Journal of Manufacturing Engineering, 2008, Vol.3, Issue.4

THE EFFECT OF EXTERNAL ROLLER-BURNISHING ON THE SURFACE ROUGHNESS AND SURFACE HARDNESS OF EN 24 ALLOY STEEL

*P. Ravindra Babu[1] T. Siva Prasad[2] A.V. S. Raju[3]

[1]Department of Mechanical Engineering, Gudlavalleru Engg. College, Gudlavalleru.

[2]CM college of Engg., Hakim pet, Secunderabad

[3]Department of Mechanical Engineering, J.N.T.U. Kakinada

ABSTRACT

Surface finish and surface hardness of the components play vital role in quality of products. In most of the conventional finish machining process only surface finish will be improved, but improvement on surface hardness is less considerable. More over all finishing process are metal cutting in nature and introduces tensile stresses in the surface layer. But instead of tensile stress, if compressive stresses are introduced in surface layer, it will improve various properties of components like fatigue strength. Therefore the requirement in finishing an industrial component is that the process should improve surface finish, surface hardness and induce compressive stresses in the surface layer. A process of finishing by surface plastic deformation can meet this requirement. One of such process, which was in use since long time is "**Burnishing".** Even though the process is an old one its process parameters were not fully established, because of which it is not finding wide range of industrial application. In Burnishing, the surface layer will be plastically deformed with the help of a Ball or Roller which is harden than the work material. The process parameters include **Burnishing Force, Burnishing Speed, Burnishing Feed, and Number of Tool Passes.** In the present study external burnishing tool is used to perform roller burnishing process on EN 24 alloy steel to study the surface properties variation by varying the burnishing parameters like force, speed, feed and number passes.

Key words*:* Roller burnishing, surface roughness, surface hardness.

1. Introduction

The 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 region. The study of the contact aspects between machine elements is essential due to the fact that more than 50% of provided energy is lost by friction results from the relative movements between the elements [1, 2].

Roughness values less than 0.1µm are required for good aesthetic appearance, easy mould release, good corrosion resistance and high fatigue strength. It is observed that conventional machining methods leave inherent irregularities on surface and it becomes necessary to very often resort to a series of finishing operations such as grinding, lapping, honing with high costs [3, 4].During recent years however considerable attention has been paid to the post-machining metal finishing operations such as burnishing which improves the surface characteristics by plastic deformation of surface layers [5]. But burnishing is considered as cold-working finishing process which produces good surface finish and residual compressive stresses at metallic surface layers [6]. Burnishing distinguishes itself from chip-forming finishing process such as grinding, honing, lapping and super finishing which induce residual tensile stresses at machines surface layers [7].

Burnishing is economically desirable, because it is a simple and cheap process, requiring less time and skill to obtain a high quality surface finish [8].The study of surface finish is very much essential because the fatigue life, bearing properties and lubrication of a part depends upon the appropriate surface finish [9]. If the surface is Perfectly smooth, then seizure would occur due to difficulty of maintaining the lubricating oil film. The hills in irregular surface reduce the metal to metal contact and valleys help to retain the film of lubricating oil. In order to increase the life of any part which is subjected

***Corresponding author Email: prbabu_1961@yahoo.co.in**

to repeated reversals of stress, the working and non-working surfaces of that surface must be given very good finish.

For hard roller burnishing experiments indicate that really constant surface roughness can be achieved over a wide range of process conditions [10]. Burnishing can generate compressive residual stresses through out the surface layers although tensile stresses exist on the prior machined surfaces.

Experiments conducted in this area should encompass not only the problems of the technology, but also the problems of contact mechanics [11] considering their remarkable usefulness in the description of the deformation process during elastic and plastic forming of the surface layer of the machine parts.

Published works indicated that burnished surfaces have many advantages over ground surfaces [12], some researchers [12,14] concentrated on burnishing parameters such as burnishing speed, burnishing depth, burnishing force[12], burnishing feed rate [13,14] number of tool passes[14,15,16] and burnishing tool dimensions in relation to surface roughness and surface hardness.

The present work is an attempt to study the effect of External roller burnishing on surface roughness and surface hardness of EN 24 Alloy steel by varying the burnishing parameters.

2. Experimental Evaluation of Burnishing Process

In order to establish the clear picture of burnishing process, a series of experiments were conducted on metals which find wide range of industrial applications of EN 24 alloy steel to study the fundamental aspects of the process. Burnishing experiments were conducted on external and internal surfaces with roller burnishing tools.

In the experiments, the work pieces were burnished after turning on lathe, in the same set-up. While burnishing, the roller burnishing tool was fixed in lathe tool dynamometer. The dynamometer is capable of measuring three force components. The z- component was taken as the burnishing force.

2.1 Material Properties Used For Experimental work

The work piece material is EN 24 (alloy steel). Alloy steel may be defined as one whose characteristic properties are due to some element other than carbon.

EN 24

Chemical composition:

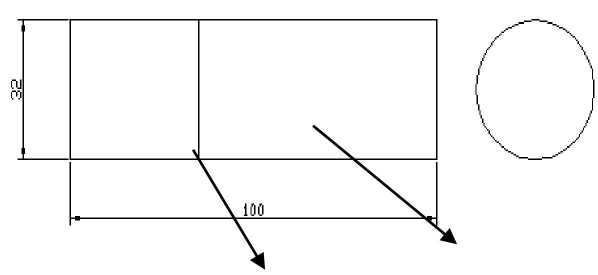
C- 0.35 to 0.45, Si-0.10 to 0.35, Mn-0.45 to 0.70, Cr-0.2 to 0.35, Ni – 1.03 to1.08.

Applications

Highly stressed components of large cross-section for air crafts, automobiles and general engineering applications such as propeller shafts, connecting rods, gear shafts, crane shafts, loading gear components, heavy forging such as rotor shafts and discs.

3. External Burnishing Experimental Details

Specimens were turned and burnished on a center lathe model ALL GEARED HEAVY DUTY LATHE. The work piece material is EN 24 (alloy steel). The work material was received in the form of rods of 32 mm diameter and then finish turned on lathe (Speed=355 rpm, feed=0.032 mm/rev). They were used for surface roughness and micro hardness tests. The work pieces were prepared with two recesses such that each specimen could be used in two different conditions. Portion a in Fig. 1 was left without burnishing for comparison purposes with portions which were burnished (B) in burnishing tests. A feed rate of 0.032mm/rev, depth of cut of 0.5, 0.75,1 mm, and spindle speeds 535,335,225,145 and 95rpm were used as the turning conditions. The surface finishes of the pre-machined and burnished specimens were measured using surf test.



Part Left without burnishing for comparison (A)
Part to be Burnished (B)
Fig.1 Work Piece Used for Experimental work

This is the shape and dimensions of the work piece. All dimensions are in mm.

The proposed study has been planned in the following manner of steps:

- Preparation of specimen
- Measurement of Surface Finish and Hardness before Burnishing.
- Burnishing.

- Measurement of Surface Finish and Hardness after Burnishing.

3.1 Preparation of Specimen

The required specimen is prepared in the following steps:

- Piece cutting to required dimensions from the bar stock
- Turning Outside diameter

3.2 Evaluation of surface finishes and surface hardness prior to burnishing

Surface Roughness values of all the work pieces are taken before Burnishing by using Mitutoyo SJ-201P Surface Roughness Tester and the values are tabulated.

3.3 Burnishing Operation

Burnishing is done on ALL GEARED HEAVY DUTY LATHE with the following specifications:

Speeds	:	9
Feeds	:	18
Power of the motor	:	2.2 Hp.
Length of the bed	:	1800 mm

The process is done with varying speed conditions, under continuous lubrication of water emulsion type oil.

3.4 Tool used in this experiment work

Bright single roller 'H'-type tool can burnish component diameter between 25mm and 400mm. Interchangeable carbide/HSS rollers are assembled in the retaining cage and guide roller arrangement. Rollers can be changed easily. This tool is highly suitable for Batch production and mass production

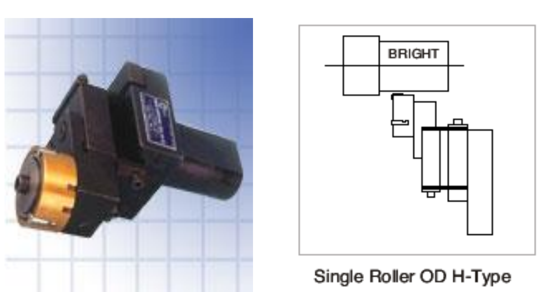


Fig.2 Single Roller Burnishing Tool

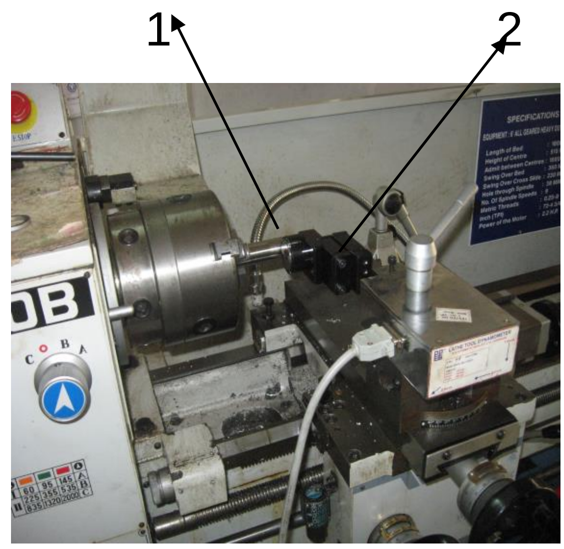


Fig.3 External Roller Burnishing Close View
1. Work piece. 2. Burnishing toll

Fig.4 Lathe Tool Dynamometer

3.5 Evaluation of surface finishes and surface hardness after burnishing

Surface Roughness values of all the work pieces are taken after Burnishing by using stylus probe instrument (Mitutoyo SJ-201P) Surface Roughness Tester and the values are tabulated and the surface hardness is measured with help of Rockwell hardness tester.

Table 1.Comparison of surface finish values before and after burnishing for a 30 mm diameter work piece of EN 24 alloy steel by varying burnishing speeds and keeping burnishing force as 21 kgf.

Burnishing speed m/min	Surface finish before burnishing R_a (µm)	Surface finish after burnishing R_a (µm)			% increase in surface finish		
		First pass	2nd pass	3rd pass	First pass	2nd pass	3rd pass
51	2.00	0.25	0.27	0.56	87.5	86.5	72
34	3.88	0.36	0.15	0.26	90.72	96.13	93.3
22	3.92	0.18	0.17	0.27	95.41	95.66	93.11
14	3.48	0.48	0.62	0.90	86.20	82.18	74.14
9	3.71	0.53	0.51	0.92	85.72	86.25	75.20

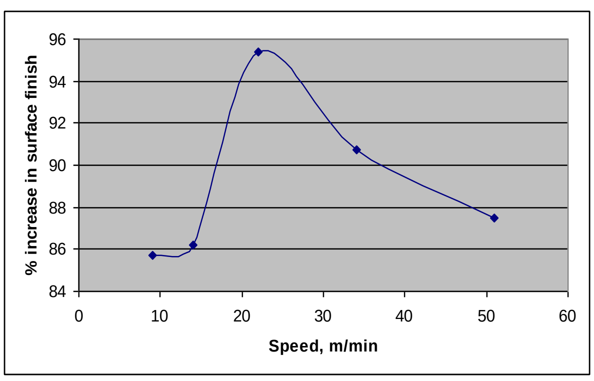


Fig.5 Speed Vs % Increase in Surface Finish for 1st pass

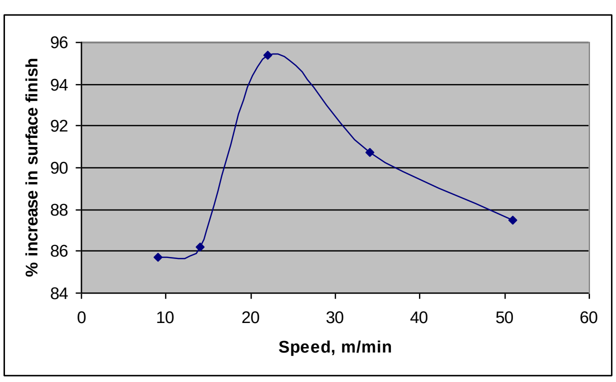


Fig.6 Speed Vs % Increase in Surface Finish for 2nd pass

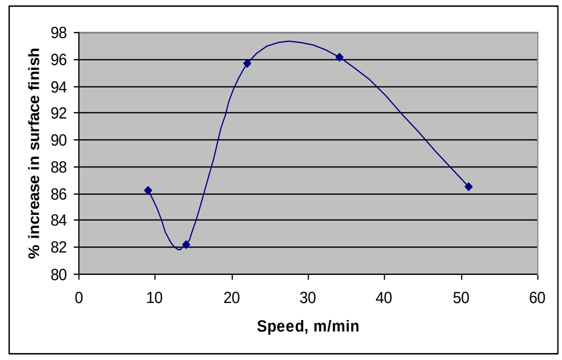


Fig.7 Speed Vs % Increase in Surface Finish for3rd pass

Table2. Comparison of surface hardness values before and after burnishing for a 30 mm diameter work piece of EN 24 alloy steel by varying Burnishing speeds and keeping burnishing force as 21 kgf.

Burnishing speed m/min	Surface hardness before burnishing	Surface hardness after burnishing			% increase in surface hardness		
		First pass	2nd pass	3rd pass	First pass	2nd pass	3rd pass
51	141.166	116.33	122.33	104.33	17.593	13.34	26.1
34	149.33	118	120	120.33	21	19.64	19.42
22	145.16	110	124.66	106.66	24.22	14.81	26.52
14	139	110	123.66	110.33	20.86	11.04	20.62
9	130.33	113.33	123	110.33	13.04	5.62	15.35

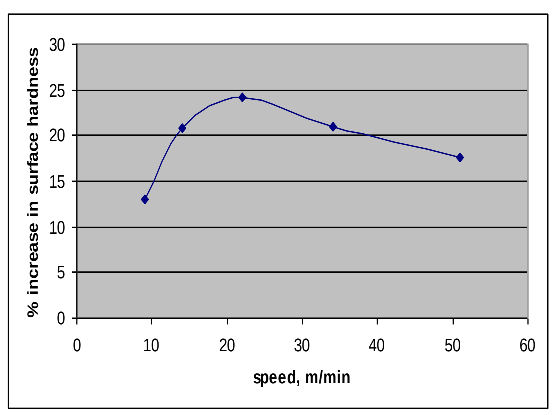


Fig.8 Speed Vs % Increase in Surface hardness for 1st pass

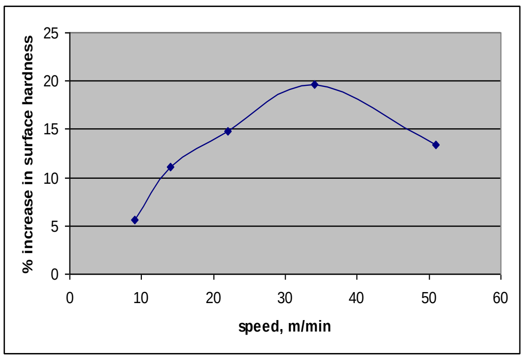


Fig.9 Speed Vs % Increase in Surface hardness for 2nd pass

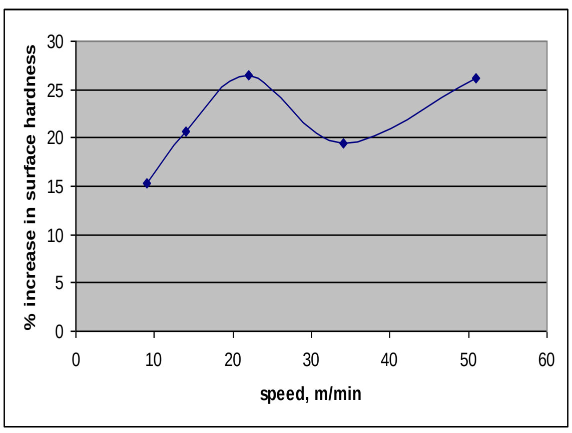


Fig.10 Speed Vs % Increase in Surface hardness for 3rd pass

Table3. Comparison of surface finish values before and after burnishing for a 30 mm diameter work piece of EN 24 alloy steel by varying burnishing feeds and keeping burnishing force as 21 kgf

Burnishing feed mm/rev	Surface finish before burnishing R_a (µm)	Surface finish after burnishing R_a (µm)			% increase in surface finish		
		51 m/min	34 m/min	22 m/min	51 m/min	34 m/min	22 m/min
0.111	2.00	1.7	0.37	0.25	15	81.5	87.5
0.095	3.88	0.97	0.22	0.54	75	94.32	86.08
0.063	3.92	2.18	0.32	0.42	44.39	90.45	89.28
0.032	1.8	0.25	0.36	0.18	86.11	80	90

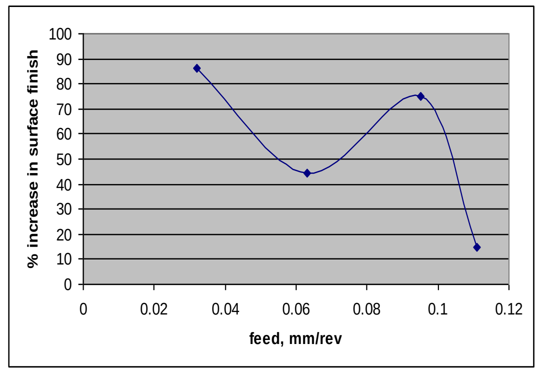


Fig.11 Feed Vs % Increase in Surface finish at a speed of 51 m/min

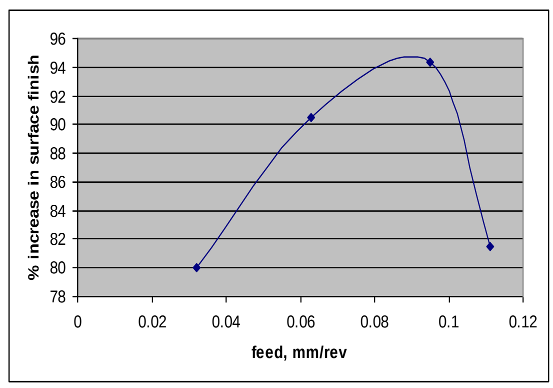


Fig.12 Feed Vs % Increase in Surface finish at a speed of 34 m/min

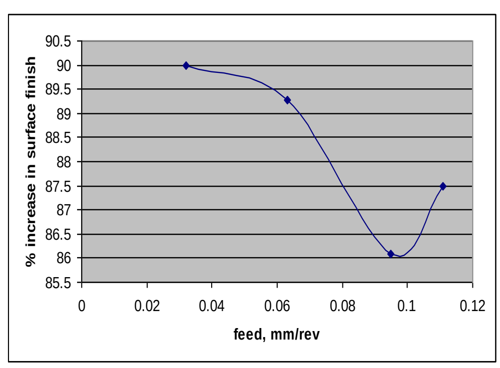


Fig.13 Feed Vs % Increase in Surface finish at a speed of 22 m/min

Table4. Comparison of surface finish values before and after burnishing for a 30 mm diameter work piece of EN 24 alloy steel by varying burnishing feeds and keeping burnishing force as 21 kgf

245

Burnishing feed mm/rev	Surface Hardness before burnishing	Surface hardness after burnishing			% increase in surface hardness		
		51 m/min	34 m/min	22 m/min	51 m/min	34 m/min	22 m/min
0.111	130.33	51	52	59	60.87	60.10	54.73
0.095	145.16	59.33	53.66	55	59.12	63.03	62.11
0.063	149.33	39	54.66	46.33	73.88	63.4	68.9
0.032	141.16	116.33	118	106.66	17.73	16.4	24.4

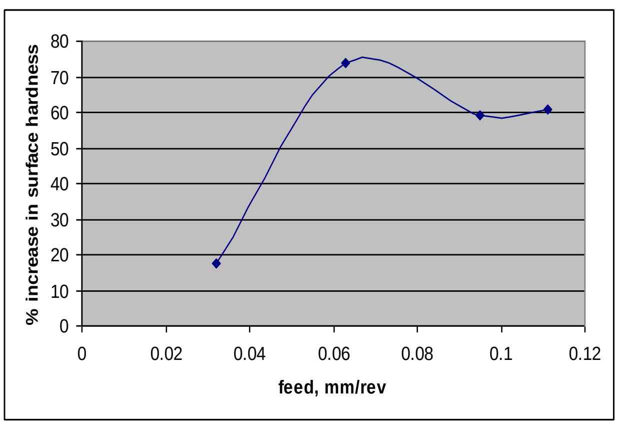


Fig.14 Feed Vs % Increase in Surface hardness at a speed of 51 m/min

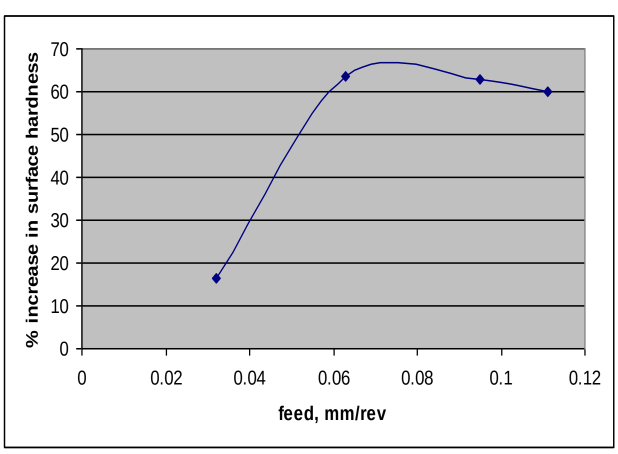
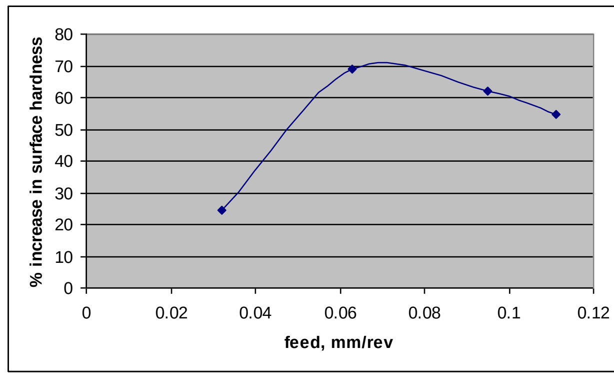


Fig.15. Feed Vs % Increase In Surface hardness at a speed of 34 m/min



246

Fig.16 Feed Vs % Increase in Surface hardness at a speed of 22 m/min

4.Results And Discussions

External roller burnishing experiments were conducted on EN 24 material. In the first experiment keeping the burnishing force and burnishing feed as constant and burnishing speed is varied. The variation in surface roughness was observed at different number of burnishing passes. From figure 6 it is observed that the optimum burnishing speed for EN 24 material is 34 m/min and number passes are two.

In the second experiment keeping burnishing force and burnishing feed as constant, burnishing speed were varied to observe variation in surface hardness of the material at different burnishing passes. It was observed from figure 10 that the burnishing speed optimum is 22 m/min and burnishing passes are three.

In the third experiment keeping burnishing force and number of burnishing passes as constant and varying burnishing feed, the surface roughness and surface hardness variation at different burnishing speed was observed from the figure 12 that the best feed is 0.095mm/rev and best speed is 34 m/min for surface roughness from figure 14 the optimum speed is 51m/min and optimum feed is 0.063 mm/rev for surface hardness.

5.Conclusions

From the experiments conducted on EN 24 material, it is observed that the burnishing speed, burnishing feed and burnishing number of passes, keeping burnishing force as constant will effect the burnishing process. From the experimental analysis the optimum burnishing speed, burnishing feed and number of passes were finalized which will be useful as guideline while external burnishing on EN 24 material.

References

1. *A.M. Hassan and A.D.Auleiman, Improvement in the wear resistance of brass components by ball burnishing process. "Journal of Mater.Proc.Technol."96 (1-3) (1999) 73-80.*
2. *G. Brandt. A. Gerendas and M.Mikus, Wear mechanisms of ceramic cutting tools when machining ferrous and non ferrous alloys." J.Eur.Ceram.Soc. 6(5) (1990) 273-290.*
3. *G.Schneider Jr. Cutting Tool Applications, Prentice-Hall Publication, 2002. pp 2-65 (chapter 1)*
4. *A.R.C Sharman, D.K. Aspinwall, R.C Dewew and P.Bowen, Work piece surface integrity considerations when finish turning gamma titanium almunide, Wear 294 (2000) 473-481.*
5. *L. Kukeilka, Designating the field areas for the contact of rotary burnishing element with the rough surface of a part, providing a high-quality product, Journal of mechanical Technology 19(1989) 319-356.*
6. *C. Wick and R.F.Veilleux, Tool and manufacturing engineers hand book, Soc. Manuf.Eng 3 (1985) 16-38.*
7. *T.Siva Prasad, B. Kotiveerachari, External burnishing of aluminum components, J. Inst. Engg. India69 (1988) 55-58.*
8. *N.H. Loh, S.C.Tam and S. Miyazawa, Applications of experimental design in ball burnishing, Int. J.Mach.Tools MAnuf. 33 (1993) 841-852.*
9. *Ted Busch, Roger Harlow and Richard.L.Thompson, 1998, A text book on "Fundamentals of dimensional Metrology", 3rd edition, Delmar publishers.*
10. *Klocke F liermann J, 1998, Roller Burnishing of hard turned surfaces, International Journal of machine tools and manufactures 38/5-6,419-423.*
11. *G.M.L.Gladwell, contact problems of classical theory of elasticity (1980)*
12. *N.S.M.EI-Tayeb, enhancement of surface quality and tribological properties during ball burnishing process.*
13. *A.M.Hassan, an investigation into the surface characteristics of burnished cast Al- Cu alloys, International machine tool manufactures 37(6) 1997.*
14. *A.M.Hassan. Influencing of burnishing process on surface roughness and hardness and micro structure of some non ferrous metals.*
15. *M.H.EL Axir, An investigation in roller burnishing, International machine tool manufactures 40(2000)[1603-1617].*
16. *A.M.Hassan, The effect of ball and roller burnishing on the surface roughness and hardness of some non ferrous metals,* 247 *International machine tool manufactures 72(3) (1997) 385-391.*