressure applications, gravity feed system is required. A bucket elevator recirculates the used shots back in the pressure vessel from where the feeding can be done. This can be achieved by the use of a two chambered pressure vessel. The upper chamber can be exposed to the atmosphere and the shots can be loaded in to it and then the chamber is pressurised and the charge is dropped in to the second lower chamber that is a constantly pressurised one. From this chamber the shots then can be fed into the high-pressure airline.

The main drawback of the air blast method for feeding the shots is that compressed air has to be produced and there should be monitoring to ensure that the air pressure does not fluctuate due to the use of the air at some other place in the plant. Also the system will require oil traps and air dryers. This can be avoided by the use of the centrifugal wheel system. These are highly efficient compared to the air blast methods. The velocity can be maintained for a longer distance. Also at a time the wheels can blast larger quantity of shots. The shot is gravity fed to the wheel that is usually powered by solid state variable frequency drive units that are capable of precise control of speed.

Only the shots travelling at correct velocity will be able to produce the proper peening intensity. If the velocity is less it will take more time to reach the saturation. An intensity monitoring can be carried out by drawing the saturation curve for the initial process development. A saturation curve should be generated for each location where intensity is to be verified. Four points other than zero must be used to define the curve, with one of those points representing double the time for the saturation. Saturation is achieved when, the exposure time when doubled does not increase the arc height by more than 10 %.

In addition to shot velocity, the angle of impact also plays an important role. The energy absorbed by the work will be varying as per the sine of the angle between the plane of the work and the line of motion of the shot.

SURFACE COVERAGE

It is the measure of how much area of the part has been uniformly dented by the shot peening process. Surface coverage is usually determined by the visual methods with the help of ten-power magnifying glass. Few methods of measuring the surface coverage are discussed below:

Visual examinations using a ten power magnifying glass.

Visual examinations using a ten power magnifying glass together with a visual examination using a liquid tracer system. Under this, the specimen is coated by the tracer liquid and the liquid is allowed to dry. This specimen is then shot peened under the specified parameters and then examined under the ultraviolet light. If all the tracer liquid coating has been removed it indicates full coverage has been done.

In this method the test strip that has been shot peened is magnified to 50 times in the field of a metallurgical camera and using a sharp pencil the indented areas are traced on a piece of transparent paper. The area of the indentations is then measured and the ratio of the indented area to the total area is determined. This method is very time consuming and assumes that the test strip will represent the work piece.

SHOT PEENING EQUIPMENT

Shot peening equipment should be able to provide a means for propelling the shots by air pressure or centrifugal force. It should have a means for collecting the shots, screening the shots whose size has been changed or which have been deformed. It also should have the means for recycling the shots and do the necessary replenishment. The equipment must also have the means of moving the work through the stream of shots. The equipment should have a suitable dust collector system.

Today's need demand that the equipment used should be computer controlled. There should be computer aided monitoring system, which will ensure that the shots are propelled automatically at the required angle with the required peening intensity and it should also ensure proper coverage. There should be the means of tilting the wheel and also allow feeding of the shots at any wheel position. All critical parameters should be monitored continuously and any discrepancy should be recorded and the corrective action should be initiated.

APPLICATION OF SHOT PEENING

Shot peening has wide spread application in the field of transport industry ranging from automobile parts right up to the aircraft parts. The automotive applications include axles, gears, shafts, automobile wheel rims, railway coach wheels etc. Engines housings of gearboxes also are shot peened. In the aircraft industry also shot peening has wide applications. The structural parts, landing gears, engine parts are shot peened. Even compressors, turbine rotors are shot peened. Bolts, studs, high strength fasteners also are shot peened. Peening also finds applications in other special applications. These include forming of the aircraft skins. Peening is also used to small reworking operations like correcting the size of the hole and shafts. It can be used to straighten the parts deformed during the heat treatment.

CONCLUSION

Shot peening has wide spread applications. Applying shot peening process results in many fold increase in the fatigue strength of the parts. If used judiciously it can give a part which is economical and at the same time is able to withstand the stress much better than a part which is strengthened by using some other technique.

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