Studies on Effect of Ball Burnishing Parameters on Ferrous and Non-Ferrous Materials with and without Presence of Abrasive Particles

Deekshith Shetty [1], Manoj Kumar K [2], Prasad [3], Bharath Kumar [4]
Mechanical Engineering, Visvesvaraya Technological University, Belagavi
Shri Madhwa Vadiraja Institute Of Technology and management
Vishwothama nagar-574115, Bantakal, Udupi, Karnataka, India

Abstract*- In the quality assurance of machine components, the so-called finishing and super-finishing processes have important roles. During recent years, the post-machining cold forming methods such as burnishing, shot peening and others have occupied a very important place in industry. Burnishing, which is one of the effective methods used to improve the surface layer properties, is essentially a cold forming process in which the raised micro-irregularities on the surface layer are plastically moved and pressed into the micro-cavities. The process is carried out with a highly polished ball or roller type tool which is traversed under force over a rotating work piece. Machines normally used for burnishing operation can be drill presses, lathes, boring machines, and automatic bar or chucking machines.*

The process of burnishing can be done on parts which are turned, bored, reamed or ground. Any ductile or malleable material with hardness less than 40 HRC can be successfully burnished. Although diamond burnishing machines are available for finishing material harder than 40 HR. the burnishing process is used to improve the shape of components besides producing a good surface finish. Quite the opposite, the burnishing tool will not correct deviations from roundness or Straightness to any degree.

In this work an attempt is made to compare the results of ball burnishing (in dry and abrasive paste conditions). The parameters taken in consideration are burnishing speed, burnishing feed, burnishing force, ball material and number of passes. Mathematical models have been developed in terms of surface roughness and surface hardness for ball burnishing process.

Keywords — *Burnishing, Ball burnishing, Surface roughness, Surface hardness, F, N,S,f*

I INTRODUCTION

A surface machined by conventional machining processes such as milling and turning consists of inherent irregularities produced by the cutter, or a finer structure due to tearing of the material during machining. There are many finishing processes used to produces surfaces with high quality textures. These processes can be classified into chip removal process, such as grinding, and chip less processes such as burnishing.

Burnishing is a cold working process and chip-less machining process carried out to improve surface roughness, surface hardness, fatigue, and compressive strength and corrosion resistance. The Burnishing process smoothed out peaks and valleys on the surface. This is very simple and an effective method for improvement in surface finish, it can be carried out using existing machines, such as lathe. The functional performance of a machined component such as fatigue strength, load bearing capacity, friction, etc. depends to a large extent on the surface as topography, hardness, nature of stress and strain induced on the surface region. During recent years, considerable attention has been paid to the post-machining metal finishing operations such as burnishing which improves the surface characteristics by plastic deformation of the surface layer by producing compressive residual stress on surface. During burnishing the micro irregularities start to deform plastically Initially at the crests are gradually flattened and zones of reduced deformation are set up. When all the crests are subjected to plastic deformation, the valleys between the micro-irregularities start to move in the direction of the newly formed surface, i.e. towards the surface in contact with the tool. The grain structure is then condensed, producing a hard surface with superior load-carrying and wear-resistant characteristics.

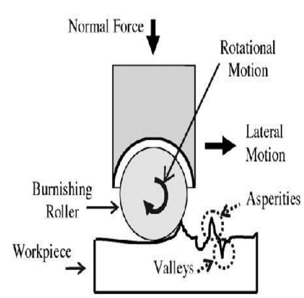

Fig 1 Schematic representation of roller burnishing process

There are several forms of burnishing processes, the most common are

1. Ball burnishing and
2. Roller burnishing.

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.

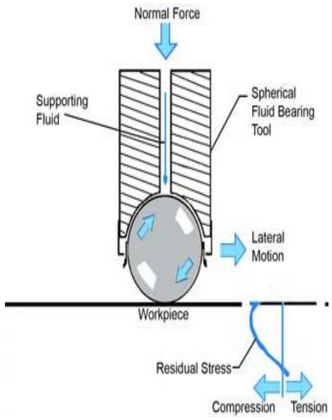

Fig 2 Ball burnishing process

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.

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

Need for Burnishing :-Most of the finishing techniques which are in use such as precision finishing techniques like lapping, honing, super finishing, ultrasonic impact grinding and Non-precision finishing techniques such as polishing, buffing, power brushing, tumbling, vibratory finishing, shot and sand-blasting only increase the surface finish of the components when it is carried out. But in burnishing in a single operation both the surface finish and hardness will increase which is not possible in any other finishing techniques. Hence, this technique became popular among researchers to continue work. So, in this work it was decided to study about burnishing effect on brass and EN24 components.

Mechanics of Burnishing:- To understand burnishing, let us consider the simple case of a hardened ball on a flat plate. 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. In this case, the stresses in the plate are always less than the yield strength of the material, so the deformation is purely elastic. Since it was given that the flat plate is softer than the ball, the plate's surface will always deform more. If a larger force is used, there will also be plastic deformation and the plate's surface will be permanently altered. A bowl-shaped indentation will be left behind, surrounded by a ring of raised material that was displaced by the ball.

If the external force on the ball drags it across the plate, the force on the ball can be decomposed into two component forces: one normal to the plate's surface, pressing it in, and the other tangential, dragging it along. As the tangential component is increased, the ball will start to slide along the plate. At the same time, the normal force will deform both objects, just as with the static situation. If the normal force is low, the ball will rub against the plate but not permanently alter its surface.

The rubbing action will create friction and heat, but it will not leave a mark on the plate. However, as the normal force increases, eventually the stresses in the plate's surface will exceed its yield strength. When this happens the ball will plow through the surface and create a trough behind it. The plowing action of the ball is burnishing.

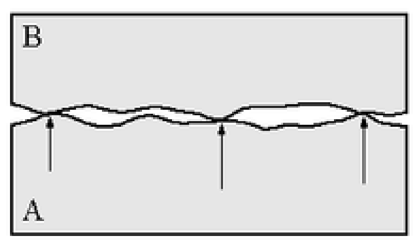

Fig 3 burnishing between two plates

Burnishing also occurs on surfaces that conform to each other, such as between two flat plates, but it happens on a microscopic scale. Even the smoothest of surfaces will have imperfections if viewed at a high enough magnification. The imperfections that extend above the general form of a surface are called asperities, and they can plow material on another surface just like the ball dragging along the plate. The combined effect of many of these asperities produces the smeared texture that is associated with burnishing.

The typical range of surface finish obtained by various surface finish methods

The following shows the various surface finish methods and their surface finish ranges.

TABLE I
Typical ranges of surface finish, Ra, µm

Process	Average applications
Grinding	0.1 to 1.6
Lapping	0.05 to 0.4
Honing	0.1 to 0.8
Buffing	0.05 to 0.5
Super finishing	0.05 to0.2
Burnishing	0.2 to 0.8

II DESIGN OF EXPERIMENTS

In this chapter the topics discussed are: selection of process parameters, burnishing tool and machine used to conduct experiment etc., the work piece material, lubricants etc., specifications regarding method of Burnishing, design of the experiments.

Selections of process parameters:- It is required to choose the process parameters, also called as input variables or controlled variables. The very nature of the design dictated the type of the input variables. As these are to be monitored continuously and should be able to be monitored continuously and should be able to maintain at exactly at the desired upper and lower levels through the experimental runs a judicious selection of these parameters is important. From literature survey it can be seen that the burnishing process can be controlled by different parameters such as burnishing speed, burnishing feed, burnishing force, and Number of passes etc. as we developed roller burnishing tools to suit for working in lathe machine we have taken the parameters in accordance with controllable factors in lathe machine, as we can control the burnishing speed i.e. spindle speed, also we can set the value of burnishing feed and no. of tool passes which is easy to change during need of experiments we have taken these factors in our experiment. Also, the spring which we have used in tools can measure the force which we had applied on at the work piece during machining, so we take the burnishing force as one of the factor in consideration. so, totally as per requirement of work and the sources available we taken four factors into account such as (1) burnishing speed, rpm, (2) burnishing feed, mm/rev, (3) burnishing force, Kgf and (4) number of passes.

Work piece material (Brass) :- Work piece chosen free machined Brass and EN24 steel material. Brass materials are so soft and they cannot be easily hardened by the heat treatment. The chemical and mechanical properties of the work piece material as shown in following table,

TABLE II

Chemical composition and properties of the work piece material

Material identification	Cu	Zn	Pb	Fe
Brass rod, IS 319-2007 Gr.1	57.4	39.10	3.02	0.349

Brass is an alloy of copper and zinc; the proportions of zinc and copper can be varied to create a range of brasses with varying properties.

Brass is a substitution alloy. It is used for decoration for its bright gold-like appearance; for applications where low friction is required such as locks, gears, bearings, doorknobs, ammunition, and valves; for plumbing and electrical applications; and extensively in musical instruments such as horns and bells for its acoustic properties. It is also used in zippers. Because it is softer than most other metals in general use, brass is often used in situations where it is important that sparks not be struck, as in fittings and tools around explosive gases.

Brass has a muted yellow color, which is somewhat similar to gold. It is relatively resistant to tarnishing, and is often used as decoration and for coins. In antiquity, polished brass was often used as a mirror.

Brass has higher malleability than bronze or zinc. The relatively low melting point of brass (900 to 940°C, depending on composition) and its flow characteristics make it a relatively easy material to cast. By varying the proportions of copper and zinc, the properties of the brass can be changed, allowing hard and soft brasses. The density of brass is approximately 0.303 lb/cubic inch, 8400 to 8730 kilograms per cubic meter (equivalent to 8.4 to 8.73 grams per cubic centimeter).

To enhance the machinability of brass, lead is often added in concentrations of around 2%. Since lead has a lower melting point than the other constituents of the brass, it tends to migrate towards the grain boundaries in the form of globules as it cools from casting. The pattern the globules form on the surface of the brass increases the available lead surface area which in turn affects the degree of leaching. In addition, cutting operations can smear the lead globules over the surface. These effects can lead to significant lead leaching from brasses of comparatively low lead

Work Piece Material : EN24 Steel EN24 is a popular grade hardening alloy steel due to its excellent machinability. EN24 is used in aircraft, automobiles components such as gear, shaft, studs and bolts.

TABLE III

Chemical composition and properties of the work piece material EN24

Material Identification	**Percentage Proportion**
Carbon	0.09
Silicon	0.208
Manganese	0.479
Sulphur	.0150
Posperus	0.0170
Chromium	0.950
Molybdenum	0.209
Nickel	1.45

TABLE IV

mechanical properties of the work piece

Metal	**Brass**	**EN 24 Steel**
Tensile strength, Mpa	406.698	850-1000
Yield stress, Mpa	220	680
Hardness, HB	91	248/302

Ball material:-The specification of the ball, which is used in the tool, is as follows,
Ball is made up of a tungsten carbide and high chrome steel.
The steel ball used here is harder than the brass and causes plastic deformation when pressed or forced against brass material.

Experimental set up on lathe:- By reviewing the literature, papers it was came to know that the burnishing process can be performed either by lathe or using vertical machining centres such as milling machines. In this project, the lathe is used to perform the burnishing process because it a machine in which various operations can be carried out and also the burnishing is such a process which can be carried out successively on the easily available machines such as lathe. As it was decided previously, the tools, which can be adjusted on the lathe machine to perform burnishing process, were developed in ball forms. It is a universal machine compare to all other machines. The burnishing tool attachments can be easily mounted on the tool post without any extra set up. The lathe which is used here is engine lathe all geared has the unique options to set the parameters as per the requirements in this work to perform the experimental runs

.

III EXPERIMENTAL PLANNING

Since it was decided to improve the surface hardness and surface finish of the materials, EN24 Steel and Brass materials were used, which have wide application in day-to-day life. The primary reason for selecting EN 24 steel is its wide range of application in automobile industry. Even though this material is hard, the automotive industry requires it to be even harder. Brass is a softer material compared to other materials used in industry. Brass material with a higher strength and a good surface finish is desirable to the industry.
The metal EN24 Steel is widely used in automotive industry and Brass is used in devotional items and kitchen utensils. Therefore, it requires burnishing process to fulfill the criteria of high hardness and good surface finish. Thus, a special ball burnishing tool was designed for this purpose and tested.
The Ball burnishing tool consists of Upper body, Lower body, Carbide ball holder, Carbide rod holder, Spring, Carbide ball, Tension screw. The body of the tool is made up of EN12 Steel, ball and ball holders are made up of Tungsten carbide material, spring and tension screws are made by hardened steel.
The carbide rod was reduced into two pieces of 20mm each and V shaped groove was made on top of one of the cut ends of the carbide rod, to mount the ball on it. To fabricate the body, the EN12 Steel was machined into size.
The lower body consists of spring and tension screw. Tension screw is used to obtain the required tension in the spring. The carbide rod holder was mounted on the spring on which carbide ball holder was fixed, on top of which carbide ball was mounted. These components were enclosed by the upper body.
The developed tool was used to carry out burnishing process (with and without abrasives) on ferrous and nonferrous metals.

The input parameter also known as factors, chosen were:
(1) Burnishing speed, rpm (S)
(2) Burnishing feed, mm/rev (f)
(3) Burnishing force, Kg (F)
(4) Number of passes (N).
The spring stiffness was calibrated (Fig 4.16) and the results were noted down.. From the calibrated result, we found that for 1mm rotation of the tool post, 3kg of force was applied on the work piece. A carbide tip tool was used to turn the EN24 steel work piece, as this is the hardest material present. Whereas high speed steel was used to turn brass work piece as it was a softer material.
80 tests were conducted altogether, while 40 tests were done on EN24 steel, 40 more were done on brass. Then the 40 work piece of each materials were divided into 20 samples. In that 20 samples were tested with abrasive and remaining 20 samples were tested without abrasive and burnished using the above parameters.
First set of 5 samples were burnished by keeping the values of Force, Speed and Number of passes as constants and Feed value was varied for each samples.
Second set of 5 samples were processed by keeping the values of Feed, Speed, and Number of passes as constants. Here the Force value was varied for each samples.
Third set of 5 samples had done by keeping the values of Feed, Force, and Number of passes as constants and Speed value was varied for each sample.
Fourth set of 5 samples were burnished by keeping the values of Feed, Force, Speed as constants and Number of passes were varied for each samples.
These experiments were conducted for both EN24 Steel and Brass with abrasive and without abrasive.The output parameters, also known as effects, chosen are:
(1) Surface finish (2) Surface hardness
All the experiments were carried out using tungsten carbide ball of 10mm diameter. Silicon carbide paste was used as an abrasive in case of experiments with abrasives. Keeping three parameter fixed at one level, the effect of variation of the other parameter was studied.

TABLE V

The following table will give the details of experimental planning

Expt No	Constant Parameters with levels	Varying Parameters
1-5	f, S, N (0.119, 585, 3)	F 1-5 (5, 10, 15, 20, 25)
6-10	F, f, N (15, 0.119, 3)	S 1-5 (140, 255, 585, 1170, 2000)
11-15	F, S, N (15, 585, 3)	f 1-5 (0.049, 0.076, 0.119, 0.163, 0.256)
16-20	F, f, S (15, 0.119, 585)	N 1-5 (1, 2, 3, 4, 5)

IV EXPERIMENTATION

The experimental work is covered in this chapter. As mentioned earlier the whole work is divided into two stages. Those are burnishing with abrasive and without abrasive on both materials.– stage 1, stage 2.
Thus the whole experiment comprises of: -
Stage 1: where the experiment is carried out using ball burnishing tool.
Stage 2: where the experiment is carried out by ball burnishing tool with abrasive paste.
The experimental work involved the following steps:
1. Calibration of the spring which is used in the tool for the sake of force measurement and tool specification.
2. Preparation of the required no. of work pieces on which to do burnishing as decided earlier.
3. Making the system ready for experiment.
4. Actual running of experimental runs as per the input parameters.
5. ‘Relieving’ the system.
Each one of these steps is in detail in the following tables.

TABLE VI

EXP NO	FEED (f) ‘mm/rev’	FORCE (F) ‘Kg’	SPEED (S) ‘RPM’	NUMBER OF PASS (N)
1	0.049	15	585	3
2	0.076	15	585	3
3	0.119	15	585	3
4	0.163	15	585	3
5	0.256	15	585	3
6	0.119	5	585	3
7	0.119	10	585	3
8	0.119	15	585	3
9	0.119	20	585	3
10	0.119	25	585	3
11	0.119	15	140	3
12	0.119	15	255	3
13	0.119	15	585	3
14	0.119	15	1170	3
15	0.119	15	2000	3
16	0.119	15	585	1
17	0.119	15	585	2
18	0.119	15	585	3
19	0.119	15	585	4
20	0.119	15	585	5

Burnishing tool:- The ball burnishing tool used in this process in self designed and fabricated. A burnishing tool with interchangeable adopter are designed and fabricated for the experimental tests.

Fig 4 Burnishing tool

Calibration of tool Spring:-

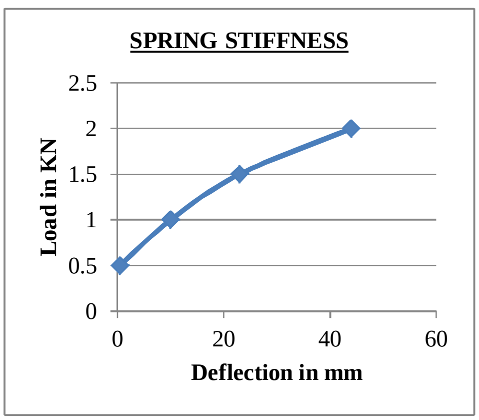

Fig 5 graph between load, kg vs. deflection, mm

From graph it is given that,

Spring Stiffness = Load/Deflection

= 0.5/17 = 0.02941KN/mm=

(0.02941x1000)/9.81 = 2.998 = **3Kg/mm**

TABLE VII

Determination of Parameters for En24 Steel and Brass:

Parameter /level	1	2	3	4	5
Speed (S) ,RPM	140	255	585	1170	2000
Feed (f.) ,mm/ rev	0.049	0.076	0.119	0.163	0.256
Force (F) , Kg	5	10	15	20	25
Number of passes (N)	1	2	3	4	5
Ball material (BM)	Tungsten Carbide	Carbon steel			

Preparation of work pieces for burnishing:- The cylindrical brass rod and EN24 which were not available in as required sizes, so they were cut by using hack saw cutting hand tool to required sizes with allowance for facing etc. at the faces. The brass rod size chosen was 20mm dia. of 50mm lengths each. The work pieces are made to convenient size to work by between the center methods. The preparation of work pieces involved following steps.

1. The cylindrical brass is marked by chalk to cut 40+1(turning) =41 pieces.
2. The cylindrical EN24 is marked by chalk to cut 40+1(turning) =41 pieces.
3. The brass rods are marked to the required length by manually by keeping necessary allowance.
4. The cut pieces are drilled at both ends so as to do between center methods.
5. Similarly, 82 pieces were made ready to conduct the experiments as per plan.

making the system ready for experiment:-

This was done as depicted below:-

1. First the prepared brass pieces for experimental run is to check for its correctness i.e. number wise,

2. Once it was cleared with work pieces next is to check with the lathe and its parameters, the lathe is first check with its operation, the feed, speed setting must be exact.

3. The burnishing tool is adulated at the tool post and tested for the application of force on the work pieces.

4. The force application measurement must be exact. The giving depth of penetration is nothing but the force applied on to the work piece.

5. After setting all it is helpful to check the burnishing initially on two or three of brass pieces just for checking the set up.

6. if it is found ok in above step then it was concluded that the whole system i.e. work pieces, burnishing tools and Turn master-400 lathe are ready to conduct experiment.

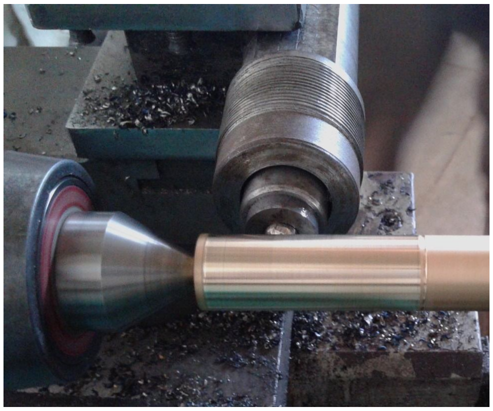

Fig 6 Ball burnishing operation for brass

Fig 7 Ball burnishing operation for EN24 Steel

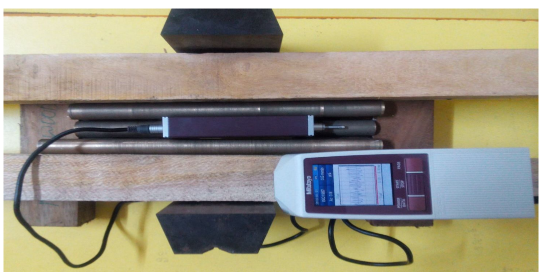

Fig 8 Surface finish testing

Fig 9 Rockwell Hardness Machine

V. OBSERVATIONS AND RESULTS

As per the objectives set in the current work, firstly we have turned the work pieces of EN 24 and Brass by setting the moderate range of parameters and tested for its surface roughness and Surface hardness and obtained the results as per following table;

TABLE VIII

Surface roughness values for EN 24 Steel sample (Reference)

0'			120'			240'			Avg Ra microns	Avg Rq microns	Avg Rz microns
Ra	Rq	Rz	Ra	Rq	Rz	Ra	Rq	Rz			
3.056	3.557	11.671	2.083	3.657	10.751	3.010	3.475	10.463	2.716	3.563	10.961

average surface roughness value of EN24 Steel sample taken was **2.716** microns and it was the selected reference for turned work piece.

TABLE IX

Surface roughness values for Brass sample (Reference)

0'			120'			240'			Avg Ra microns	Avg Rq microns	Avg Rz microns
Ra	Rq	Rz	Ra	Rq	Rz	Ra	Rq	Rz			
2.076	2.528	10.412	1.863	2.277	9.666	2.010	2.381	9.451	1.983	2.395	9.843

average surface roughness value of Brass sample taken was **1.983** microns and it was selected reference for turned work piece.

TABLE X

Micro hardness values for EN 24 Steel Sample (Reference)

0'	120'	240'	ROCK WELL HARDNESS NUMBER HRC	VICKERS HARDNESS NUMBER VHN
23	32	28	27.6	283.57

From the table 10 average micro hardness value of EN24 Steel sample taken was **283.57** VHN and it was selected reference for turned work piece.

TABLE XI

Micro hardness values for Brass sample (Reference)

0'	120'	240'	ROCKWELL HARDNESS NUMBER HRB	VICKERS HARDNESS NUMBER VHN
92	90	88	90	192.5

From the table 11 average micro hardness value of EN24 Steel sample taken was **192.5** VHN and it was selected reference for turned work piece.

TABLE XII

Design matrix surface roughness value for EN 24 Steel without abrasive

W/P NO	E/NO	(f) 'mm/rev'	(F) 'Kg'	(S) 'RPM'	(N)	Ra microns
1	1	0.049	15	585	3	0.350
	2	0.076	15	585	3	0.586
	3	0.119	15	585	3	0.495
	4	0.163	15	585	3	0.933
	5	0.256	15	585	3	0.993
2	6	0.119	5	585	3	0.184
	7	0.119	10	585	3	0.203
	8	0.119	15	585	3	0.193
	9	0.119	20	585	3	0.287
	10	0.119	25	585	3	0.259
3	11	0.119	15	140	3	0.580
	12	0.119	15	255	3	0.336
	13	0.119	15	585	3	0.213
	14	0.119	15	1170	3	0.242
	15	0.119	15	2000	3	0.376
4	16	0.119	15	585	1	0.219
	17	0.119	15	585	2	0.311
	18	0.119	15	585	3	0.209
	19	0.119	15	585	4	0.215
	20	**0.119**	**15**	**585**	**5**	**0.136**

TABLE XIII

Design matrix Micro hardness value for EN 24 Steel without abrasive

W/P NO	E/NO	f 'mm/rev'	F 'Kg'	S 'RPM'	N	HRC	VHN
1	1	0.049	15	585	3	28	286.40
	2	0.076	15	585	3	29.6	298.33
	3	0.119	15	585	3	32.6	323.63
	4	0.163	15	585	3	33	327.27
	5	0.256	15	585	3	36	354.54
2	6	0.119	5	585	3	32.3	320.90
	7	0.119	10	585	3	33.6	332.72
	8	0.119	15	585	3	34	336.36
	9	0.119	20	585	3	33	327.27
	10	0.119	25	585	3	36.3	357.27
3	11	0.119	15	140	3	32	318.33
	12	0.119	15	255	3	34.6	341.81
	13	0.119	15	585	3	33	327.27
	14	0.119	15	1170	3	35.6	350.90
	15	**0.119**	**15**	**2000**	**3**	**37.6**	**369.09**
4	16	0.119	15	585	1	31.3	312.50
	17	0.119	15	585	2	30.3	304.16
	18	0.119	15	585	3	32.3	320.90
	19	0.119	15	585	4	30.6	306.66
	20	0.119	15	585	5	29.6	298.33

VI CONCLUSION

1. Ball burnishing is an effective method in improving both surface finish and micro hardness.
2. During ball burnishing process of EN24 Steel without abrasive least value of surface roughness that got 0.136 microns and percentage decrease of roughness is 94.99%. During EN24 Steel with abrasive, minimum surface roughness got 0.464 microns and percentage decrease is 82.91%.
3. Maximum value of micro hardness during ball burnishing of EN24 Steel without abrasive is 369.09 VHN, percentage increase compared to turned work piece 22.40%, and for EN24 Steel with abrasive 388 VHN and percentage increase in hardness is 26.91%.
4. Ball burnishing of Brass without abrasive for that surface roughness got 0.299 microns and percentage decrease when compared to turned work piece 84.92% and for Brass with abrasive 1.400 microns and percentage decrease is 29.39%.
5. Maximum value of micro hardness during ball burnishing of Brass without abrasive is 202.50VHN and percentage increase compared to turned work piece 17.55% and for Brass with abrasive 215.53 VHN and percentage increase in hardness is 10.68%.

ACKNOWLEDGEMENT

The credit of the completion of the project work goes behind our own work, to those people who have always been with us throughout and we take this opportunity to express our heartfelt gratitude to each one of them.

We wish to thank our guide **Mr Pavan Kumar**, Assistant professor, Department of Mechanical Engineering, Shri Madhwa Vadiraja Institute of Technology and Management, Bantakal for being a constant source of inspiration, encouragement and providing proper technical guidance at all stages of the project.

We are thankful to **Dr. Sudharshan Rao K,** H.O.D, Department of Mechanical Engineering, SMVITM for allowing us to carry out this project and for ensuring all the facilities required to carry out this project.

At the outset we take this opportunity to thank **Prof. Dr.Thirumaleshwar Bhat**, Principal, Shri Madhwa Vadiraja Institute of Technology and Management, Bantakal for his guidance and encouragement for completion of this project.

We would like to thank **Mr Basavaraj** (Long Life Hardmetals, Bangalore) for providing materials which are needed for project.

We would also like to thank **Mr Stanley M Kotian** (SEATO TECHNIQUES) for helping us to build a tool of our requirement.

We specially thank **Mr Raghuram Shettigar**, Instructor and also we thank all the teaching and non-teaching staff Department of Mechanical Engineering, Shri Madhwa Vadiraja Institute of Technology and Management, Bantakal for helping us in completion of the project work

REFERENCES

1. S.Rajesham and Jem Cheong tak, A study on the surface characteristics of Burnished components, Journal of Mechanical working Technology, 20 (1989) 129-138.
2. N.H.Loh,S.C.Tam and S.Miyazawa, A study of the effects of ball Burnishing parameters on surface roughness using factorial design, Journal of Mechanical working Technology, 18 (1989) 53-61.
3. N.H.Loh,S.C.Tam and S.Miyazawa, A study of the effects of ball Burnishing parameters on surface roughness using factorial design, Journal of Mechanical working Technology, 18 (1989) 53-61.
4. C.S.jawalkar and R.S.walia, Study of Roller Burnishing processes on EN-8 specimens using design of experiments, Journal of Mechanical Engineering Research Vol. 1 (1) pp. 038-045, November, 2009.
5. Dabeer,P.S and Purohit,G.K, Effects of ball Burnishing parameters on surface roughness using surface roughness methodology, APEM journal, 5(2010) 2,111-116.
6. M.fattouh, M.H.elaxir and S.M.serage, Investigating into the Burnishing of external cylindrical surfaces of 70/30 Cu-Zn alloy-, wear, 127 (1988) 123-137.
7. Tareq A. Abu shreehah, Developing and investigating of elastic ball Burnishing tool, Int. J Adv Manuf Techno (2008) 36:270-279.
8. A.M.Hassan, aiman sharef Al-Bsharat, Influence of Burnishing process on surface roughness, hardness, and microstructure of some non-ferrous metals ,wear 199 (1996) 1-8.
9. Aysun Sagbas, Funda Kahraman, DETERMINATION OF OPTIMAL BALL BURNISHING PARAMETERS FOR SURFACE HARDNESS, Materials and technology 43 (2009) 5, 271–274.
10. S. Thamizhmanii , B. Saparudin, S. Hasan,A study of multi-roller burnishing on non-ferrous metals, VOLUME 22 ISSUE 2 June 2007,AMME journal.
11. P R Babu,Dr T S Prasad, Dr A V S Raju, The Effect of External Roller-burnishing on the Surface Roughness and Surface Hardness of EN 31 Alloy Steel, IE(I) Journal–MM.
12. U M Shirsat and B B Ahuja,parametric analysis of combined turning and ball Burnishing process, Indian journal of engineering and Material sciences,Vol. 11 , October 2004,pp. 391-396.