International Journal of Advance Research in Science and Engineering
Vol. No.6, Issue No. 07, July 2017
www.ijarse.com
IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

ROLLER BURNISHING-A Literature Review of Developments and Trends in Approach to Industrial Application

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ABSTRACT

Burnishing is a cold working, surface treatment; chip less process in which plastic deformation of surface irregularities occurs by exerting pressure through a very hard and smooth roller on a surface to generate a highly smooth and work-hardened surface. Roller burnishing is an economical process, where skilled operators are not required. This paper presents the reviews of different works in the area of burnishing and tries to find out latest developments and trends available in industries in order to minimize the total equipment cost and result in high production rate, with accuracy and without considerably increasing existing inventories.

Keywords- Roller Burnishing, Surface Finish, Burnishing tool, Surface Roughness.

I. INTRODUCTION

The Machining operations are used to produce required Dimensions by removing excess material from a blank in the form of chips. The work piece is subjected to intense mechanical stress and localized heating by tools having one more shaped cutting edges. Each cutting edge leaves its own mark on the mechanical surface. Also the work piece and tool together with the machine on which they are mounted form a vibratory system liable to random, forced or induced vibration. Due to these reasons, the surface of the machined component is more or less damaged. The ball burnishing process is done to improve the surface finish of work pieces that have been previously machined.Surface finish and surface integrity are the terms used to denote the degree of such damage. To answer this Burnishing is capable of producing surface finish of 0.2-0.8 ra, μm. Burnishing, a plastic deformation process, is becoming more popular as a super finishing process. The selection of the burnishing parameters to reduce the surface roughness and to increase the surface hardness is especially crucial because of the non-linear characteristic of the burnishing parameter.

1.1 Classification of Burnishing

a. Ball Burnishing

b. Roller Burnishing

The above two types are explained below,

1.2 Ball Burnishing

In this method, machined surfaces are burnished by a ball burnishing tool. The experimental work is carried out on a lathe machine or milling machine. The ball burnishing process is done to improve the surface finish of work pieces that have been previously. In case of ball burnishing process best roughness values are also

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

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.

1.3 Roller Burnishing

Roller burnishing is a cold working process which produces a fine surface finish by the planetary rotation of hardened roils over a bored or turned metal surface. Roller burnishing involves cold working the surface of the work piece to improve surface structure.

As all machined surfaces have series of peaks and valleys of irregular height and spacing, the plastic deformation created by roller burnishing is a displacement of the materials in the peaks in which cold flows under pressure into the valleys. This results in a mirror-like finish with a tough, work hardened, wear and corrosion resistant surface.

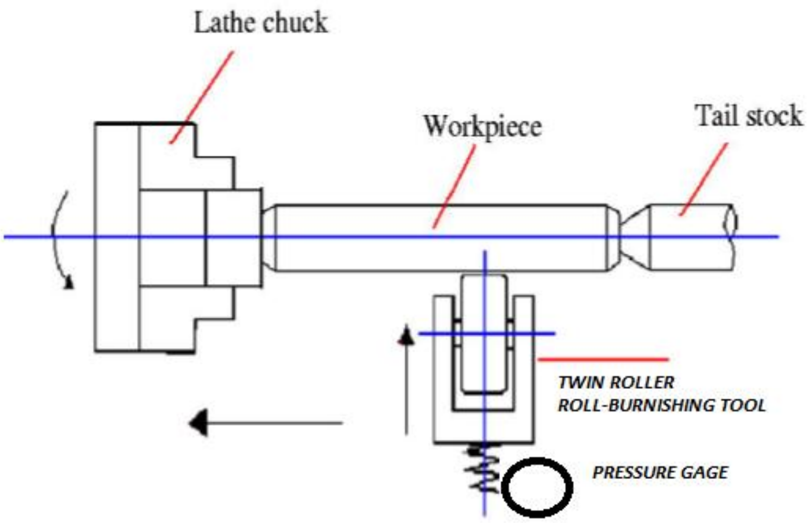

Figure 1: Roller burnishing process for surface finish of Outer Diameter

1.4 Pre-machining of the work piece

The work piece must be prepared for the roller burnishing with the right stock allowance and the right surface finishing rate. The amount of the stock allowance depends from the job conditions, the material properties, the wall thickness of the part, the type of the machined surface and the quality of the desired surface finishing. The following chart shows typical stock allowances for internal and external burnishing. However, because of the number of variables involved, these references should be considered only not binding. An exact stock allowance can be established by tests. It is important never to burnish parts with too much stock allowance: a roller burnishing in such conditions reduces the life of the tool but can also produce flaking of the burnishing surface. High ductility materials have an elongation of more than 18% and hardness less than RC 25. They include annealed steel, aluminum, brass, bronze. Low ductility materials have an elongation less that 18% and a hardness of max. RC 45.

Also the internal surface quality plays an important role in the part performance. Internal surfaces of non-ferrous materials are difficult-to-finish due to many problems encountered in grinding which is optimum for ferrous

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

metals. Internal burnishing process is believed to be more suitable since it eliminates sticking, wheel dulling and overheating.

II. AIMS AND OBJECTIVES OF THE WORK

The aim of this study is to minimize the workloads and increasing the quality of machining by latest technologies available for producing high grade of surface finish.

The aims and objectives of the present study are as follows:-

1)To reduce production cost and improve productivity

2)To improve efficiency of production systems where high machining accuracy and high grade surface is required

3)To study the latest technologies available and adaptability of burnishing in modern production systems.

III. LITERATURE REVIEW

Burnishing methods have become the topic of research in the "recent period. Many researchers investigated and formulated the methodologies of Burnishing which has helped in optimizing production with high accuracy and surface finish. Research and development efforts over the last decade have resulted in improvement and increased effectiveness of processes.

The literature on burnishing methods has been reviewed thoroughly and has been presented and discussed below:

Hassan and Maqableh (2000) [1] studied the effects of initial burnishing parameters on non-ferrous components. They have used Carbon chromium as ball material and two non-ferrous work piece materials, namely free machining Brass and cast Al-Cu alloy and found that the initial burnishing parameters such as initial surface roughness and hardness of the work piece, the ball diameter of the burnishing tool, use of different lubricants have significant effects on the burnishing process. In the same work two types of lubricants were used to study the effect of lubricant in the burnishing process. As a result of this study it was concluded that the use of a lubricant in the burnishing process causes a general reduction in surface roughness and in the amount of the increase in surface hardness, but change in the viscosity of the lubricant seems to have no significant effect on either of the above-mentioned properties. They concluded that an increase in initial surface roughness will cause an increase in the final surface roughness of the ball burnished work pieces, but it has no effect on the surface hardness of these metallic work pieces. An increase in the initial surface hardness will cause a decrease in the reduction of surface roughness, and in the total amount of the increase in surface hardness.

Axir (2000) [2] published his work on an investigation of roller burnishing by using RSM method and taking Steel-37 as work piece and a roller bearing having outside diameter of 22 mm and a width of 6 mm, using feed rate as 0.1mm/rev. depth of cut 0.2mm, spindle speed 600 rpm RSM) and he concluded a good correlation between the experimental and predicted results derived from the model Thus, used the proposed procedure, the optimum roller burnishing conditions obtained to control the surface responses of other materials. It was shown that the spindle speed, burnishing force, burnishing feed and number of passes have the most significant effect on both surface micro hardness and surface roughness, tend to have many interactions and recommended spindle speeds that resulted in high surface micro hardness and good surface finish are in the range from 150 to

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

230 rpm and also the residual stress is at a maximum near the surface and decreases with an increase in the depth beneath surface.

Khabeery and Axir (2001) [3] worked upon the experimental techniques for studying the effects of milling roller-burnishing parameters on the surface integrity. They have used 6061-T6 Aluminum alloy work piece to investigate the effect of roller-burnishing upon surface roughness, surface micro hardness and residual stresses. They have used response surface method (RSM) with the Box and Hunter method to investigate the effect of the burnishing process parameters. In order to determine the independent, interactive, and higher-order effects of the different variables on the burnished surface roughness, hardness and maximum residual stress, a special technique called Group Method of Data Handling (GMDH) is used in this work. They concluded that the mathematical models for burnishing responses (mean roughness, burnished surface micro hardness, and maximum residual stress) are identified by GMDH considering burnishing speed, depth of penetration and number of passes. The literature study shows that the increasing both the number of passes and the burnishing depth of penetration causes the changes in mean roughness, surface micro hardness and maximum residual stress. Also they concluded that the burnishing speed should not exceed about 120m/min to obtain high surface quality.

An experimental analysis was undertaken by Nemat and Lycons (2001) [4] on ball burnished mild steel and aluminum using a purpose built burnishing tool. The analysis was designed to assess the effects of burnishing feed, force and speed and the number of tool passes on the surface roughness and surface hardness of mild steel and an aluminum

work piece. In some cases, experiments showed that improvements of as much as 70% in surface quality were obtained when varying the mix of parameters.

Martin (2002) [5] investigated the computational evaluation of the roller burnishing process to address the permanent deformation needed to introduce a desirable residual stress state. The analysis used a series of incrementally applied pressure loadings and finite element methodology to simulate the behavior of a roller burnishing tool. Various magnitudes of applied pressure loadings coupled with different size plates and boundary conditions were examined to assess the degree and depth of the residual compressive stress state cold working. Both kinematic and isotropic hardening laws were evaluated.

Ingole and Bahedwar (2002) [6] published work on the effect of lubricants on the surface finish of En8 specimens Using 23 factorial designs, in terms of surface roughness, model equations. The burnishing parameters considered were speed, feed and force and the other parameters were kept constant.

Axir and Khabeery (2003) [7] presented the work on influence of orthogonal burnishing parameters on surface characteristics for various materials. They used 2014 Aluminum alloy, Brass, and three carbon steel materials; namely, A387, grade 2; A285, grade C and A455, type 1 as work piece materials and steel roller burnishing tool and concluded that the output responses of the burnished surfaces are mainly influenced by the four parameters used, namely: burnishing speed, depth of penetration, burnishing time and initial hardness of the work piece materials. The literature Review show that an increase in burnishing speed leads to a decrease in both the percentage of micro hardness increase and change in work piece diameter, whereas the increase in burnishing speed more than 1.5 m/s results in a considerable increase in out-of-roundness. The authors have concluded that an increase in depth of penetration leads to a considerable increase in both surface micro hardness and change in

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ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

work piece diameter, whereas it causes a decrease in the out-of-roundness. The best result for out-of-roundness was obtained by applying high depth of penetration with low burnishing time.

Shiou and Chen (2003) [8] have presented their work on free form surface finish of plastic injection mold by using ball-burnishing process. In this study PDS5 tool steel was used as work piece material and three types of ball materials with diameter of 10mm, namely tungsten carbide ball (WC), steel ball coated with chromium (CrC), and tungsten carbide ball coated with titanium nitride (TiN), were used as ball material for ball burnishing tool. Four burnishing parameters, namely the ball material, burnishing force, burnishing speed and feed were selected as the experimental factors of Taguchi‟ s design of experiment to determine the optimal burnishing parameters. They concluded that optimal burnishing parameters for the plastic injection mold steel PDS5 were the combination of the tungsten carbide ball, the burnishing speed of 200mm/min, the burnishing force of 300N, and the feed of 40μm. The surface roughness Ra of the specimen can be improved from about 1 to 0.07μm by using the optimal burnishing parameters for plane burnishing. The Vickers hardness scale of the tested specimen was improved from about 338 to 480 after ball-burnishing process where hardened layer thickness was about 30μm. By applying the optimal burnishing parameters for plane burnishing to the surface finish of the freeform surface mold cavity, the surface roughness improvement of the injection part on plane surface was about 62.9% and that on freeform surface was about 77.8%.

A work on modeling of metal cutting and ball burnishing, prediction of tool wear and surface properties was presented by Yen (2004) [9] In this work, the effect of different cutting edge designs (hones and chamfer geometries) on the cutting variables and process mechanics was first investigated using Finite Element Method (FEM) cutting simulations. Then, an FEM-based methodology involving nodal wear rate calculations were developed to predict the progression of tool wear geometry during cutting the surface enhancement generated by ball burnishing, which is used following machining to improve surface finish and provide a surface layer of compressive residual stresses. For a successful ball burnishing process, the selection of process parameters (burnishing pressure, ball diameter, speed, and feed rate) needs to be optimized. In this research, a full 3-D FEM analysis model and a simplified 2-D model were developed for this purpose and the predictions of residual stresses were evaluated with limited experimental data. For the 2-D model, the strong elastic recovery of the burnished surface caused contact with the ball around its trailing end during unloading, making the simulation like a series of “indenting” cycles. Furthermore, the effects of the initial plastic strain and residual stresses in the machined surface, as opposed to uniform bulk material, were analyzed.

IV. DISCUSSION

From the Review of literatures it is found that Burnishing can be used almost all types finishing operations in industries. From the literature Review following points needs to be discussed:-

1) Experiments on Burnishing parameters showed that depth of penetration and burnishing time are the most important parameters controlling the values of both out-of-roundness and change in work piece diameter.

2)An increase in burnishing speed leads to a considerable reduction in the micro hardness index.

3)The results showed that in case of Aluminum Alloy 2014 from an initial roughness of about Ra 4 μm, the specimen could be finished to a roughness average of 0.14 μm through ball burnishing.

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

4) In internal burnishing process surface finish and surface hardness increases with burnishing speed up to an optimum value (62 m/min) and then decreases.

5) Experiments revealed that the burnishing effectively improves surface finish, depth of burnishing, micro hardness and compressive residual stresses.

6) Cold deformation of peaks to valleys on surface results with higher surface hardness. Depending on material ductility, peaks of the soften materials are more deformed.The possibility of burnishing steel components with high hardness is recommended

7) Experiments showed that surface waviness ratios were about 40% bigger in case of surface after burnishing than in case of surface after turning. Burnishing elements with a surface designed to reduce waviness decrease only short term waviness.

8)The surface roughness on various no-ferrous metals improved by high spindle rotations with highfeed rate and depth of penetration.

V. CONCLUSION

1) From the critical literature Review it is concluded that there is a wide applicability of Roller Burnishing that improves bored or turned metal surface quality by improving surface roughness and surface hardness. This process can be effectively used in many fields such as Automobiles Manufacturing sector, Production of Machine tools, Aerospace Industries, thermal and hydro power plants components, for ships and submarines etc due to the following advantage offered by roller burnishing processes.
2) Burnishing is capable of generating very high degree of surface finish ranging from 0.2 Ra, µm to 0.8 Ra, µm.
3) Very close and consistent dimensional tolerance can be achieved in several thousand components by using Burnishing Tools also assembly problems are totally eliminated since part dimensions are maintained within tolerances.
4) Since the roller burnishing process is a single pass operation manufacturing cycle times can be considerably reduced.
5) Roller burnishing operation is cold rolling process; work hardening takes place on the cold worked surface. Roller Burnishing resulting in better wear resistance
6) High repeatability finish sizing tolerance can be achieved easily by conventional machining methods.
7) Generation of high repeatable sizing minimizes rework and rejection during the assembly process thus saving time and cost.

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