PRESENT STATUS OF SHOT PEENING MACHINE IN AUTO PARTS PROCESSING LINES IN JAPAN

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ABSTRACT

In common manufacturing process of automotive gears, shot peening is set up between hardening process and final grinding process. As the purpose of shot peening is surface modification, the machine is commonly found in the same area with heat treatment equipments. In recent years, particularly in some production line for small size gears for automotive transmission, the peening machine is often installed at the first process of machining line right after the heat treatment. In other words, the location of machine is changed from heat treatment plant to machine shop. Due to this trend, the installation space allocated to the peening machine is getting tighter. In response to this demand, the construction of shot peening machine of compact shape to fit to the machining line and the method of controlling various elements related to the peening intensity in actual machine are introduced in this paper.

KEY WORDS

- Shot Peening machine
- Space Saving Equipment
- Peening Treatment Conditions
- Experimental Proof Test

Selection of Blasting Method

In shot peening treatment, the shot projection method can be divided into wheel type and air type. Among these two types, the machines are further classified as batch processing type like apron type, and continuous type like table and conveyor type. The choice depends on factors like the shape and treatment volume of work, cycle time requirement and method of handling. In case of small gears for automotive transmission taken up in this paper, due to its advantage of small size, a number of pieces of gears undergo heat treatment process simultaneously. They are often piled up at the station right before shot peening treatment. The optimum model for shot peening the workpieces like this is wheel type. Some slight fluctuations of arc height and coverage even within the range of hot spot are unavoidable in Impeller type, but the fluctuation falls within the generally accepted standard. In the main, with wheel type machine it is possible to achieve a uniform peening treatment for quite a large area like 100mm wide and 500mm high depending on the arrangement of the wheel. However, the advantage of wheel having capability of processing a wide range, on the other hand, brings forward some disadvantages. These include the large consumption of steel shot and the bulky volume occupancy. Air peening machine, on the contrary, is widely used for small parts with narrow tolerance range of arc height by putting the superior convergence of projection range to good use.

The blasting area of air peening is generally as small as about 20mm in diameter, and it is best suited for piecemeal treatment of small parts. It is possible to make the size of

equipment much smaller than wheel type machine. Particularly in automotive industries today, the concept of single piece treatment is strongly demanded. Shot peening machine is transforming to the type suited for piecemeal treatment keeping pace with the demand of the times. It is also transforming to compact size for easy installation in machining line.

Air type Shot Peening Machine for In-line Use

Model *ISPX* (Fig. 1) introduced here is an air type shot peening machine furnished with 1 unit of stationary self-rotation table and 2 sets of shot projection nozzle. More or less 75 units of *ISPX* are working in domestic and international markets since its first delivery in 2000. In most cases, shot peening process is aimed at the in-line application in the machine shop. Majority of ISPX is installed as the first process of finishing line where shot peening → grinding and polishing → various inspections are consisting an independent line.

Fig. 1 Appearance of ISPX

As this type of machine is purposed to install in machining line, it is normally designed as the special purpose machine exclusive for the specific work. However, if the work size is within the range of 225mm in diameter, with tooth width up to 40mm and shaft length up to 250mm, the machine is capable to cope with by only changing work set jig and arrangement of nozzle without modifying the construction of the machine proper.

The clear difference in comparison withconventional pressurizing shot peeningmachine is the location of pressurizing tank. For the purpose of conducting most effective shot peening treatment, the machine is provided with 2 sets of blasting nozzles. The method of blasting volume control was shifted from the method by weight variation of pressurizing tank to the control of shot flow volume of each nozzle. Because of this change, the machine needs only 1 unit of pressurizing tank unlike the conventional system in which as many numbers of tanks were required as the numbers of nozzles.

Moreover, by installing the tank directly below the blasting chamber, the screw conveyor and other devices for transporting the blasting media to the tank are no longer required.

These modifications and the development of exclusive mini dust collector augmented the space saving. The installation space including dust collector and control panel is reduced to 1.2m x 2.6m. (not including maintenance space, air compressor and air dryer.)

Method of Control

For the purpose of imparting the peening effect to the target work, it is essential to control the peening performance in considerations of residual stress, surface roughness, surface property, hardness, stock removal, deformation, change of metallurgical properties, etc.

The factors influencing the peening performance are divided broadly into the conditions of target work (the material that undergoes peening treatment) and the peening treatment conditions. Under the conditions of target work are the mechanical properties, shape, dimensions, kind of heat treatment and other factors. Among the peening treatment conditions are the size of blasting media, hardness, projection speed, projection density, etc. The degree of shot peening treatment is generally evaluated by the peening intensity called Arc height in Almen method, and the uniformity of treatment called Coverage. These results vary in accordance with the blasting conditions and the selection of blasting media (shot). It is not possible to improve the peening effect simply by increasing the arc height and coverage, but it is influenced greatly by physical property, shape and size of the work to be peened. It is important, therefore, to select the optimum peening conditions by paying considerations to all these factors.

This paper gives an outline of control system on equipment side for controlling the peening treatment conditions among these factors. The basic construction of shot peening machine is shown in Fig. 2.

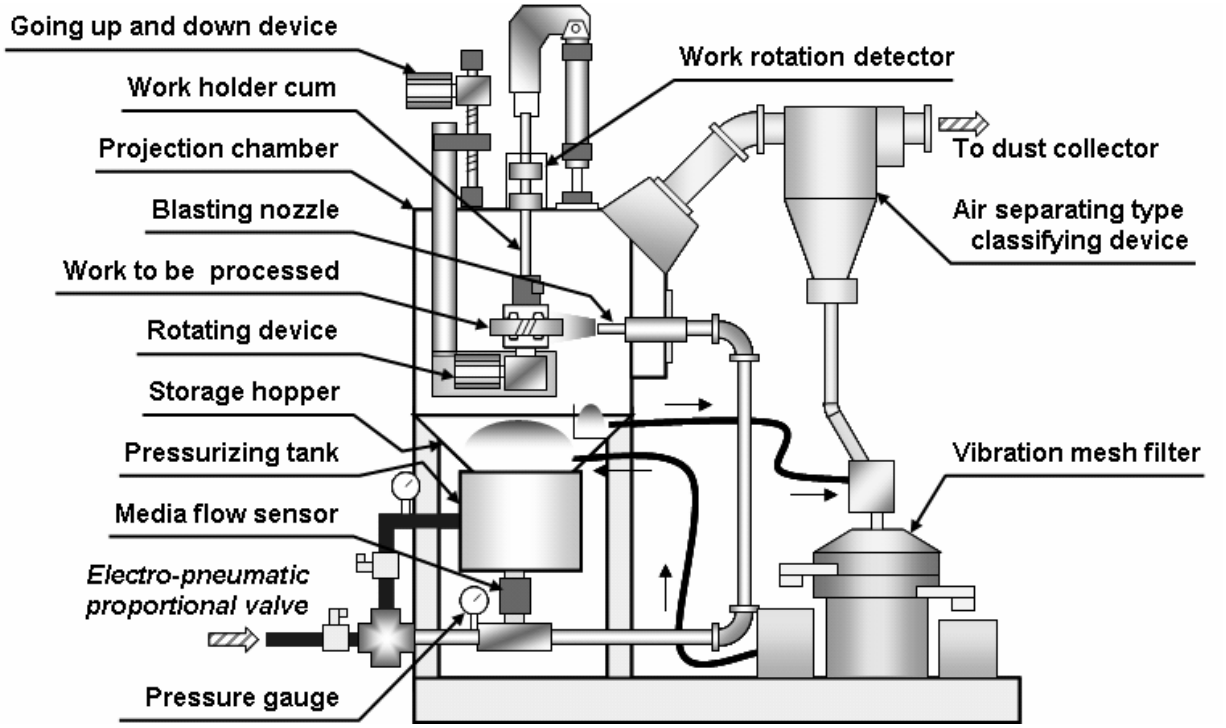

Fig. 2 Standard Composition of Shot Peening Machine

Shot Projection Control System

For the purpose of controlling the stabilized shot projection, it is necessary to control the projection density and projection speed. The control of projection volume is essential for the control of projection density. Shot projection volume is monitored by shot flow volume sensor attached to each nozzle piping. With this setup, it is possible to confirm the volume of shot projected from each nozzle. The total projection volume can be calculated from the volume of shot projected from each nozzle, the nozzle size, the efficiency coefficient depending on the installation distance, and the projection time. Then, the projection density can be calculated for the total surface area of the work to be peened.

Projection speed is one of the most important factors in peening effect. In case of air type shot peening machine, the speed may fluctuate due to the influence of the supply air pressure. To maintain a constant projection speed in test purpose machine may not be difficult. However, in case of actual production machine, the measuring and monitoring of projection speed is quite difficult. In such case, the air blasting pressure is normally used as substitute value for control. The measurement of pressure in the shot flow system up to the nozzle point is difficult. Instead, the measurement and control of blasting pressure are conducted at the point immediately before the mixing of shot and air. The method of controlling the flow volume of air is also practiced for detecting more delicate fluctuation.

Work Position Control System

Work position control system can be divided into 3 items – i.e. table position control,blasting nozzle position control and work rotation detection.

Against the fixed nozzle, the table position control, considering the height of the work, obtains the optimum relative position between the area requiring shot peening and the height of nozzle. This control is particularly effective for the work like shafts requiring peening on several spots as well as for the work requiring wide range of peening along its longitudinal axis.

On the contrary, there is the case of controlling the position of nozzle while the work conducts only self-rotation. In this nozzle position control, there are wide range of applications such as the method of single-axis control to widen the projection range by rotating horizontally against work as well as the sophisticated method to install the nozzles directly on 6-axis industrial robot. This control system is commonly used for large size work, the size of which is too large for loading on the up-and-down table, or for the methods other than table. An example is the machine with hanger conveyor system. This method is effective for conducting shot peening for the work having more complicated shape.

Above 2 items of control are not necessary for the machine with fixed table and fixed blasting nozzle like *ISPX* introduced here. Unlike these 2 control methods, work rotation detecting system is indispensable for most table type machines. In normal table type machine, work is simply pressed down to the table by work holder, and is not tightened to the table firmly by bolts, etc. On that account, there is possibility that the sufficient contacting surface of work against table is not secured. It is also possible that the shot and other foreign matters are caught in between work and table or work holder. These irregularities may make the rotation of work unstable, and there may be possibility of causing quality defects because uniform projection density on all circumferences may not be achieved.

For preventing these problems, it is necessary to pay full considerations for designing the jig to secure sufficient pressing surface of work, and it is also necessary to change

jigs before the distortion of shape due to wear takes place. The simplest way to control such an improper rotation of work, in case of table-driven, is to install a sensor for affirming the work rotation on the work holder side to verify whether the work rotation is synchronized with the table or not.

Shot Fineness Control System

The blasted shot is sent to air separating type classifying device by shot transporter and to pressurizing tank. In many cases, classification by vibrating screen is applied after air separator. As the shot transporter is not required for *ISPX*, the classification device is installed midway of air suction duct from the blasting chamber. The reusable shot is conveyed to vibrating screen. The purpose of shot fineness control device installed at shot peening machine is to separate and remove extra-fine particles produced by pulverization and abrasion, so the device is normally not capable to remove any particle larger and heavier than steel shot. Accordingly, burrs and scales generated during the processes of forging and machining may enter into the machine and cause machine trouble. Therefore, it is a normal practice to require shotblasting treatment before shot peening to remove burrs and scales.

Daily control of shot classification device includes measurement of air velocity at classifying part, visual check of screen mesh of vibrating screen, etc. It is also quite important to conduct periodical measurement of grain fineness distribution of circulating shot as well as to verify whether there is any fluctuation of arc height and coverage of shot peening treatment.

Determination of Treatment Condition

The stabilized operation of peening equipment becomes possible by these quality control systems as stated above. However, the controllable items are mere guideposts of processing degree like arc height and coverage, and they cannot be the index for controlling residual compressive stress, surface hardness and surface roughness required for the work. In other words, the contents of specification required from work side and those required for shot peening machine are different.

In the Peening Center (in the premises of SINTO. See Fig. 3), various trials to connect such specifications required from work side and that required from peening machine side are implemented daily. There are 13 types and 15 sets of wheel type and air type

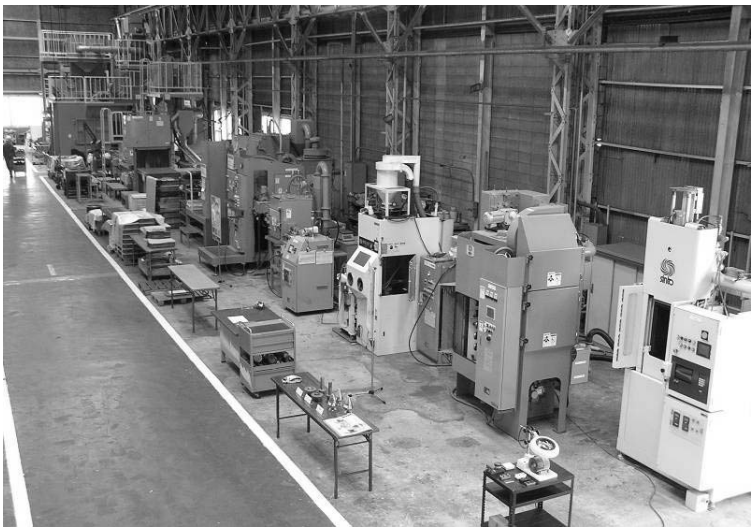

Fig. 3 A View of Peening Center

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peening machine ready for the test.
Among these test machines, the most appropriate machine for the shape of work is selected to conduct verification test. Peening Center is capable to enforce not only the peening treatment matching to the arc height and coverage designated by customers, but it is also possible to propose the shot peening conditions for obtaining residual compressive stress, surface hardness and surface roughness critically required for the work. Peening Center also conducts actual peening operations. When the project comes to the stage of firm order through these verification tests, the detailed information including shape of work set, shape of nozzle, arrangement of nozzle and other mechanical elements, not merely arc height and coverage, are easily developed to determine the equipment specifications.

The specifications of shot peening can be clarified by the guideposts such as the value of residual compressive stress and the value of surface hardness. However, to judge whether the value is satisfactory for the required strength of work or not, there is no other way but to rely on durability and other verification tests.

1) To establish definite specifications of work on the basis of durability test results.
2) To connect these specifications with equipment conditions such as arc height and coverage by verification test.
3) To conduct quality control introduced in this paper on the actual production equipment.

The most appropriate and stabilized shot peening treatment is now possible by implementing the equipment plan in compliance with the above 3 procedures.

REFERENCES

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