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Mechanical Behavior of Ball Burnishing on Composite Material

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Abstract: **Burnishing is a chip less finishing method which employs a rolling tool pressed against the work piece for achieving of the surface layer. Ball burnishing process is largely considered in industrial cases in order to restructure surface characteristic. Ball burnishing process is employed on 100% aluminum alloy and aluminum (99%, 98%) with zirconium (+1%, +2%) work piece for current study.**

In this thesis, work the effect of burnishing parameter like speed, and feed and the number of passes is going to be examined on the surface quality and its wearing characteristics of aluminum with zirconium (+1%, +2%). For this experimental work, I utilize Taylor Hobson for measuring surface roughness and Brinell hardness for measuring surface hardness. In this thesis force and number of passes of tool are kept constant. The main aim of this thesis is to compare surface roughness and surface hardness values on 100% aluminum alloy and aluminum (99%, 98%) with zirconium (+1%, +2%) work piece

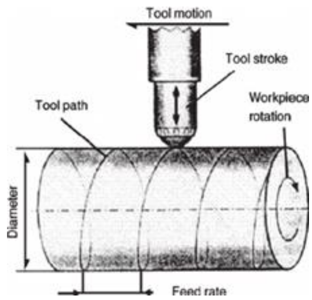
Keywords: **CAD; CREO; BURNISHING;**

I. INTRODUCTION

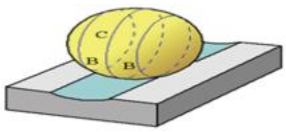
Turning is the removal of metal from the outer diameter of a rotating cylindrical work piece. Turning is used to reduce the diameter of the work piece, usually to a specified dimension, and to produce a smooth finish on the metal. Often the work piece will be turned so that adjacent sections have different diameters.

1.1 BURNISHING TOOL: Burnishing is a post finishing operation, in which highly polished ball or roller burnishing tools are pressed against pre-machined surfaces to plastically deform peaks into valleys as shown in fig. Today it is becoming more beneficiary process among the conventional finishing operations in metal finishing processes in industries because of its many advantages. Inducing the compressive stresses in metal surface increases many properties associated with metal surface like surface finish, surface hardness, wear resistance, fatigue resistance, yield and tensile strength and corrosion resistance

It is observed that the conventional machining methods such as turning and milling leave inherent irregularities on machined surfaces and it becomes necessary to very often resort to a series of finishing operations with high costs. However, conventional finishing processes like grinding, honing and lapping are traditionally used finishing processes, but these methods essentially depend on chip removal to attain the desired surface finish, these machining chips may cause further surface abrasion and geometrical tolerance problems. Accordingly, burnishing process offers an attractive post-machining alternative due to its chip less and relatively simple operations.



1.2 MECHANICS OF BURNISHING:



To understand burnishing, let us consider the simple case of a hardened ball on a flat plate as shown in fig.2. If the ball is pressed directly into the plate, stresses develop in both objects around the area where they contact. As this normal force increases, both the ball and the plate's surface deform. The deformation caused by the hardened ball is different depending on the magnitude of the force pressing against it. If the force on it is small, when the force is released both the ball and plate's surface will return to their original (un-deformed) shape.

1.3OBJECTIVES OF THE WORK:

- To model Ball burnishing tool in creo and fabrication of tool using HCHCR material on cnc lathe.

- To fabricate work piece using stir casting machine.
- To fabricate the workpiece of 100% aluminium and two other rods of different compositions of 99%aluminium+1% zirconium & 98%aluminium+2% zirconium.
- To find surface roughness and surface hardness measuring instruments are considered.
- To analyze surface roughness and surface hardness work piece is prepared for burnishing process using lathe machine
- The analytical results of the surface roughness and surface hardness are compared with different composition of aluminium and zirconium.

II. LITERATURE SURVEY

Jayakrishnan J, Suraj R. et all , are discussed about Roller burnishing is a technique used to super finish various components. In this technique, the type of contact between the work piece and the tool is a line.. The effect of various operating parameters such as burnishing force, speed, feed, roller width, and number of pass are investigated for better surface finish. Workpeice material is HCHCr tool steel (35 HRC) and the burnishing tool material is tungsten carbide (69 HRC).He concluded by showing minimum surface roughness obtained was 0.122 µm and the maximum micro hardness was 589 HV.

M.Ramachandra, G.Dilip Maruthi, R.Rashmi. , are discussed about The corrosion property of aluminium matrix nanocomposite of an aluminium alloy (Al-6061) reinforced with zirconium dioxide(ZrO_2) particles. In this thesis zirconium dioxide particles are synthesized by solution combustion method. The nanocomposite materials are prepared by mechanical stir casting method. Varying the percentage of n-ZrO_2 (2.5%, 5%, and 7.5% by weight).

Himanshu Tripathi, Harish Pungotra, Sandeep Gandotra, Naveen Beri, are discussed about a Burnishing is a chipless finishing process, which employs a rolling tool, pressed against the work piece, in order to achieve plastic deformation of the surface layer. In this experimental study, presented in this paper, ball burnishing of brass was done using standard L-18 array Taguchi's design of experiments.In this paper he concluded results using of optimum burnishing parameters resulted in improvements in the surface finish and increase in the surface hardness.

S.Banerjee, S.Mithra, B.Panja., are discussed about the present paper deals with the experimental study of roughness characteristics of EN 47 spring steel in WEDM and optimization of the machining process parameters based on L27 orthogonal design. It is observed that pulse on time together with wire feed play a vital role in controlling the roughness characteristics of EN 47 spring steel. A reduction of around 26% is observed in roughness at the optimal condition compared to the initial condition. The composition of specimen material is studied with the help of chemical test

R. G. Solanki , Kiran. A. Patel, R. B. Dhruv., are discussed about in present era of globalization for every industry, surface quality of machined components is of utmost importance. They used burnishing parameters which includes speed, feed, depth of cut, No. of tool passes, burnishing force etc. They concluded results with the effect of various burnishing parameters on the surface characteristics like surface roughness, hardness, microstructure properties, fatigue strength, corrosion resistance, wear resistance.

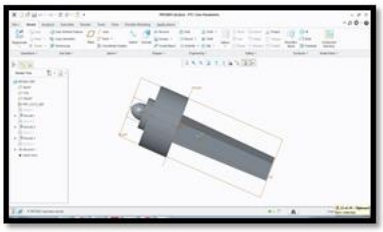
Grzesik worked on effect of the role of ball burnishing in improving of the surface integrity produced in finish hard machining of hardened 41Cr4 steel. He divided surface integrity in two standardized sets of 2D and 3D roughness parameters, the distributions of micro hardness, residual stresses and the microstructure of the sub layer which were examined using SEM/EDS technique. This investigation revealed that ball burnishing performed on hard turned surfaces improved not only surface roughness but also resulted in better service properties compared to those generated by CBN hard turning.

The above mentioned papers were closely relevant to my thesis. Papers were selectively studied and helped to predict the surface characteristics in consideration of different parameters like speed, passes and feed. These papers we gave the initial idea in the area of design and analysis of surface characteristics. Some papers gave information about diameter of ball burnishing tool. So in this work design and fabrication of ball burnishing tool in first case and in second case fabrication of workpiece using stir casting machine and surface roughness, surface hardness will be obtained.

III. DESIGN AND FABRICATION OF BALL BURNISHING TOOL

3.1INTRODUCTION TO CAD: Computer-aided design (CAD) is the use of computer systems (or workstations) to aid in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations. The term CADD (for Computer Aided Design and Drafting) is also used.

3.2INTRODUCTION TO CREO: CREO, formerly known as Pro/ENGINEER, is 3D modeling software used in mechanical engineering, design, manufacturing, and in CAD drafting service firms. It was one of the first 3D CAD modeling applications that used a rule-based parametric system. Using parameters, dimensions and features to capture the behavior of the product, it can optimize the development product as well as the design itself.



3.3 FABRICATION OF BALL BURNISHING TOOL: D2 Steel Consolidates maximum wear resistance, great durability, exceptional front line maintenance and treating resistance. 12 % ledeburitic chromium steel. It can be nitride after special heat treatment. It can be utilized as threading rolls and dies, icy trimming, cutting and stamping tools for sheet thickness's up to 6 mm.

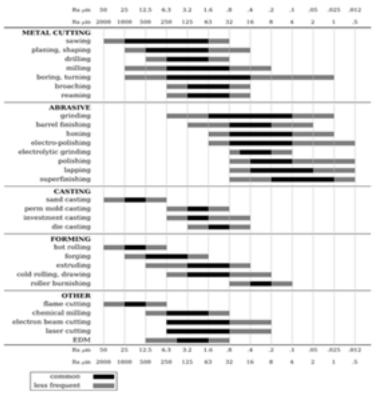
3.4 HEAT TREATMENT OF BALL BURNISHING TOOL: Heat treating (or heat treatment) is a group of industrial and metalworking processes used to alter the physical, and sometimes chemical, properties of a material.The most common application is metallurgical. Heat treatments are also used in the manufacture of many other materials, such as glass.

IV. FABRICATION OF WORKPIECE

4.1 INTRODUCTION TO CUTTING FORCES AND SURFACE FINISH

Knowing the magnitude of the cutting forces in the turning process as function of the parameters and conditions of treatment is necessary for determining of cutting tool strength, cutting edge wearing, limit of the maximum load of the cutting machine and forecasting the expected results of the processing. In particular, during machining with high cutting speed, using modern materials and modern cutting machines imposes the necessity of studying physical phenomena in the cutting process and their mathematical modeling.

4.2 Manufacturing: Due to the abstractness of surface finish parameters, engineers usually use a tool that has a variety of surface roughnesses created using different manufacturing methods.



4.3EXPERIMENTAL INVESTIGATION

The experiments are done on the Lathe machine(turning) with the following parameters:

CUTTING TOOL – Ball burnishing tool

WORK PIECE MATERIAL – ALUMINIUM COMPOSITIONS

FEED – 0.56mm/min, 0.48 mm/min, 0.44 mm/min

CUTTING SPEED – 97 rpm, 192 rpm, 256 rpm,

ALUMINUM COMOPOSITION-Al, Al+1%, Al+2% zirconium

PURE ALUMINUM 7075 MATERIAL

7075 aluminum alloy is an aluminum alloy, with zinc as the primary alloying element. It is strong, with strength comparable to many steels, and has good fatigue strength and average machinability.

4.4 STIR CASTING PROCESS: Stir casting process is a simplest and cost effective liquid state fabricating method of metal matrix composites, In this process, Aluminum alloy was superheated to 800°C and then the temperature is lowered gradually below the liquids temperature to keep the matrix material in the semi-solid state. At this temperature, the preheated zirconium particles with different volume proportions.

Placing aluminum material in sand mould AND Heated material up to 760^{0}C

Pouring zirconium powder into molten metal

Pouring composition into pattern

Placing zirconium powder in sand mould

Pouring zirconium powder into molten metal

Stirring the stir casting machine

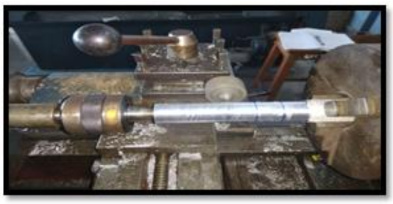
Pouring molten metal from sand mould into pattern

Final rods

V. EXPERIMENTATION

5.1Preparation of work piece for burnishing process on lathe machine

After fixing the work piece lock the tailstock to support the work piece held stiff. Next select the perfect tool to perform turning operation on work piece. Turning operations done to decrease the diameter of rod and to increase the surface finish of work piece.Now advance the cross slide crank about 10 divisions or .010" (ten one-thousandths or one one-hundredth of an inch). Turn the carriage handwheel counterclockwise to slowly move the carriage towards the headstock. As the tool starts to cut into the metal, maintain a steady cranking motion to get a nice even cut. It's difficult to get a smooth and even cut turning by hand.Continue advancing the tool towards the headstock until it is about 1/4" away from the chuck jaws. Obviously you want to be careful not to let the tool touch the chuck jaws!



Mark the choosen parameters on the work piece using marker.9 divisions were made on each rod.on each part number of passes of ball burnishing tool is fixed as 3passes.

5.2Constant parameters choosen for experiment

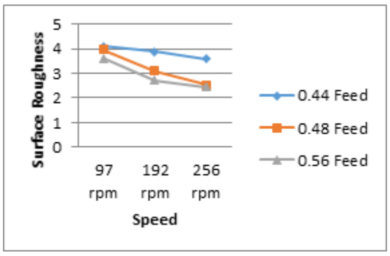
FACTORS	PROCESS PARAMETERS	LEVEL1	LEVEL2	LEVEL3
A	CUTTING SPEED	97	192	256
B	FEED RATE	0.56	0.48	0.44
C	AL COMPOSITION	AL	AL+ZR1%	AL+ZR2%

OPTIMIZATION PARAMETERS

FEED RATE mm/min	Spindle speed rpm
0.44	97
0.44	192
0.44	256
0.48	97
0.48	192
0.48	256
0.56	97
0.56	192
0.56	256

SURFACE ROUGHNESS VALUES FOR 100% Al

FEED RATE mm/min	Spindle speed rpm	Surface roughness
0.44	97	4.1
0.44	192	3.9
0.44	256	3.6
0.48	97	3.96
0.48	192	3.09
0.48	256	2.53
0.56	97	3.62
0.56	192	2.72
0.56	256	2.45



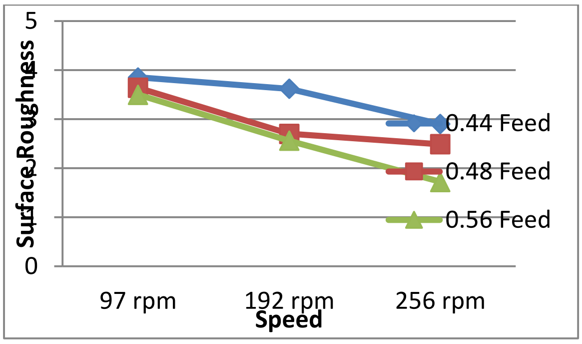
Surface Roughness Vs Speed by keeping force, number of passes constant of 100% aluminium

At 0.44 of feed: Surface roughness decreases with increase in speed.At 0.48 of feed: Surface roughness decreases till medium speed 192rpm and remains constant for higher speed of 256rpm.At 0.56 of feed: Surface roughness decreases with increase in speed.

SURFACE ROUGHNESS VALUES FOR 99% Al+1% Zr

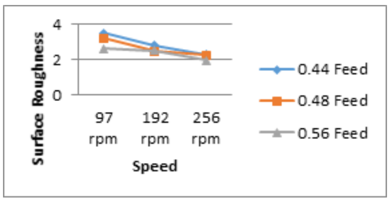
FEED RATE mm/min	Spindle speed rpm	Surface roughness
0.44	97	3.85
0.44	192	3.62
0.44	256	2.9
0.48	97	3.64
0.48	192	2.70
0.48	256	2.49
0.56	97	3.50
0.56	192	2.56
0.56	256	1.72

Surface Roughness Vs Speed by keeping force, number of passes constant of 99% al+1% Zr



SURFACE ROUGHNESS VALUES FOR 98% Al+2% Zr

FEED RATE mm/min	Spindle speed rpm	Surface roughness
0.44	97	3.51
0.44	192	2.82
0.44	256	2.31
0.48	97	3.24
0.48	192	2.50
0.48	256	2.27
0.56	97	2.63
0.56	192	2.53
0.56	256	1.98



Surface Roughness Vs Speed by keeping force, number of passes constant of 98% aluminium+2% zirconium

At 0.44 of Feed: Surface roughness decreases with increase in speed. Surface roughness gradually decreases from 97 to 256.At 0.48 of Feed: Surface roughness decreased gradually till medium speed of 192 rpm then it slowly decreased to 256 rpm.At 0.56 of Feed: Surface roughness slightly decreased till medium speed of 192 rpm then it gradually decreased to 256 rpm.

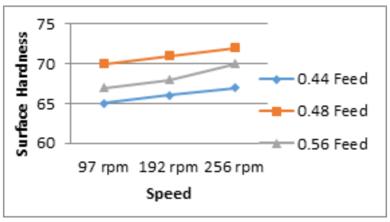
HARDNESS TEST REULTS

MACHINE DETAILS

Hardness is a characteristic of a material, not a fundamental physical property. It is defined as the resistance to indentation, and it is determined by measuring the permanent depth of the indentation. The Brinell hardness test method as used to determine Brinell hardness, is defined in ASTM E10. Most commonly it is used to test materials that have a structure that is too coarse or that have a surface that is too rough to be tested using another test method, e.g., castings and forgings. The Rockwell hardness test method, as defined in ASTM E-18, is the most commonly used hardness test method.

SURAFACE HARDNESS VALUES for 100% Al

FEED RATE(mm/min)	SPINDLE SPEED (Rpm)	ROCKWELL	BRINELL (BHN)
0.44	97	29	65
0.44	192	31	66
0.44	256	33	67
0.48	97	37	70
0.48	192	41	71
0.48	256	44	72
0.56	97	34	67
0.56	192	40	68
0.56	256	42	70

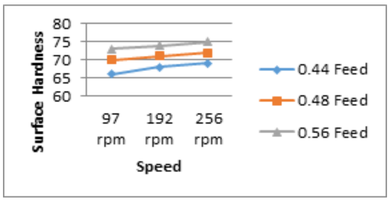


Surface Hardness Vs Speed by keeping force, number of passes constant of 100% aluminium

At 0.44 of Feed: Surface Hardness increases by increasing speed.At 0.48 of Feed: Surface hardness increases by increasing speed. It gradually increases till medium speed of 192 rpm and increases upto extinct in 256 rpm speed.At 0.56 of Feed: Surface hardness increases by increasing speed. The hardness of the material increases gradually by increasing speed from 97 to 256 rpm speed.

SURFACE HARDNESS VALUES FOR 99%Al+1%Zr

FEED RATE(mm/min)	SPINDLE SPEED (Rpm)	ROCKWELL	BRINELL (BHN)
0.44	97	29	66
0.44	192	31	68
0.44	256	33	69
0.48	97	36	70
0.48	192	41	71
0.48	256	42	72
0.56	97	35	73
0.56	192	36	74
0.56	256	38	75

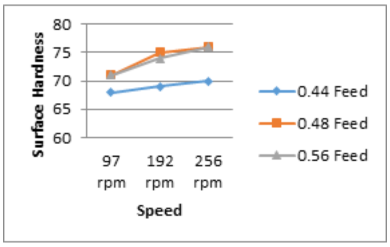


Surface Hardness Vs Speed by keeping force, number of passes constant of 99% aluminium+1% zirconium

SURFACE HARDNESS VALUES FOR 98%Al+2%Zr

FEED RATE(mm/min)	SPINDLE SPEED (Rpm)	ROCKWELL	BRINELL (BHN)
0.44	97	36	68
0.44	192	37	69
0.44	256	38	70
0.48	97	39	71
0.48	192	40	75
0.48	256	44	76
0.56	97	39	71
0.56	192	43	74
0.56	256	44	76

At 0.44 of Feed: Surface Hardness increases by increasing speed.It increases gradually from speed of 97 rpm to 256 rpm.At 0.48 of Feed: Surface hardness increases by increasing speed. It gradually increases till medium speed of 192 rpm and increases upto extinct in 256 rpm speed.At 0.56 of Feed: Surface hardness increases by increasing speed. The hardness of the material increases gradually by increasing speed from 97 to 256 rpm speed.



Surface Hardness Vs Speed by keeping force, number of passes constant of 98% aluminium+2% zirconium

VI. RESULTS AND DISCUSSION

Comparison of surface roughness: For 100% of aluminium rod the surface roughnesses are calculated with varying the speed and feed. It is observed that increase in speed decreases the surface roughness till high speed of 256rpm and feed rate of 0.56.With 2% zirconium and 98% aluminium the surface roughness values are calculated by varying the speed and feed as shown in figure 5.9.It is observed that surface roughness are higher at a speed of 97rpm and feed rate 0.44.The surface roughness values are higher at a speed of 256rpm and feed rate of 0.56.

Sl no	Speed	Feed	100%Al	99%+1%Zr	98%Al+2%Zr
1	97	0.44	4.1	3.85	3.51
2	192	0.48	3.09	2.70	2.50
3	256	0.56	2.45	1.98	1.72

Comparison of Surface Roughness with different compositions

From whole experimentation the surface roughness is higher for 100% aluminium at 0.44 feed rate and 97 rpm speed and surface roughness is lower for composite material having 98% aluminium with 2% of zirconium at feed rate of 0.56 and speed of 256 rpm. Overall it can be observed that increase in percentage of zirconium in aluminium surface roughness values are decreased.

Comparison of surface Hardness: For 100% of aluminium rod the surface hardness is calculated with varying the speed and feed. It is observed that increase in speed increases the surface hardness. With zirconium as 1% and aluminium 99% the surface roughness are calculated by varying the speed and feed.It is observed that increase in speed increases the surface hardness till high speed of 256rpm and feed rate of 0.56.

Sl no	Speed	Feed	100% Al	99%+1% Zr	98%Al+2% Zr
1	97	0.44	65	66	68
2	192	0.48	71	71	75
3	256	0.56	70	75	76

Comparison of Surface hardness with different compositions

VII. CONCLUSIONS AND FUTURE SCOPE

7.1 CONCLUSIONS: The Ball burnishing tool has been successfully modeled using CREO.The developed model has been validated using earlier and also by taking different types of material the workpiece are fabricated. The Ball burnishing tool fabricated here are carried out for experimental analysis using lathe machine by varying the composition of zirconium in aluminium to study the surface roughness and surface hardness on different work piece. The results obtained from the experimentation analysis clearly shows that with increase in the composition of zirconium in aluminium there is an increase in the surface hardness for the same values of different materials.

From the results it can said The surface hardness values are higher at a speed of 256rpm and feed rate of 0.56.From whole experimentation the surface hardness is lower for 100% aluminium at 0.44 feed rate and 97 rpm speed and surface hardness is higher for composite material having 98% aluminium with 2% of zirconium at feed rate of 0.56 and speed of 256 rpm.Overall it can be observed that increase in percentage of zirconium in aluminium surface hardness values are increased.From whole experimentation the surface roughness is higher for 100% aluminium at 0.44 feed rate and 97 rpm speed and surface roughness is lower for composite material having 98% aluminium with 2% of zirconium at feed rate of 0.56 and speed of 256 rpm.Overall it can be observed that increase in percentage of zirconium in aluminium surface roughness values are decreased.

7.2 FUTURE SCOPE OF WORK:

- Thermal analysis of burnishing process can be taken up to study the effect of heat treatment, if any, on the surface characteristics
- Dynamic analysis can be performed for different contact models subjected to various loads, especially fem analysis
- Investigations are making use of different size of balls is used to conduct tests on the components. the effect of burnishing on improving the thermal conductivity of materials can be investigated.

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