Comparative study: Impact of Ball burnishing and shot peening Process on Aluminium 2024 alloy

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Abstract:

Compressive residual stress is the major aspect in the extension of the fatigue life of aero-engine components. In this study, a modified burnishing surface treatment and conventional shot peening process was used was proposed to improve surface integrity characteristics such as surface finish, hardness, and stable, advantageous compressive residual stress in turned Cylindrical Aluminum 2024Specimen. In burnishing process, a rolling rigid spherical HSS ball is pressed across an Aluminum 2024Specimen under definite fluid pressure generated by the hydraulic unit and also shot peening was carried out at a shot velocity of 300 m/s. This research examined the effect of burnishing treatment and shot peening process on beneficial compressive residual stresses.

Keywords: *burnishing, shot peening, residual stress*

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1. INTRODUCTION

The components used for aerospace applications fail mainly due to cyclic loads as they are constantly subjected to high cyclic and low cyclic loads. A poor surface finish would increase the rate of crack propagation and gradually leads to the failure of component [1]. There are various surface treatment processes are available to enhance surface properties like shot peening, laser shock peening, deep cold rolling, Burnishing and so on, which helps to improve the fatigue life of a components. In this work ball burnishing and roller surface treatment is employed to improve the surface properties [2]. The process parameters like burnishing pressure, force, speed, feed, types of lubricant will Ball burnishing mainly focuses on process parameters like pressure (force), speed, and feed, followed by number of passes, ball diameter, lubricant, etc., on surface integrity. Shot peening is a cold working process used to increase the fatigue properties and hardness of metal components. During the peening process, the surface of the component is bombarded with small spherical media called shot. Overlapping dimples develop a uniform layer of residual compressive stress in the metal. It is well known that cracks will not develop in a compressively stressed zone. Since nearly all fatigue failures originate at the surface of a part, compressive stresses induced by shot peening provide considerable increase in part life.

2.1 Material

Aluminium alloy 2024 is a most widely used copper-based alloy. It is used in applications that require a high strength-to-weight ratio as well as fatigue resistance.

Table 1 Composition of Aluminum 2024 alloy

Composition	Al	Cu	Cr	Mg	Mn	Si	Zn	Fe	Ti
Percentage	94.7	4.9	0.1	1.8	0.9	0.5	0.25	0.5	0.15

2.2 Burnishing Process

In hydrostatic ball burnishing, due to pressurized fluid flowing over the tip of tool and work piece surface helps in ways like lubricating and cooling [3]. In ball burnishing, the tool consists of one or more spherical balls, supported in shank by the hydraulic pressure of the fluid or a spring and the reactive force of the work piece. Schematic of ball burnishing is shown in fig. 1.1. Fluid is circulated constantly, using a hydraulic pump, through the recesses around the ball to keep it in contact with the work piece. When the tool is fed along the work piece, the ball is pressed against the work piece, resulting in the burnishing operation.

2.2.1 Description of Ball burnishing and Roller burnishing set-up and process

The ball burnishing tool was fabricated to monitor the burnishing force applied to the cylindrical work piece. A spring enclosure screw mechanism is designed to accomplish this. The burnishing force on the specimen can be increased by tightening at the desired torque at the screw. The hydraulic oil constantly supplied to the burnishing tool acts as a lubricant as well as holding the ball in place during burnishing. After burnishing mechanism , the oil can be collected and reused. The ball initially makes contact with the metal surface [5, 6].The work piece is clamped to the lathe chuck here, and the tool is inserted into the tool post. The tool post keeps the tool firmly in place [7, 8]. Connecting the pipes and opening all of the valves completes the hydraulic circuit [9].In order to perform Shot peening on the material we first need to be calculating the intensity by which the shot ball made to be strike on the material for a calculated time. In this project work, to find the intensity several pieces of Almen strips is used as shown in figure 4.4. Each Almen strips is first placed on the bending measure equipment (shown in figure 4.4) which shows zero reading that means there is no bending on the strips. Strips is now placed inside the Wheel blasting type of Shot peening machine (as shown in figure 4.3) and cast steel Shot ball (S330 type) of diameter ranging from 0.7 to 1.20 mm is made to strike with velocity of 47 m/sec at an angle of 45 ° on the strips for a particular time period. Strips are now taken out and its bending is measured. Which gives some value and this indicates there is some bending occurs after shot peening. The process is repeated for several numbers of strips for different time period. Now the intensity is selected for strips which gives maximum bending (or Almen height or Arc height) for minimum time (in this Peening intensity is selected as 0.53 mm for 25 sec) [10] .

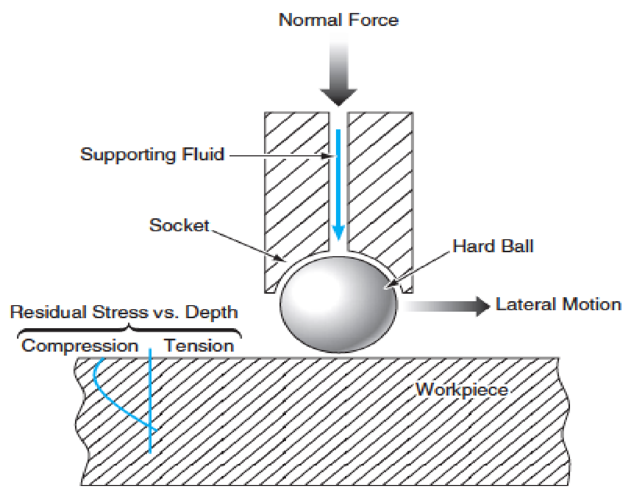


Figure 1 Working principle of burnishing mechanism

Figure 2 Ball burnishing tooling system

Figure 3 Aluminium specimen after turning and grooving

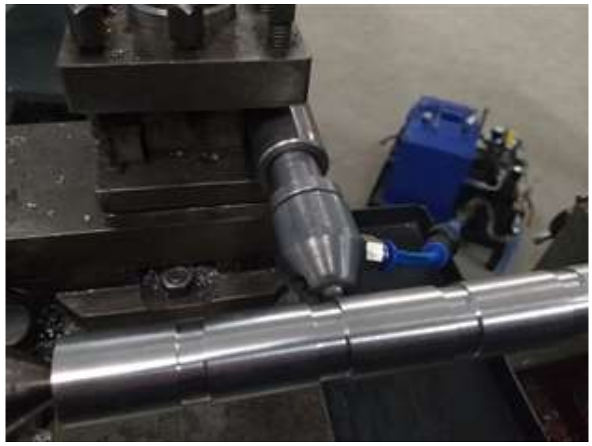
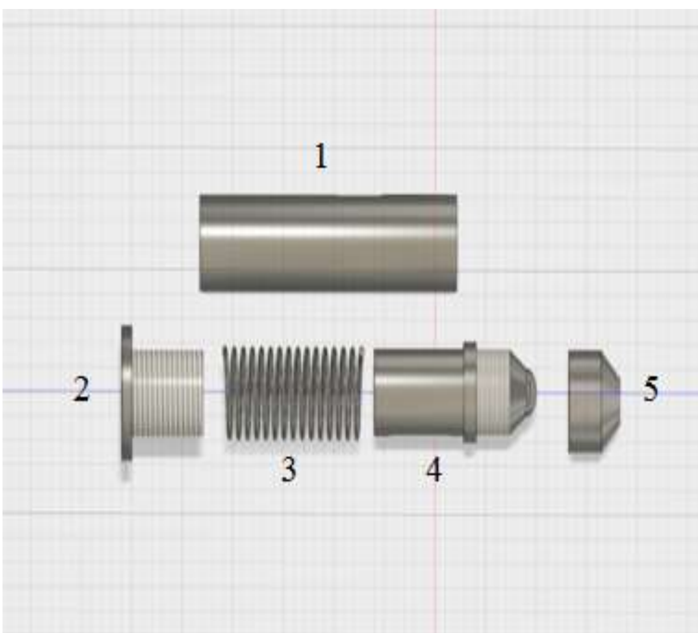


Figure 4 Tooling system

The various parts of the ball burnishing tool were modelled on AutoCAD fusion 360 using the above calculations, and the images below show the various parts of the ball burnishing tool and its final assembly [4].



NUMBER	PART
1	SLEEVE
2	PRESSURE ADJUSTMENT SCREW
3	SPRING
4	TOOL BODY
5	REATINING CAP

Figure 5 CAD geometry of burnishing tool

2.3 Shot peening process

Shot peening is traditional surface enhancement process is used to induce compressive residual stress by impacting shot materials. Shot peening is a cold work process used to finish metal parts in order to prevent fatigue and stress corrosion failures and to extend the part's life. It requires simple equipment and treatment and is widely used to improve fatigue life and material hardness. Shot

Figure 6 shot peening testing set up

3. Results and discussion:

The ball burnishing and shot peening process is performed on the Aluminium 2024 specimen in the due intention of enhancement of residual stress. The residual stress was measured before the treatment and after the shot peening, burnishing process was measured with the help of X-ray diffractometer. Figure.7 shows the residual stress profile for untreated, shot peened and ball burnished components. It is observed that the maximum residual compressive stress was -250MPa induced for burnishing surface treatment, -150MPa in shot peening. For unburnished component, the residual stress was found to be 0MPa.

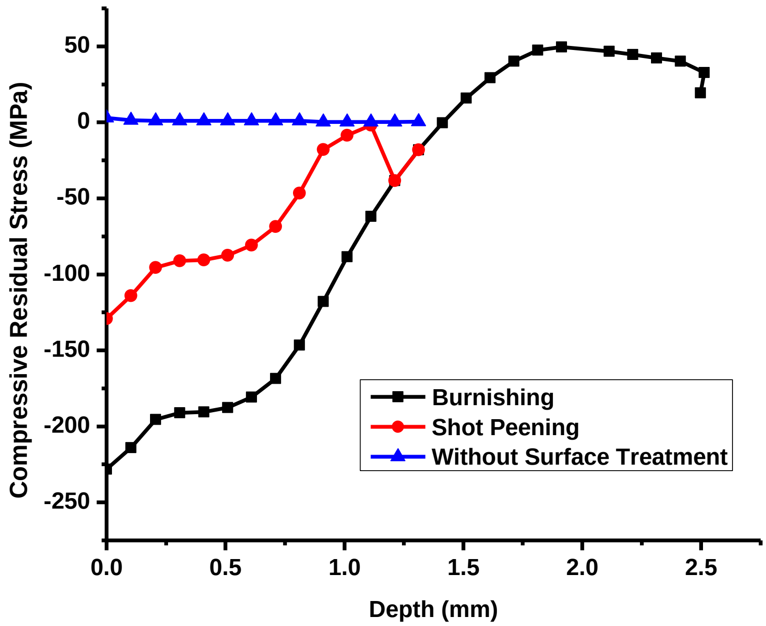


Figure 7 Residual stress profile : un treated, shot peened, burnished.

Conclusion:

Significant conclusions were obtained from these experimental investigations are

1. Burnishing surface treatment is the most effective method to induce compressive residual stress than shot peening method.
2. The depth of compressive residual stress induced in Burnishing is greater than shot peening method.

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