A Review -Parametric Evaluation of Ball Burnishing Process on Aluminium Alloy 6061

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***Abstract* -The main purpose of this review paper is to optimization of newly design ball burnishing tool and process parameters in conventional lathe using taguchi method. Here the work piece materials used is Alluminium Alloy 6061 and tool material HSS ball with 8mm diameter. The input parameters during process are burnishing feed, burnishing speed, spring deflection and number of passes. The output parameter is surface hardness.**

1. INTRODUCTION

Machined surface by conventional process such as Turning and milling have inherent irregularities and defects like tool marks and scratches that cause energy dissipation (friction) and surface damage (Wear). To Overcome These Complications, Conventional Finishing Processes Such As Grinding, Honing, And Lapping Have Been Traditionally Employed. However, since these methods essentially depend on chip removal to attain the desired surface finish, these machining chips may cause further surface abrasion and geometric tolerance problem especially if conducted by unskilled operators.

Accordingly, **burnishing process** offers an attractive post-machining alternative due to its chip less and relatively simple operations. Burnishing is a cold working process in which plastic deformation occurs by applying a pressure through a very hard and smooth ball on metallic surfaces. The burnishing process is made with the intention of improving the surface finish of some pieces that have been previously mechanized. It is a finishing and strengthening process.

2. ADJUSTABLE PROCESS PARAMETER

Burnishing Speed

The surface average roughness decreases slightly with an increase in burnishing speed due to the stability of the ball burnishing tool at high speed of (55 m/min) for AA 2014 using carbon Chromium steel ball with 8mm diameter [2]. For AISI D3 tool steel burnished with high speed steel. The hardness is maximum and the surface roughness is minimum at 1000 rpm. The maximum and minimum deviation of simulation from experimental is 23.9% at 1100 rpm and 13.24% at 1000 rpm. The residual stress increases (416 MPa to 623 MPa) with increase in speed (800rpm to 1000 rpm). Beyond 1000rpm, residual stress decreases. This may be due to insufficient lubrication [6]. Optimum condition of a surface finish on brass material using high carbon high chromium ball is obtained at 425 rpm speed within range of 200 to 540 rpm speed [10].

Burnishing Feed

The average roughness decrease with an increase in burnishing feed, reaching a minimum value at burnishing feed of (0.15-.025mm/rev) for AA 2014 using carbon chromium steel ball with 8mm diameter. So Low feeds are favourable because the deforming action of the ball burnishing tool is greater and metal flow is regular feed [2]. The optimal parameters for feed rate on AA7178 are 0.25mm/rev with range of 0.25 to 0.45 mm/rev [3]. The best roughness values are also obtained on the surface of smaller radius and in case of higher feed rates. In the case of the direction of burnishing, the measurements in the parallel direction to the milling feed rates are smaller for the perpendicular burnishing and in the perpendicular direction to the milling process. The lower roughness values were obtained in the burnishing parallel to the milling feed rates [5]. The best finish for AISI D3 tool steel burnished with high speed steel was obtained at a feed of 0.1 mm/rev with range of 0.10 mm/rev to 0.15 mm/rev. [6]

Number Of passes

A combination of low burnishing speed with high number of passes leads to a substantial improvement in the burnished surface average roughness. The combination between high number of passes and low fed results in a considerable reduction in burnished surface roughness for AA 2014 using carbon chromium steel ball with 8mm diameter [2]. The optimal parameters for surface hardness have 4 passes [3]. For AISI D3 the roughness decreased with no. of passes. The maximum and minimum variation of simulation from experimental was 39.6% at 3rd pass and 13.24% at 1st pass [6]. Optimum condition of a surface finish on brass material using high carbon chromium ball is obtained with 4 pass [10].

Burnishing spring deflection

With increasing spring deflection, there is decrease in surface finish. This may be due to the increase in plastic deformation. The optimal parameters for surface hardness is achieved at have deflection 260 N from range of 220N, 240N, 260N, 280N [6].

Optimum condition of a surface finish on brass material using high carbon high chromium ball obtained at force of 70 N forces up to 50 to 200 N [10].

Ball Diameter

The surface finish decrease with the ball diameter as the surface waviness increases by using a smaller ball diameter. Hardness decreases with increase in ball diameter due to plastic deformation. The residual stress and increase in ball diameter [6] optimum condition of a surface finish on brass material using high carbon high chromium ball of 7mm within range of 6 to 10mm diameter. [10]

3. TAGUCHI METHOD

Taguchi's approach has been built on traditional concepts of Design of Experiments (DOE), such as Full factorial, fractional factorial design and orthogonal arrays based on signal –to-noise ratio, robust design and parameter and tolerance designs. DOE is a powerful statistical technique introduced by R.A. Fisher in England in 1920s to study the effect of multiple variables simultaneously [Philips (1989)]. Since, the research work concentrates on the experimental work, the number of experiments is to be conducted, the effect of the individual parameters on the turning operation, either independently or combined have to be studied. Therefore, the well known Taguchi technique is chosen and adopted in the present research work. In order to reduce the total number of experiments "Sir Ronald Fisher" has developed the solution: "Orthogonal Arrays". The orthogonal array is a distillation mechanism by which the engineers can select the experimental process. The array allows the researcher engineer to vary multiple variables at one time and obtain the effects such that set of variables has an average and the dispersion. Taguchi employs the design of experiments using specially constructed table, known as "Orthogonal Arrays" (OA) to treat the design process, such that the quality is build into the product during the product design stage. Orthogonal Arrays are the special set of Latin squares, constructed by Taguchi to lay-out the product design experiments. experiments were planned according to taguchi's l25 orthogonal array, which has 25 rows corresponding to the number of tests (24 degree of freedom) with 5 columns at five levels.the first column of table was assigned to speed, the second to the feed rate, the third column was assigned to the force and the forth column to no. of tool passes. It means a total 25 experimental number must be conducted using the combination of levels for each independent factor (speed, feed, force, and no. of tool passes. This orthogonal array is chosen due to its capability to check the interactions among factors.The experimental results are then transferred in to a Signal to Noise (S/N) ratio. The category the-lower-the-better was used to calculate the S/N ratio for surface roughness.

4. LITERATURE SURVEY

M.H. El-Axira *et al.* used simple newly designed internal ball burnishing tool to burnish the internal machined surfaces. The effect of four internal ball burnishing parameters; namely, burnishing speed, feed rate, depth of penetration and number of passes on surface roundness and surface micro hardness using Response surface method (RSM) to design experiment were studied. A significant improvement in out of-roundness and surface micro hardness in aluminum alloy 2014 work piece has been obtained without the need for the difficult to set-up grinding equipment normally used for inner surfaces super-finishing. [1]

M.H. El-Axir *et al.* investigated the effect of four internal ball burnishing parameters; namely, burnishing speed, feed rate, depth of penetration and number of passes on surface roughness by internal ball burnishing process. The experiment was designed using RSM with Box and Hunter method. The results show that from an initial roughness of about Ra 4µm, the specimen could be finished to a roughness average of 0.14 µm. [2]

Aysun Sagbas *et al.* have studied the effect of the main burnishing parameters burnishing force, feed rate and number of passes on surface hardness was examined using full factorial design and analysis of variance (ANOVA). Optimal ball burnishing parameters were determined after the experiments of the Taguchi's L9 orthogonal array. As result, the optimal burnishing parameters for surface hardness were the combination of the burnishing force at 200 N, number of passes at 4, feed rate at 0.25 mm/r. [3]
Aysun Sagbas *et al.* studied, an optimization of ball burnishing on 7178 aluminum alloy with stainless steel ball using desirability function approach (DFA) and quadratic regression model was developed to predict surface roughness using RSM with rotatable central composite design (CCD) and considered burnishing force, number of passes, feed rate and burnishing speed were as model variables. They found an absolute average error between the experimental and predicted values for surface roughness was 2.82%. [4]

J.A Travieso-Rodriguez *et al.* analyzed the ball burnishing process is done to improve the surface finish of aluminum A92017 and steel G10380 with concave and convex surfaces and considering the curvature radius as parameter along with speed and feed with tungsten carbide ball and concluded that for aluminum AI 92017, better results obtain with a smaller radius in convex surfaces and with a bigger radius in concave surfaces. For steel 1038 the prior peak height as parameter on milling machine, affect the indexes of surface roughness. [5]

Prasad Bhardwaj *et al.* investigate effect of burnishing process on the AISI D3 tool steel material using finite element method based software DEFORM-2D DX-160 CNC lathe. That concludes that Surface roughness improves up to 86.18%. Obtained about 0.19µm with force = 220 N, feed = 0.13 mm/rev, speed = 1000 rpm, number of passes = 1. And also determine the minimum and maximum deviation between the experimental and simulation values of surface roughness was 11.7 % and 44.2% respectively. The minimum and maximum deviation between the experimental and simulation values of residual stress for AISI D3 Tool steel was 1.3% and 29.2%.[6]

R. Avilés *et al.* analyzed improvement in the high-cycle fatigue strength of AISI 1045 normalized steel after low-plasticity ball burnishing with ceramic ball pressed hydraulically by means of pump at max 40MPa. The specimens were tested in a rotating bending fatigue machine. They determine the bending fatigue limit is increased by 21.25%.As an alternative to this coefficient, a UN axial effective mean stress that remains constant in time is defined and obtained for each stress level. [7]

Wit GRZESIK *et al.* Carried out the functionality comparison for improving the surface finish of low alloy 41Cr4 steel with a hardness of about 57 HRC using CBN hard turning,Si3N4ceramicball burnishing and super finishing techniques and characterized machined surfaces using 3D scanning techniques. They conclude that Dry hard turning produces initial surface profiles with regular tool nose traces and surface roughness with the Ra=0.5mm which was reduced to about 0.2mm by ball burnishing and to about 0.06mm by super finishing.[8]

R. Sadeler *et.al* investigated the fatigue behaviour of AISI 1045 steel with effect of ball burnishing parameters at different Pressures 100, 200 and 300 bars. The hard steel ball was hydrostatically forced toward work piece. They conclude that roughness improve with increasing pressure and also enhance both fatigue life of specimens for each pressure value. [9]

P. S. Dabeer *et al.* Carried out experiment on brass material with central composite second order rotatable design and develop mathematical model to correlate effect of burnishing parameter on material, using ANOVA techniques and F-TEST effects on surface roughness. They conclude that Optimum Surface finish is obtained at speed of 425rpm, ball diameter of 7mm, normal force of 70N and no. of tool pass was 4. [10]

7. CONCLUSION

In this study the To carry out experimental determination of the effects of the various burnishing process parameters such as speed, feed, spring deflection and no. of passes on the material and measures surface hardness. Analysis the effect of burnishing parameter on material using Taguchi's Orthogonal array method and signal to noise ratio method.

8. SCOPE OF WORK

Experimental determination of the effects of the various process parameters such as speed, feed, burnishing spring deflection and number of passes on the performance measures like surface roughness in Ball Burnishing Process.

1. To identify the requirement of ball burnishing operation.
2. To design and prepare burnishing tool.
3. To Analyze the effect of burnishing parameter on material.
4. To develop mathematical model using taguchi method for optimizing parameters of ball burnishing process.

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