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Burnishing Process for Surface Enhancement in Manufacturing Industry: A Comprehensive Review

Himanshu Khanna [*]
Harminder Singh [**]
**Department of Mechanical Engineering, Guru Nanak Dev University, Amritsar, Punjab, 143005, India*
***Department of Mechanical Engineering, Guru Nanak Dev University, Amritsar, Punjab, 143005, India*

***Abstract*: *Burnishing is a mechanical surface enhancement process widely employed in various manufacturing industries to improve the surface characteristics of metallic and non-metallic materials. It involves the plastic deformation of a workpiece surface using a hard tool or roller, resulting in refined surface texture, increased hardness, improved fatigue resistance, and enhanced tribological properties. This review paper provides a comprehensive overview of burnishing, encompassing its principles, techniques, applications across different industries, recent advancements, and prospects. The paper synthesizes existing research findings to elucidate the mechanisms underlying burnishing, its practical applications, comparative advantages over other finishing processes, and emerging trends in technology and materials. By examining the evolution of burnishing techniques and their impact on material properties, this paper aims to offer insights into optimizing surface finishing processes in contemporary manufacturing.*

***Keywords*: *Burnishing; Surface roughness; Surface Finish; Surface Hardness; Plastic Deformation.*

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I. INTRODUCTION

Burnishing is a cold-working process in which plastic deformation occurs by applying pressure through a very hard and smooth metal ball or roller. Application of burnishing processes can improve surface finish, yield strength, fatigue resistance, wear resistance, surface hardness, tensile strength, and corrosion resistance. As in this process, there is no removal of the extra material from the surface of a workpiece, so burnishing is a chipless finishing process. However, in recent years, attention has been paid to operations, which improve the surface characteristics, of plastic deformation. Such operations are sometimes referred to as plastic surface deformation. Roller burnishing falls into this category and is becoming more widely employed. In this process, a very hard roller is used to move over the surface of the workpiece. During the conventional machining process some geometric errors like, roundness and cylindrical inaccuracies surface defects such as roughness, micro-cracks, waviness surface burning, residual tensile stresses, and plastic creep make the component unfit for precision applications. Poor surface furnishings will lead to the rupture of oil films on the peaks of micro irregularities that result in dry friction and excessive wear of the surface in contact. Some functional and tribological properties like fatigue strength, corrosion, wear resistance, and friction are dependent on surface finish and surface texture.

To minimize the above-listed imperfections, the burnishing process is used to smooth the surface by decreasing the peak-to-valley height. Its other use is that it decreases the residual tensile stresses and macro irregularities by filling up cracks. Further, it hardens the surface and toughens the skin to make it more wear-resistant. The process called burnishing is a micro-finishing process; it was first commercialized by the French Enterprise Inc. with several applications by Gazan and others in 1966. Knowledge of burnishing has been limited to a couple of promoters only. The main reason may be the lack of understanding of the surface smoothening mechanism involving burnishing tribology. Russian scientists have been the leaders in developing the industrial use of this process. Burnishing finds its origins in ancient metalworking techniques where artisans used polished stones and bones to improve the aesthetic and functional properties of metal surfaces. Over centuries, the practice evolved with the development of specialized tools and techniques tailored to different materials and applications. Industrialization further propelled burnishing into a standardized process, integrating mechanical principles with advancements in materials science and manufacturing technologies

II. LITERATURE REVIEW

Rajasekariah and Vaidyanathan,(1975) worked on steel components, concluded that the burnished surface finish depends on the burnishing load, feed rate and initial surface roughness. There is an optimum burnishing load, which gives the best results. Increasing the feed rate and an increase in the initial surface roughness leads to a reduction in the burnished surface quality. Burnishing of steel components produces a high degree of strain hardening in the surface layers; the burnishing load is the main factor affecting work-hardening and wear-resistance of the surface.Murthy and Kotiveerachari,(1980) reviews the basic analytical and operational aspects of burnishing such as Burnishing force, Tangential or feed forces in burnishing, Characteristics of burnished components, Surface smoothening, Hardening of the surface layers, Depth of work-hardened layer, Fatigue strength, Burnishing configurations and Tool shape. They give some typical applications of burnishing process such as finishing inner diameter of relatively short holes; taper seats for line contact and better wear resistance, inner diameter's and outer diameter's of hydraulic cylinders, grease pit lifts and hydraulic elevator cylinders; pistons for hydraulic systems; face seals; spherical seats; recesses (internal and external);fillets; sizing (sleeve bearings for proper fit); press fits; salvage operations; assembly jobs involving flaring and crimping often on components too delicate to withstand impact; and outer diameter's of bearing surfaces of crankshaftsPande and Patel,(1984) investigated on vibratory burnishing process and Mathematical models have been presented to correlate the process parameters like speed, feed, etc. to the surface roughness and microhardness of burnished surfaces. The models can be used to select optimum process parameters to get desired surface characteristics. They also found that the deforming action of the ball, which governs the surface roughness and microhardness, is strongly governed by the network angle. Network angle can be adjusted to be in the range of 20-30 ° by selecting proper combinations of speed, feed, vibration frequency and amplitude. Reduction in burnishing speed results in better surface finish and micro hardness of specimen in the range of speeds studied. Pande found that in vibratory burnishing, as the frequency increases (oscillation amplitude decreases) the Ra parameter increases until a maximum value was reached and then Ra decreases. An interaction effect between the burnishing force and the vibratory frequency was found to be present and a very good surface finish can be obtained with a combination of large frequency and high force. The surface finish obtained is affected by numerous parameters although each affects the finish to a different degree. The effect is an interaction between the various process parameters rather than the total dependence of the individual parameter.Loh and Tam, (1988) did literature survey on effects of ball burnishing parameters like burnishing force, types of ball burnishing, feed-rate, ball material, ball diameter, lubrication, ball diameter, pre-machined surface finish, burnishing speed, nature of work material, frequency and amplitude of oscillation and number of burnishing passes on surface-finish. They concluded that ball burnishing, as a finishing process is not only technically viable but also has commercial potential. A required surface roughness can be obtained by proper selection of the process parameters, The effect on the surface finish is a combined interaction between the various parameters. The burnishing force and feed-rate are two of the most important factors. Ultrasonic ball burnishing gives a higher surface finish improvement than normal ball burnishing.Loh and Tam,(1989) did statistical analyses of the effects of ball burnishing parameters on surface hardness and showed that the main effects on surface hardness of ball material, lubricant, feed and depth of penetration were significant. An interaction effect between the ball material and the linear feed was also evident. The ball burnishing process can obtain an increase in surface hardness of 260 HV to 303 HV, an improvement of about-33% - 55%.Loh et al., (1993) conducted experimental work to establish the effects of various burnishing parameters on the surface finish of (high-carbon, high-chrome steel), including burnishing speed, ball material, lubricant, burnishing forces (depth of penetration), and feed. Within the parameter space explored, it was found that Grease is a better lubricant than cutting oil in improving the surface finish. The burnishing speed affects the surface finish. Generally, a speed of 1,200 mm/min gives the worst surface finish regardless of the type of ball material or lubricant used. There is no obvious trend between surface roughness parameter Rtm and the burnishing forces, except that SUJ2 ball gives the lowest corresponding force and the worst surface finish. By keeping the burnishing speed constant at 900 mm/min, as the depth of penetration and feed increase, generally the tangential and orthogonal forces increase, and the surfaces become rougher. In the case of the normal force, an optimum value (at -500 N using a feed of 112 μm) corresponding to the best surface finish of 0.32 μm is obtained.

Mahmood Hassan, (1996) used simple ball- and roller-burnishing tools for the experimental work of the study, these tools being quite similar in their design principles. The performance of the tools, together with the effects of the burnishing force and the number of burnishing tool passes on the surface roughness and surface hardness of commercially available aluminum and brass, were studied. The results show that improvements in the surface roughness and increases in the surface hardness were achieved by the application of both ball burnishing and roller burnishing with the non-ferrous metals under consideration.

Hassan et al., (1997) optimize the surface finish for ball-burnishing brass components using the response surface method. A mathematical model was established to correlate the most pronounced parameters, i.e. the burnishing force and the number of tool passes, with the surface finish. The model predicted that an optimum surface finish of 0.172 mm can be obtained when burnishing at a force of 20.7 kgf (203 N) with two passes of the burnishing tool.Klocke and Liermann, (1998) performed roller burnishing of hard turned surfaces. They determined optimum working parameter ranges. Parameter settings were shown to be non-critical in this process, since constant surface qualities were attainable over wide setting ranges. They also examined the improvements obtained for various original roughness. Reductions of 30 to 50 % in mean peak-to-valley height Rz are achievable depending on the original roughness. Structure analyses and residual stress measurements were used to examine the effects of the process on the workpiece surface zone. Hard roller burnishing transforms tensile residual stresses present in the surface zone after hard turning into compressive residual stresses. Hard roller burnishing has no effect on the formation of white layers in the surface zone.El-Axir, (2000) investigated into roller burnishing of Steel-37 with the help of mathematical models and 3D graphs between different parameters. He concluded that 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, and there are many interactions between these parameters. The principle factors which affect the results of both surface micro hardness and roughness are the tool chatter that occurs when using a high spindle speed and then the impact between tool and workpiece surface. The workpiece over hardening and then flaking generally occurs when using a combination of high burnishing force with a high number of passes, and the great deforming action of the tool and the increase of structural homogeneity of the surface layers that occurs when using low burnishing feed. The recommended spindle speeds that result in high surface micro hardness and good surface finish are in the range from 150 to 230 rpm. The recommended burnishing force for high surface micro hardness is about 35 kgf, whereas for good surface finish (low surface roughness) it is about 25 kgf. The best results for both responses were obtained at the lowest value of the burnishing feed used in this investigation. The best results for surface micro hardness were obtained at a high number of passes whereas for the surface finish they were obtained in the range from 3 to 4 passes. Compressive residual stress is generated in the surface region of a ring-shaped workpiece of St-37 burnished using a force of more than 25 kgf and high speeds under lubricated orthogonal conditions. The residual stress is at a maximum near the surface and decreases with an increase in the depth beneath the surface.El-Axir and El-Khabeery, (2003)carried experimental work on a lathe to establish the effect of four roller burnishing tool parameters namely; burnishing speed, depth of penetration, burnishing time and the initial hardness of five different materials (2014 aluminum alloy, brass, and three different carbon steel materials; namely, A387, grade II; A285, grade C and A455, type I) on the surface hardness, the out-of-roundness and the change in work piece diameter. They found that the output responses of the burnished surface 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 depth of penetration and burnishing time play a major role and their effects can be considered as the most important input parameters. 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. An increase in depth of penetration leads to a considerable increase in both surface micro hardness and change in work piece diameter, whereas it causes a decrease in the out-of-roundness. Depth of penetration interacts with both burnishing time and initial hardness of work piece material. The best results for surface micro hardness obtained at both low depth of penetration with high burnishing time and high depth of penetration with low initial hardness of material. The best result for out-of-roundness is obtained when applying high depth of penetration with low burnishing time. The initial hardness of work piece material is one of the most important parameters controlling the effects of the other parameters on each response. There are many interactions between initial hardness of material and other parameters.Shiou and Chen, (2003) 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%.Bouzid et al., (2004) analyse the evolution of surface roughness finished by burnishing. Burnishing is done on a surface that was initially turned or turned and then ground. It has been noted that burnishing an AISI 1042 steel offers the best surface quality when using a small feed value. This finishing process improves roughness and introduces compressive residual stresses in the machined surface. So, it can replace grinding in the machining range of the piece. Also, an analytical model has been defined to determine the R_t factor in relation to the feed. Good correlations have been found between the experimental and analytical results.Ghani et al., (2004)studied the application of Taguchi method in the optimization of end milling parameters by using hardened steel AISH H13 as work piece material and TiN coated P10 carbide tool. They found that Taguchi method was suitable to evaluate the milling parameters cutting speed, feed rate and depth of cut. In the same work an orthogonal array, signal-to-noise (S/N) ratio and analysis of variance (ANOVA) are employed to analyze the effect of milling parameters. As a result of this study the optimal combination for low resultant cutting force and good surface finish are cutting speed, low feed rate and low depth of cut. Also other significant effects such as the interaction among milling parameters are also investigated by using Taguchi method. They concluded Taguchi method is suitable to solve the stated problem with minimum number of trails as compared with a full factorial design. They concluded that the Taguchi's robust design method is suitable to analyze the metal cutting problem as described in the paper. Conceptual S/N ratio and Pareto ANOVA approaches for data analysis draw similar conclusion. In end milling, use high cutting speed (355m/min), low feed rate (0.1mm per tooth) and low depth of cut (0.5mm) were recommended to obtain better surface finish for the specific test range. Low feed rate (0.1mm per tooth) and low depth of cut (0.3mm) lead to smaller value of resultant cutting force the specific test range.Yen et al., (2005) applied finite element (FEM) modeling which provides a fundamental understanding of the process mechanics. In his study, 2D and 3D FEM models for hard roller burnishing were established. The simulation results (i.e. surface deformation and residual stress) were evaluated and compared between initial hard turned and burnished surfaces. The predicted residual stress was validated with the experimental data obtained from the literature.Axir and Ibrahim, (2005) worked on the surface characteristics after center rest ball burnishing. In this study, the center rest was used as a super-finishing tool by replacing the three original adjustable jaws of the center rest with three ball burnishing tool. They concluded that an increase in burnishing speed up to 1.5m/s leads to a decrease in both the burnished surface roughness, out-of-roundness, and change in work piece diameter whereas the increase in burnishing speed more than 1.5m/s result in an increase in both surface roughness and out-of-roundness. The literature review showed that an increase in burnishing feed up to 0.12mm/rev leads to a decrease in surface roughness and roundness also the best results for the surface roughness and roundness were obtained at burnishing force of 150N and burnishing feed 0.12mm/rev. surface roughness and surface roundness was obtained using the center rest burnishing tool applying one ball or three balls.Tian and Shin, (2006) worked on a new hybrid burnishing process, laser-assisted burnishing and investigated experimentally. During laser-assisted burnishing, the work piece surface layer is temporarily and locally softened by a controllable laser beam, and then immediately processed by a conventional burnishing tool. Laser-assisted burnishing and conventional burnishing experiments were conducted on MP35N annealed and hardened AISI 4140 respectively, to evaluate the effect of laser power on the burnishing. The results showed that laser-assisted burnishing can reduce the ratio of feed force to normal force, which suggests that less tool wear may be achieved in laser-assisted burnishing than in conventional burnishing at the same normal burnishing force level. Compared to its conventional counterpart, Laser-assisted burnishing substantially improves work piece surface finish, particularly for hard materials, because the softening of work piece material prior to burnishing enables Laser-assisted burnishing to produce more deformation for the same force. When the temperature during Laser-assisted burnishing is lower than the start point of the tempering temperature for the work piece material, Laser-assisted burnishing can produce higher hardness in the work piece surface layer, because more plastic deformation and hence greater work hardening of the work piece occur in Laser-assisted burnishing due to the temporary softening of work piece material by locally laser heating. Laser-assisted burnishing also generates large compressive residual stresses on the work piece surface comparable to those produced by conventional burnishing. The experiments conducted on the three materials have shown that the overall effect of laser power on the force ratio depends on the work piece properties and the laser power range.

Swirad,(2007)experimentally demonstrated the effect of burnishing parameters on steel fatigue strengths with his main focus on possibilities of sliding burnishing with cylindrical elements made of diamond composite with ceramic bonding phase. Author identified that technology of sliding burnishing with cylindrical elements of diamond composite can be used in very simple and uncomplicated way for smoothing machining of various types of material and cylindrical elements are easier to manufacture and easier to grind, which reduces the costs of their production, when the contact zone "tool machined object" will wear, it can easily grinded in this way it was possible to extend its life several dozen times. Author showed the distinctly advantageous effect of diamond burnishing with cylindrical elements on the improvement of the fatigue strength of the steel 40HM.Tayeb et al., (2007) investigated the influence of roller burnishing contact width and burnishing orientation on surface quality and tribological behavior of Aluminum 6061. In this study Aluminum 6061 used as work piece material and carbon chromium rollers with different roller contact widths were used in a burnishing tool with interchangeable adapters for ball and roller for the purpose of the experimental tests. Here optimum ranges of burnishing speed and force were identified to be 250-420 rpm for 1mm roller contact width. They found Burnishing with smaller roller contact width (1mm) is capable of improving the surface roughness up to 40%. Mean-while, surface morphologies revealed that using roller with larger contact width 1.5 and 2mm, the surface deteriorates with excessive plastic deformation. Burnishing force above 220N is capable of decreasing the surface roughness by 35%. Below this limit, the surface roughness starts to deteriorate plastically. In the same study the Burnishing speed 110 rpm yields the highest improvement in hardness, as much as 30% increase. The authors have found that the friction coefficient of burnished surfaces is dependent on the surface roughness. Low friction coefficient corresponds to low surface roughness, which may be attributed to less mechanical interlocking of asperities and entrapped debris. In this study the SEM examination of the worn surface reveals that interposinglubricant during Tribo-test acts as a cooler and polishing agent, resulting in smoother surface compared to the burnished surface. Under dry contact condition, burnished surface using smaller roller contact width produces the lowest friction coefficient. Increasing burnishing force has a negative impact on the wear resistance of burnished Aluminum 6061 surfaces.Thamizhmanii et al., (2008) presented a workon surface roughness investigation and hardness by burnishing on titanium alloy by using a multi roller burnishing tool on square titanium alloy material by designing various sliding speed/ spindle speed, feed rate and depth of penetration and concluded that the roller burnishing is very useful process to improve upon surface roughness and hardness and can be employed to impart compressive stress and fatigue life can be improved. The titanium alloy is a difficult to machine and burnishing is difficult process for this grade material also flaws and micro cracks on the surface of work piece were developed by increasing burnishing parameters.

Babu et al.,(2008) worked on effects of internal roller burnishing on surface roughness and surface hardness of mild steel and observed that in internal burnishing process, surface finish and surface roughness of M.S material increased with increase in burnishing speed due to repeated deformation of surface irregularities with increased burnishing speed, and also surface finish and surface hardness increases with burnishing speed up to an optimum value (62m/min)and then decreases on further increase in speed.

Yeldoseet al.,(2008) presented a work on comparison of effect of uncoated &TiN coated by reactive magnetron sputtering on EN31 rollers in burnishing with varying process parameters such as burnishing speeds, feeds, burnishing force, number of passes upon surface roughness of EN24 steel work material. It was observed that the performance of the TiN-coated roller is superior to uncoated rollers in burnishing operations. The burnishing speeds, feeds, depth of cut and number of passes were considerably influencing parameters on the burnishing operation. The burnishing speeds, burnishing force and number of passes are having almost equal importance on the performance of the roller in burnishing, particularly with reference to the surface finish of the components produced.

El-Taweel and El-Axir,(2009) studied the analysis and optimization of the ball burnishing process and Taguchi technique was employed to identify the effect of burnishing parameters, i.e., burnishing speed, burnishing feed, burnishing force and number of passes, on surface roughness, surface micro-hardness, improvement ratio of surface roughness, and improvement ratio of surface micro-hardness. The analysis of results showed that the burnishing force with a contribution percent of 39.87% for surface roughness and 42.85% for surface micro-hardness had the dominant effect on both surface roughness and micro-hardness followed by burnishing feed, burnishing speed and then by number of passes.

Sundararajan,(2009) published a work on optimization of roller burnishing process for aluminium using Taguchi technique. Roller burnishing tool is used to perform roller burnishing process on aluminium 63400 material under different parameters and different burnishing orientations. The impact of burnishing force, burnishing feed, number of passes and step over on the surface roughness and surface hardness are investigated and It was found that burnishing force of 1200N, burnishing feed of 200mm/min, step over 1mm and number of pass 3 is capable of improving surface finish. Roller burnishing process also enhances the hardness of burnished aluminium 63400. The Taguchi analysis of results concluded that the optimal combinations for good surface finish were at the burnishing force 600N, the burnishing feed 200mm/min and the step over 1mm for third number of pass.

Prabhu et al., (2010) studied the influence of deep cold rolling and low plasticity burnishing on surface hardness and surface roughness of AISI 4140 steel and focused on the surface roughness and surface hardness aspects of AISI 4140 work material, using fractional factorial design. The assessment of the surface integrity aspects on work material was done, in order to identify the predominant factors amongst the selected parameters and it was observed that by using LPB process surface hardness has been improved by 167% and in DCR process surface hardness has been improved by 442%. It was also found that the force, ball diameter, number of tool passes and initial roughness of the work piece are the most pronounced parameters, which has a significant effect on the work pieces surface during deep cold rolling and low plasticity burnishing process.

Korzynskia and Pacanab,(2010) presented the work on the centre less burnishing and influence of its parameters on machining effects by using 41Cr4 steel as specimen and burnishing rollers made of 100Cr6 bearing steel using rotation speed 100 rpm and obtained results by using 24 plan matrix and surface roughness tests. They concluded that the center less burnishing can be easily applied as a surface finish method without any major technological problems it is possible to achieve a surface roughness Ra within 0.25–0.50m. After center less burnishing, the average surface roughness (Ra) was three to six times smaller than that of the surface which was turned. Due to burnishing, there forms an isotropic surface and the height of surface irregularities gets reduced as well as the values of the rest of the surface topology indices after center less burnishing were fairly good. Based on the empirically derived mathematical models and its graphic interpretations, the hardness of the studied work pieces before center less roller burnishing does not significantly affect the result of burnishing while quenched and tempered work pieces (HB = 340daN/mm2) showed very good surface condition after burnishing.

John and Vinayagam(2011) presented the investigation of roller burnishing process onaluminium 63400 material to study the influence of different burnishing conditions on both surface roughness and hardness: namely, burnishing force, feed, step-over and number of passes is demonstrated and responses of surface methodology are used to optimize the burnishing parameters.

Rodríguez et al.,(2011) presented a deep ball-burnishing as a mechanical surface treatment for improving productivity and quality of rotating shafts. When this technique is combined and applied after conventional turning, the resulting process is rapid, simple and cost-effective, directly applicable in lathes and turning centers of production lines. This process provides good surface finish, high compressive residual stresses, and hardness increment of the surface layer. These characteristics are the key for the fatigue life improvement of the component, and for wear resistance due to the higher hardness. This work presents a complete analysis of the principal beneficial aspects produced by the application of ball burnishing. To determinate the influence of each process parameter, several tests were carried out. Once the optimum parameters were established, a complete analysis of the surface characteristics was performed. Surface topographies, sub-surface micro-hardness and residual stresses were measured. Complementary, a finite element model of ball-burnishing was used to understand and predict residual stress values and their variety with the process parameters. Results showed that burnishing is an economical and feasible mechanical treatment for the quality improvement of rotating components, not only in surface roughness but in compressive residual stresses as well.

Sagbas,(2011) uses optimization strategy based on desirability function approach (DFA) together with response surface methodology (RSM) to optimize ball burnishing process of 7178 aluminum alloy and developed a regression model to predict surface roughness using RSM with rotatable central composite design (CCD). In the development of predictive models he considered burnishing force, number of passes, feed rate and burnishing speed as model variables. The results indicated that burnishing force and number of passes were the significant factors on the surface roughness. The predicted surface roughness values and the subsequent verification experiments under the optimal conditions were confirmed the validity of the predicted model.

Babu et al.,(2012) studied effects of various burnishing parameters on the surface characteristics, surface microstructure, micro hardness are evaluated, reported and discussed in the case of EN Series steels (EN 8, EN 24 and EN 31), Aluminum alloy (AA6061) and Alpha-beta brass. The burnishing parameters considered for studies principally are burnishing speed, burnishing force, burnishing feed and number of passes. Taguchi technique was employed by them to identify the most influencing parameters on surface roughness. Effort was also made to identify the optimal burnishing parameters and the factors for scientific basis of such optimization.

Dzionk and Przybylski, (2012) presented a work on surface waviness of components machined by burnishing method. Author’s evaluated cylindrical surfaces burnished on the basis of waviness ratio and concluded that surface waviness ratios were found about 40% greater in case of surface after burnishing than in the case after turning.

Kamble and Jadhav, (2012) experimentally studied roller burnishing process on plain carrier of planetary type gear box authors employed internal roller burnishing tool to burnish the drilled hole speed, feed, and number of passes were varied using taguchi method to examine the surface finish and micro hardness and anova analysis is carried out and Surface finish from 2.44 micron to 0.13micron was achieved through internal roller burnishing

Babu et al., (2012) presented a work on optimization of burnishing parameters by DOE and surface roughness, microstructure and micro hardness characteristics of AA 6061 aluminum alloy in T6 condition .The burnishing process parameters studied in this investigation include depth of cut, speed, feed, and number of tool passes. The data obtained from systematically conducted burnishing experiments was correlated with theoretical design using Taguchi method. Further, surface characterization was conducted using optical microscopy and XRD studies that were employed to estimate the micro hardness and magnitude of residual stress. The study revealed a one-to-one correlation between various burnishing parameters and a peak in all the three parameters, viz. burnishing depth, average micro hardness and compressive residual stress levels.

Yang, (2012) published a work on cryogenic burnishing of co-cr-mo biomedical alloy for enhanced surface integrity and improved wear performance. The author investigated the effect of a SPD process, cryogenic burnishing, on the surface integrity modifications of a Co-Cr-Mo alloy, and the resulting wear performance of this alloy due to the burnishing-induced surface integrity properties through a systematic experimental study that was conducted to investigate the influence of different burnishing parameters on distribution of grain size, phase structure and residual stresses of the processed material. The results from this work showed that the cryogenic burnishing has significant improved the surface integrity of the Co-Cr-Mo alloy which would finally lead to advanced wear performance due to refined microstructure, high hardness, compressive residual stresses and favorable phase structure on the surface layer. A finite element model (FEM) was developed for predicting the grain size changes during burnishing of Co-Cr-Mo alloy under both dry and cryogenic conditions and a new material model was used for incorporating flow stress softening and associated grain size refinements caused by the dynamic recrystallization.

Patel and Patel, (2013) presented a review of parametric optimization of process parameter for roller burnishing process. A roller burnishing tool is used to perform roller burnishing process under different parameters. There are so many parameters which can be optimized for better performance of surface roughness and surface hardness. It has been used to impart certain physical and mechanical properties, such as friction, corrosion, wear and fatigue resistance. Roller burnishing is an economical process, where skilled operators are not required.

Esme et al., (2013) worked on predictive modeling of ball burnishing process using regression analysis and neural network by focusing on two techniques, namely regression and neural network techniques, for predicting surface roughness in ball burnishing process. Values of surface roughness predicted by the two techniques were compared with experimental values. Also, the effects of the main burnishing parameters on surface roughness were determined. Surface roughness (Ra) was taken as response (output) variable and burnishing force, number of passes, feed rate, and burnishing speed were taken as input parameters. Relationship between the surface roughness and burnishing parameters was found out for direct measurement of the surface roughness.

Grzesik& Zak (2013**)** presented novel sequential process which incorporates optionally CBN turning operations with (CHT) or without (HT) cryogenic pre-cooling of the work piece and ball burnishing (B) operations. Investigations include 2D and 3D surface roughness, microstructure alterations by means of SEM/BSE techniques and micro hardness distribution. The geometrical, mechanical and physical improvements of surface layer properties were revealed.

Akkurt et al (2014) investigated Surface finishing processes such as drilling, turning, reaming, grinding, honing and roller burnishing etc. are widely used in manufacturing as hole surface finishing process. In this paper, it is presented that different hole surface finishing processes were applied to the samples made of pure copper. As a result of all the measurements and assessments, the results of the study show that the roller burnishing method gives the best results in terms of mechanical, metallurgical properties and hole surface quality of the material.

Okada et al (2015) proposed a novel roller burnishing method that achieves simultaneously rolling and sliding effects on the burnishing point to accomplish a finish with superior surface integrity using a commercially available roller burnishing tool. The processing characteristics of the method with an aluminum-based alloy work piece were evaluated to compare with the conventional method. The influence of the burnishing conditions, such as the burnishing speed, thrust force, and feed rate, was also investigated. The thrust force and feed rate had a large influence on the burnished surface integrity, whereas the influence of the burnishing speed was minimal. The applicability of the proposed method for burnishing a carbon steel work piece material was also examined

Zhang et al (2015) focused on obtaining predictable models of surface roughness and residual stresses based on experimental data. Smoother surfaces of aerospace material modified by ball burnishing have been achieved and significant influences of process parameters on both surface roughness and maximum residual stresses are established. A second-order empirical model involving pressure, speed, and feed is developed for surface roughness prediction. The predictive values are compatible with experimental results. Pressure plays an important factor on compressive residual stresses; however, the empirical models only have qualitative compatibility with the experimental results.

Al Quran Fm (2015) investigated Surface texture and micro hardness tests, were applied to demonstrate the effects of the burnishing force and feed rates on the surface roughness and surface hardness of commercially available aluminum. The roughness and micro hardness were measured at the end of each burnishing combination of feeding speed and burnishing force. Significant enhancement in the surface roughness values were clearly observed, meanwhile, very little enhancement to the surface hardness were encountered. The best results were obtained at the lowest value of the burnishing feed rate and maximum burnishing force used in this investigation.

John et al (2016) worked on finite element analysis of burnishing process on the D3 tool steel material using CNC lathe. They used speed, burnishing force, and feed as input parameters. The output parameters were surface roughness, residual stress, micro-hardness and out of roundness. Surface roughness generated after the turning operation is used to model the surface roughness pattern which is further used to simulate ball burnishing process using finite element based software DEFORM-2D. For tool steel, improvement in the surface roughness values achieved after ball burnishing process is 86.2%. The surface roughness and residual stress results of FEM simulations are compared with experimental results. The minimum and maximum deviation between the experimental and simulation values of surface roughness is 3.22 % and 8.69%, experimental residual stress is 0.63% and 3.94% and theoretical values of residual stress are 1.23% and 3.57%, respectively. Considering the above, this article examines the use of a newly developed ball burnishing tool to give enhanced surface properties for brass bar. To explore the optimum combination of burnishing parameters, several experiments were designed and performed on a machining Centre based on Taguchi's L18 design of experiments. The effects of burnishing parameters i.e., burnishing speed, feed rate, and depth of penetration on the surface roughness and surface hardness were investigated, as presented by the mean surface roughness (Ra) and Rockwell hardness number (HRB), respectively. Khanna et al (2018) worked on the geometry and microstructural superiority of the machined surface. Different operations such as grinding, lapping, honing, buffing, barrel rolling, polishing, super finishing, and burnishing are required to be performed to achieve a high surface finish. Amongst all, burnishing is a process where the hard roller or a ball tool is engaged in the workpiece to get a better surface finish. In the present study, using the Taguchi approach preliminary plan is made for the experimentation then according to it a roller burnishing of the 20MnCr5 workpiece at different input conditions is performed. From the analysis, it is concluded that the hardness of the material is the main contributing factor to the burnishing process.

III. CONCLUSIONS

In conclusion, burnishing remains a versatile and effective method for enhancing surface properties across various industries. Its ability to improve surface finish, hardness, and wear resistance makes it invaluable in manufacturing processes. Recent advancements, such as nanoburnishing and hybrid techniques, continue to expand its capabilities and applicability. However, challenges such as tool wear and process optimization remain areas for further research. As manufacturing technologies evolve, burnishing is expected to play an increasingly important role in achieving high-quality surface finishes and optimizing material performance.

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