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Experimental Investigations on Surface Roughness and Microhardness in Abrasive Assisted Roller Burnishing Process

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Abstract

Burnishing, being cold working, chip less post-machining, finishing process, uses a soft and hard ball or roller to deform peaks onto the valleys plastically. In current work, an attempt has been made to make use of abrasive particles in between roller burnishing tool and work piece, to study its effect on surface properties such as surface roughness and microhardness. The experimental results of AAB (abrasives assisted burnishing) compared with dry burnishing process results to find the effectiveness of the abrasive particles. Results showed that both the cases increased hardness and surface roughness for both the materials.

Keywords: *Burnishing, Surface roughness, Micro hardness, Abrasives*

INTRODUCTION

Machined surfaces inherently consist of peaks and valleys on their surfaces, even though every precaution is taken during the machining operations such as turning. if demand calls for high values of surface finish, in most of the occasions, conventional finishing processes such as grinding, honing, lapping can be employed. The feature of the above-listed finishing processes are, they will give better surface finish, but with decreased material strength with the removal of the materials in the form of fine chips. Burnishing, when applied on components, inducing compressive stresses at surface improves micro hardness [1], wear resistance [2], fatigue strength [3], corrosion resistance [4] etc. The improvement in ductility [5], out of roundness [6], tensile strength [7] is also being reported.

There are works done in which burnishing process applied on ferrous and non-ferrous materials available and showed improvement in surface characteristics. The induced residual stress measurement has been undertaken by a few researchers to prove the impact of process on surface strength[8].

Parameters such as speed, feed, the number of passes, force, ball diameter and conditions are most considered parameters among all parameters affecting various factors at the surface. The initial conditions of the surface are also considered as a factor in some work [9].

EXPERIMENTAL DETAILS

1. Materials

Commercially available free cutting brass and EN24 grade Steel are used as work pieces in current work. The work piece materials are selected due to their use in industries. The work pieces are received in the form of bars of 20mm diameter of 500mm length. The specimens are turned (in as cast conditions) to 18 mm ensuring same level of roughness values throughout the length. Later burnishing specimens were prepared by cutting small groves at 30 mm apart in 500 mm specimen. So, in each bar 15 burnished specimens were prepared and one kept for measuring initial roughness and micro hardness values. The chemical composition of the free cutting brass and EN24 steel is given in table 1.

Table.1 Chemical compositions of Brass and EN24 (by wt %)

Materials	*C*	*Si*	*Mn*	*Cr*	*Ni*	*Al*	*Cu*	*Pb*	*Sn*	*Zn*	*Remd.*
Brass	0.0011	0.039	0.038	-	0.280	0.116	56.4	3.02	0.53	39.1	Cu
EN24	0.382	0.233	0.427	1.13	1.13	0.195	0.105	-	-	0.012	Iron

BURNISHING TOOL

A self-designed and developed roller burnishing tool is used in entire experimental procedure to carry out burnishing process on specimens. The commercial, easily available ball bearing (No. J023) with 08 mm width is used as roller to deform the specimens. The tool was made similar to conventional cutting tool shank and it can be easily mounted on tool post. The measurement of force was taken by the spring which is placed in the tool. The deflection of the spring with force is as shown in figure.1 and figure. 2 shows the figure of the tool developed in current work.

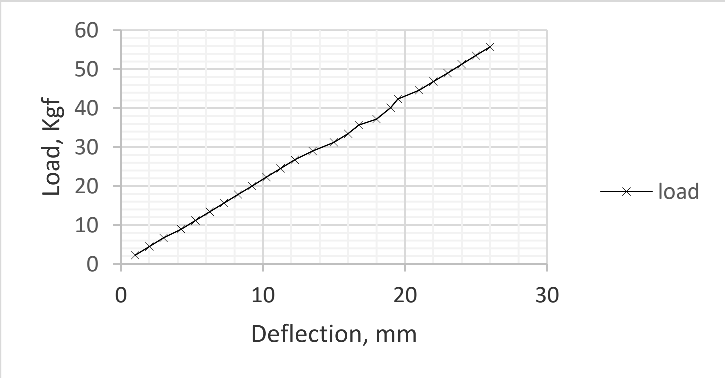

Figure.1 Deflection Vs. Load of the spring

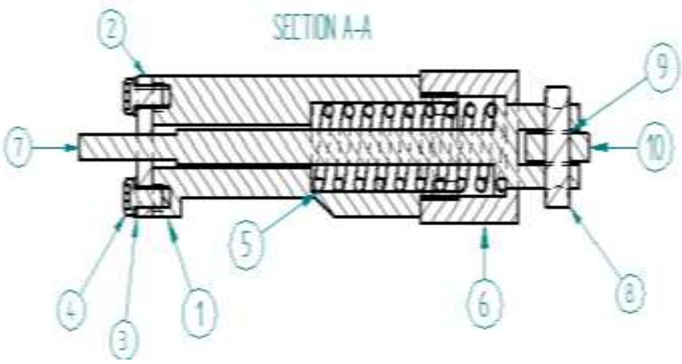

Figure.2: Burnishing tool

1. Lower body 2. Locking plate 3. Spring washers 4. Nuts 5. Spring 6. Upper body 7. Roller holder with tool shaft 8.Roller shaft 9. Roller washer 10. Roller (Ball bearing)

EXPERIMENTS

The experiments are conducted by taking four factors into consideration namely burnishing force, speed, feed and number of tool passes over the twenty samples. In total two set of experiments are conducted. In first case, where no lubricants were used (refered as dry burnishing), 20 experiments are conducted by varying each parameter at five levels and keeping other parameters at constant levels. Second case experiments are also performed under same experimental conditions and by introducing abrasive particles (silicon carbide paste, fine quality) in between tool and work piece. All geared lathe (model: MTT 636) available in the SMVITM, Bantakal laboratory was used to perform burnishing operations.

Roller was cleaned by kerosene after each experimental run to remove the foreign particles. The table 2 gives the details of burnishing parameters at different levels. The turned samples surface roughness values and micro hardness values for Brass and EN24 are 2.025 Ra, 129 Hv and 3.127 Ra, 285 Hv respectively.

Table 2: burnishing Parameters considered

Factors	***Levels***
Burnishing force, Kgf	3, 6, 8, 11, 14
Feed, mm/rev	0.49, 0.076, 0.119, 0.163, 0.256
Speed, mm/rev	140,255,585, 1170, 2000
Number of passes	1,2,3,4,5
Roller width	8 mm
Condition	Dry and With abrasive paste

EQUIPMENT'S USED

Following equipment's are used during the studies;

1. UNITECH MTT 636 ALL GEARED LATHE to carry out turning and burnishing experiments

2. Talysurf surface, Minutoyo made roughness tester for measuring surface roughness

3. Vickers hardness tester for micro hardness

4. Valve lapping silicon carbide compound as abrasives

5. RESULTS AND DISCUSSION

The table 3 Shows the experiments planned in this work along with the surface roughness and micro hardness values for different cases of burnishing. At the outset, by referring table values of Reponses and initial turned components roughness and micro hardness level, the general reduction in the both mentioned properties can be seen. Further, the changes in the parameter levels will affect the responses at different levels. These are discussed in further sections.

Table 3: Experimental Planning and Surface roughness, Microhardness values for EN24 and Brass in Dry and AAB condition

Sl. No.	Speed, rpm	Force, Kgf	Feed, mm/rev	NOP	En24 Ra, µm		En24 Hv		Brass Ra, µm		Brass, Hv	
					Dry	Abr.	Dry	Abr.	Dry	Abr.	Dry	Abr.
1	*140*	*8*	*0.119*	*3*	0.633	1.398	292	332	0.597	0.815	172	183
2	*255*	*8*	*0.119*	*3*	1.253	1.418	332	342	0.412	1.363	162	222
3	*585*	*8*	*0.119*	*3*	0.453	1.071	271	361	0.414	1.299	**255**	199
4	*1170*	*8*	*0.119*	*3*	**0.445**	1.391	320	332	0.440	1.132	235	180
5	*2000*	*8*	*0.119*	*3*	0.482	1.749	**458**	332	0.459	**0.661**	180	197
6	*585*	*8*	*0.119*	*1*	0.971	2.018	424	292	1.315	1.814	222	184
7	*585*	*8*	*0.119*	*2*	0.793	1.343	292	351	0.914	0.666	199	222
8	*585*	*8*	*0.119*	*3*	0.728	1.2	303	342	1.033	1.068	227	201
9	*585*	*8*	*0.119*	*4*	0.749	1.024	311	332	0.934	1.123	241	201
10	*585*	*8*	*0.119*	*5*	0.709	1.146	285	332	0.706	1.042	218	197
11	*585*	*8*	*0.049*	*3*	0.655	0.923	303	332	0.817	0.913	199	199
12	*585*	*8*	*0.076*	*3*	0.588	1.242	320	351	0.715	1.392	184	199
13	*585*	*8*	*0.119*	*3*	1.375	1.089	285	376	0.669	1.374	197	180
14	*585*	*8*	*0.163*	*3*	1.635	1.361	342	376	0.921	1.651	197	**227**
15	*585*	*8*	*0.256*	*3*	0.605	1.022	351	388	0.817	1.263	222	184

16	*585*	*3*	*0.119*	*3*	0.458	1.271	388	**393**	0.839	1.604	227	183
17	*585*	*6*	*0.119*	*3*	0.681	**0.839**	320	361	0.46	1.427	241	197
18	*585*	*8*	*0.119*	*3*	0.622	1.001	388	376	0.397	1.255	222	222
19	*585*	*11*	*0.119*	*3*	0.856	1.08	388	388	0.437	1.338	227	222
20	*585*	*14*	*0.119*	*3*	0.553	1.321	351	376	**0.385**	1.223	227	201

1. Effect of speed on surface roughness and Micro hardness

Figure 3 depicts the effect of varying speed on surface roughness and micro hardness values for both the materials used in experiments i.e. EN24 and brass for different conditions under given value of parameters. It is clear from the figure that; the use of abrasives does not make any influential effects on responses than that of dry burnishing. Both the materials have shown better results in dry case and at lower speed rate around 600-650 rpm ranges. For AAB cases, the roughness value reaches maximum to 1.8 Ra at higher level of forces indicating chattering, high friction effect during the burnishing process.

Figure 7 shows the microhardness values. The speed values in the range of 500-600 rpm can be used to increase hardness values to higher level in the brass. No much difference is observed by using abrasives, but at higher speeds, the micro hardness values will remain similar for two cases. For EN24, the hardness values will reach maximum up to 500 Hv in dry case, whereas, similar observation was identified in AAB case.

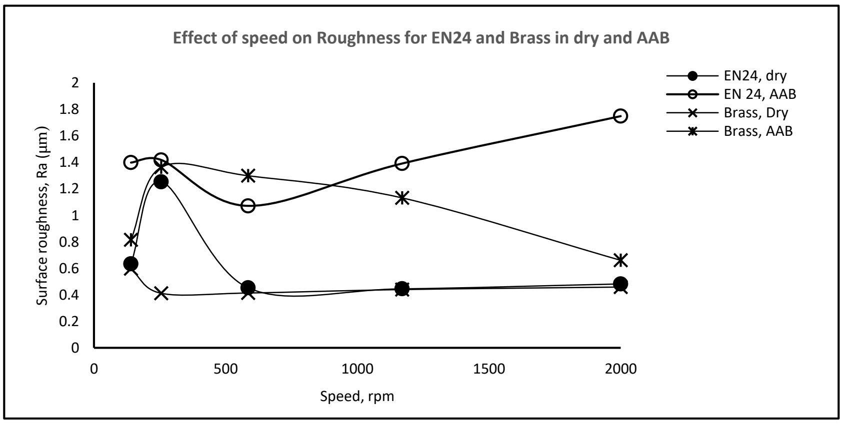

Figure 3: Effect of speed on Roughness for EN24 and Brass in dry and AAB (conditions constant Force;8 kgf, feed of 0.119 and number of passes 3)

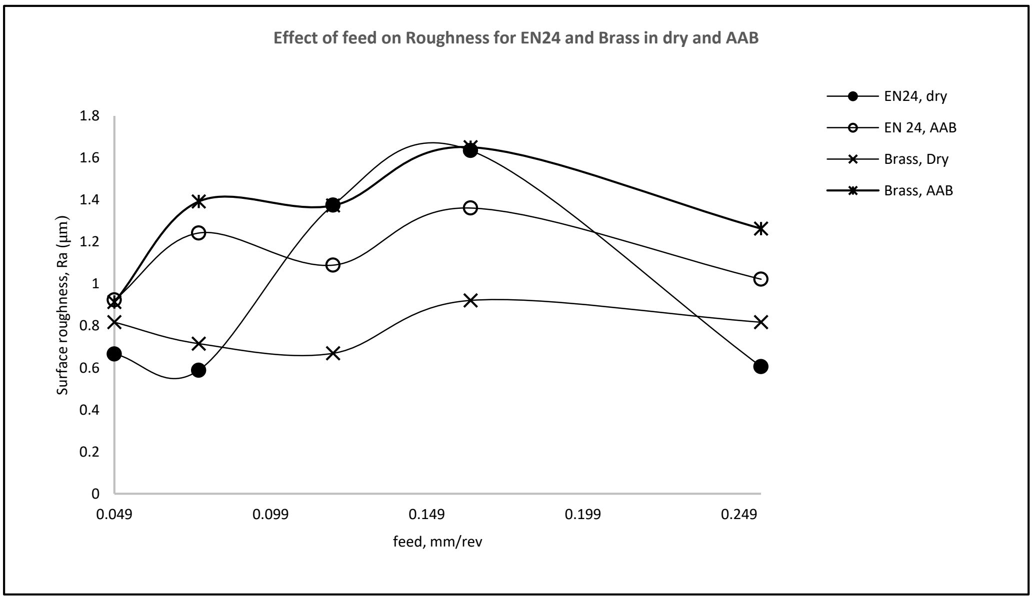

Figure 4: Effect of feed on Roughness for EN24 and Brass in dry and AAB (conditions constant Force;8 kgf, speed585 rpm and number of passes 3)

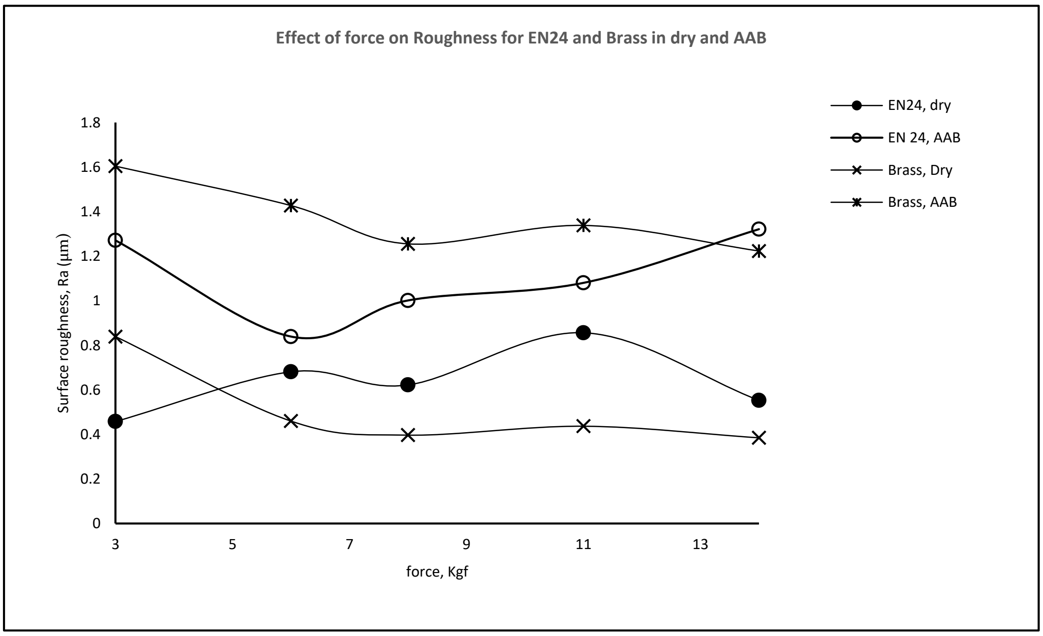

Figure 5: Effect of force on Roughness for EN24 and Brass in dry and AAB (conditions constant speed;585 rpm, feed of 0.119 and number of passes 3)

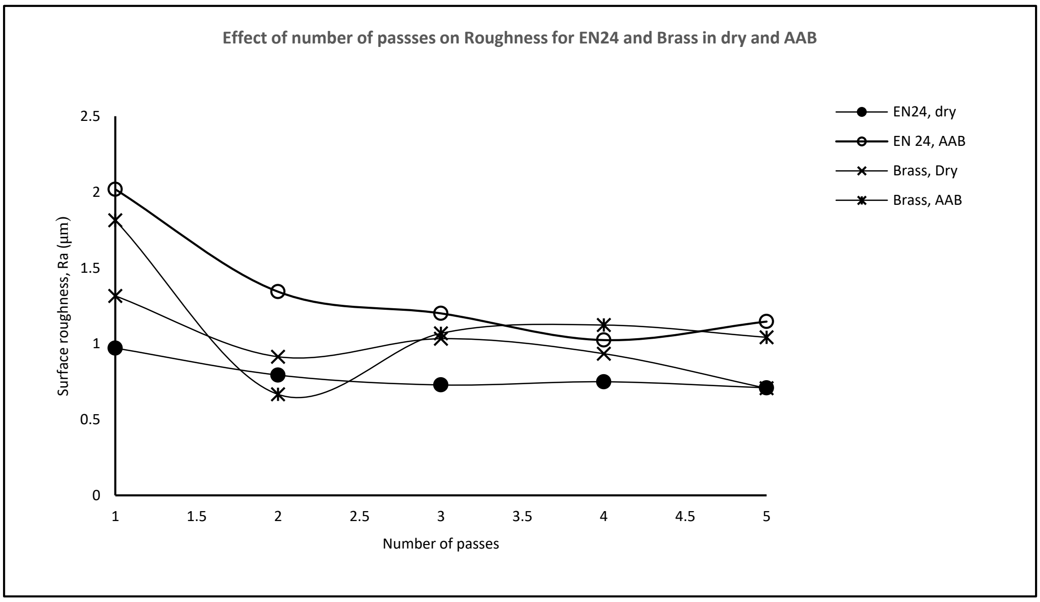

Figure 6: Effect of number of passes on Roughness for EN24 and Brass in dry and AAB (conditions constant Force;8 kgf, feed 0.119 mm/rev and speed 585 rpm)

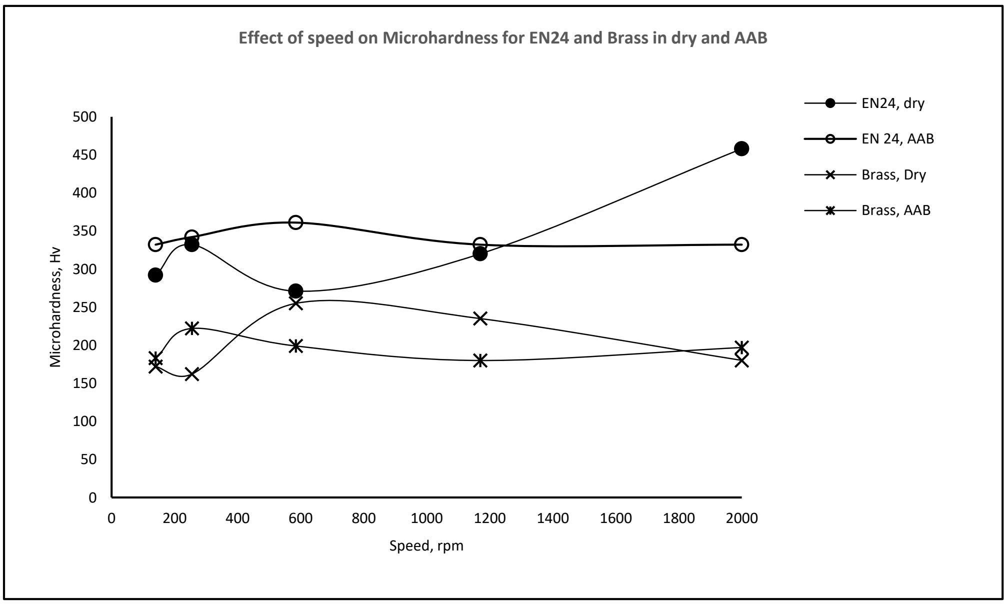

Figure 7: Effect of speed on Micro hardness for EN24 and Brass in dry and AAB (conditions constant Force;8 kgf, feed of 0.119 and number of passes 3)

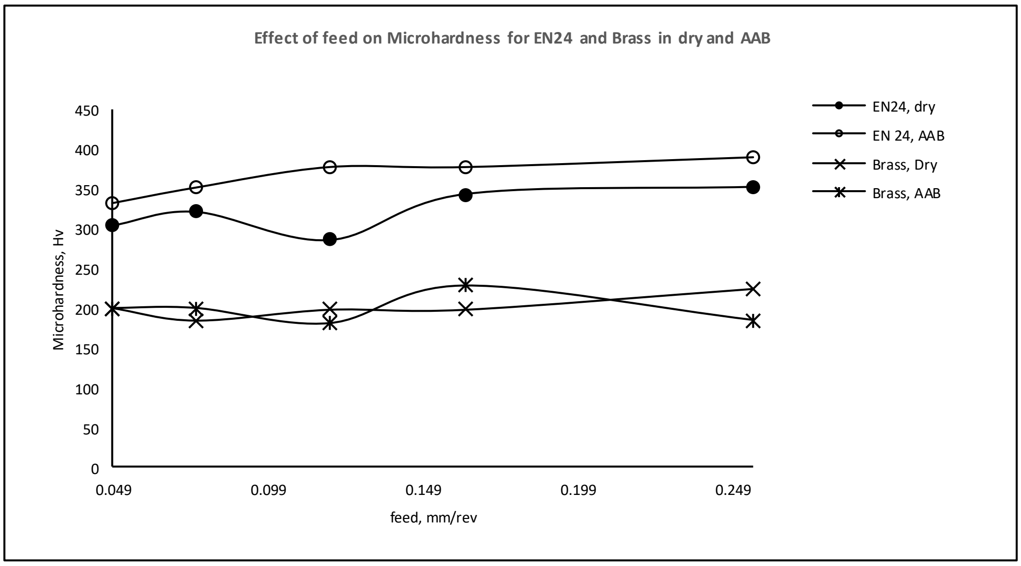

Figure 8: Effect of feed on Roughness for EN24 and Brass in dry and AAB (conditions constant Force;8 kgf, speed585 rpm and number of passes 3)

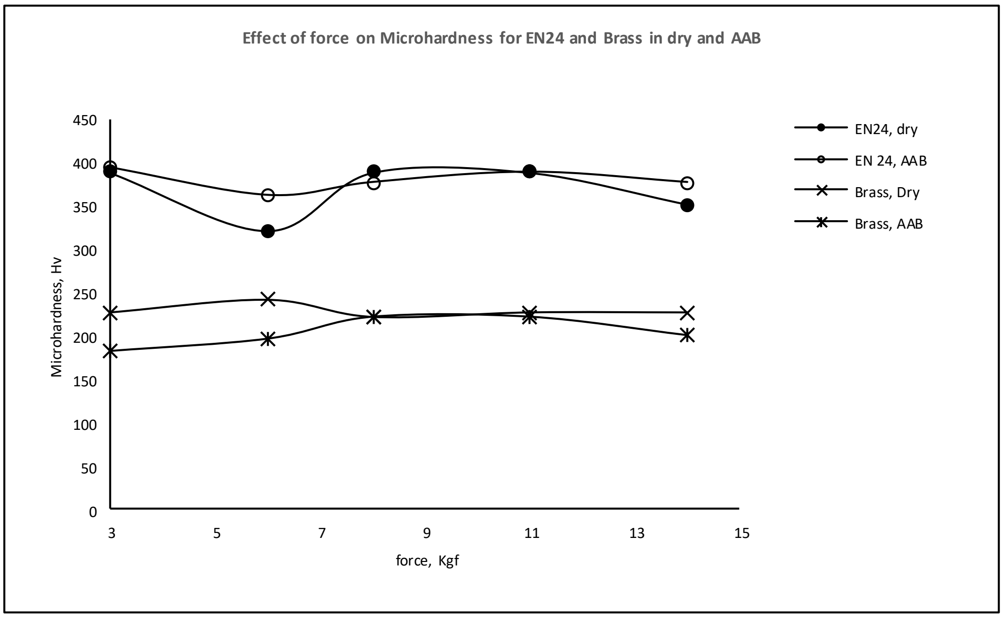

Figure 9: Effect of force on Microhardness for EN24 and Brass in dry and AAB (conditions constant speed; 585 rpm, feed of 0.119 and number of passes 3)

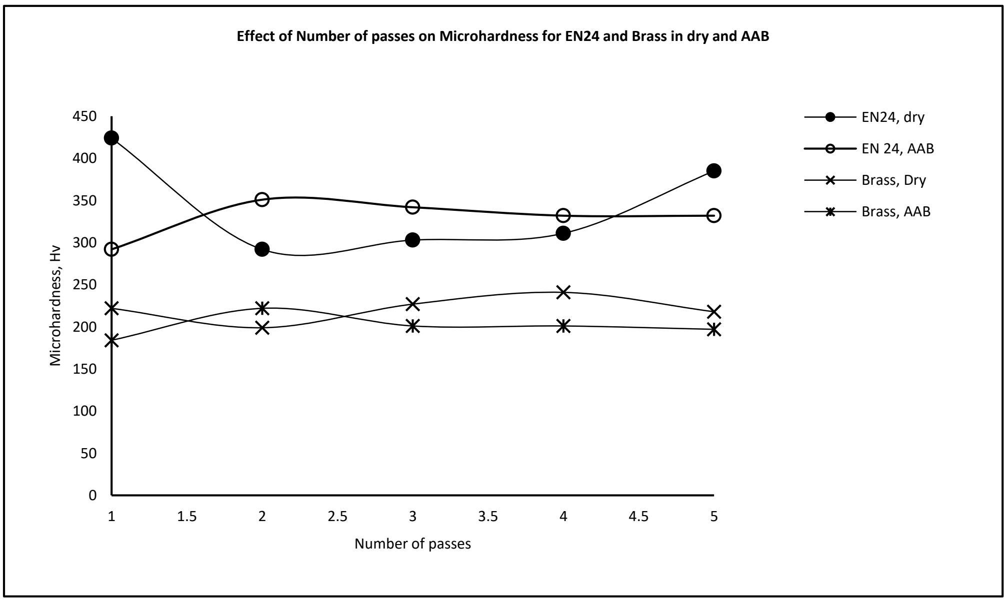

Figure 10: Effect of number of passes on Roughness for EN24 and Brass in dry and AAB (conditions constant Force;8 kgf, feed 0.119 mm/rev and speed 585 rpm)

2. Effect of feed

Effect of varying the speed on surface roughness and micro hardness can be seen from figure. 4 and figure 8. The values about the ranges 0.075-0.1 mm/rev are more influential to get better surface roughness in both the materials in dry case, after that the roughness, starts to increase at the surface due to increase in plastic deformation. In micro hardness, similar trend has been observed of that of speed. Both cases give same micro hardness values at higher speeds for brass. But during the speed 500-1000 rpm the dry burnishing has given more hardness than AAB. This might be due to fact that; plastic deformation is insufficient due to presence of abrasive particles at the surface. for EN24 increase in speed value after 500 rpm increases micro hardness exponentially in dry case.

3. Effect of force

The effect of force is seen to be more effective on surface roughness from figure. 5. For Brass, the increase in force reduces the surface roughness in both the cases. In turn, the improvement in roughness in more in dry case than AAB. In dry case, as force increases, deformation of peaks onto valleys increases effectively thus increasing finish. But due to the presence of abrasive particles, as force increased, due to chattering, the roughness improvement falls down. Influence of varying force on micro hardness can be seen from figure. 9. It is observed that, for both the cases the effect of force is almost similar in increasing micro hardness at the surface.

4. Effect of number of passes

It can be seen from the figure. 6 that, as number of passes increases the roughness values at the surface tend to decrease continuously, in general. This is attributed to fact that as tool passes increases, due to repeated deformation, the surface roughness values decreases. But, when the tool passes increases from two the brass roughness starts to increases. This is owing to fact that, the deforming ability of the material decreases after certain limit, restricting it undergo further deformation. The effect of micro hardness of the both the materials in not much affected by the dry and abrasives as seen in figure. 10.

CONCLUSIONS

1) Roller burnishing is an effective method in improving both surface finish and surface hardness.

2) In roller burnishing process of EN24 in dry condition least value of surface roughness achieved is 0.445 Ra and percentage decrease of roughness is 85.77% compared to turned components. In AAB condition minimum surface roughness achieved is 0.839 Ra and percentage decrease is 73.17%.

3) Maximum value of surface hardness during roller burnishing of EN24 in dry condition is 458Hv and percentage increase compared to turned work piece by 37.77% and for AAB condition 393 Hv i.e. 27.48%.

4) Reduction in Surface roughness of Brass in dry condition achieved is 0.385 Ra and percentage decrease when compared to turned workpiece is 80.99% and for AAB condition 0.661 Ra and percentage decrease is 67.36%.

5) Maximum value of surface hardness during roller burnishing of Brass in dry condition is 255Hv and percentage increase compared to turned workpiece 49.41% and for wet condition 227Hv i.e. 43.17%.

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