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# Experimental Analysis of Effect of Vibratory Burnishing Tool on Surface Integrity Enhancement of Ti-6Al-4V

Harish<sup>1</sup>, Raghavendra.N<sup>1</sup> Pranasha Setty<sup>2</sup>

<sup>1</sup>Department of Mechanical Engineering, BNMIT, Bengaluru 560070, India.

<sup>1</sup>Department of Mathematics, BNMIT, Bengaluru 560070, India.

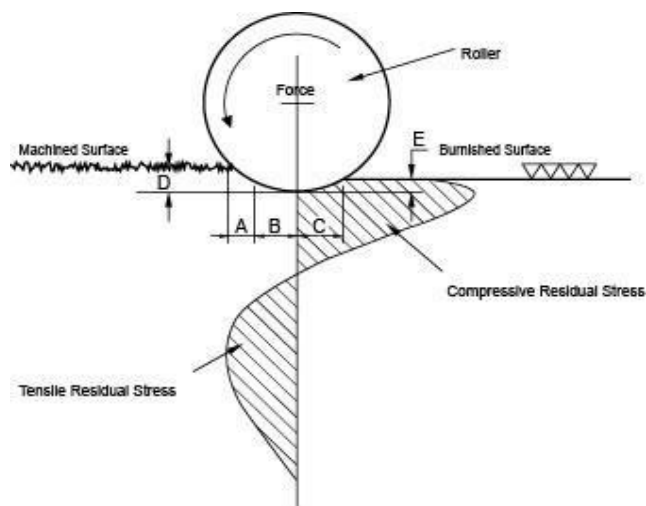
## Abstract

Vibratory roller burnishing tool is used for the experimental work of the present study on specially fabricated Ti-6Al-4V. In Vibratory roller burnishing, a hard roller is pressed against a rotating cylindrical work piece and parallel to the axis of the work piece. Burnishing is essentially a cold forming process, in which the metal near a machined surface is displaced from protrusions to fill the depressions. The results show significant improvement in the surface roughness and surface hardness of Ti-6Al-4V were achieved by the application of the Vibratory roller burnishing process. The intent of this work is to develop the Vibratory roller burnishing tool and study the effect of burnishing process on the surface characteristics of Ti-6Al-4V. In the present work, various experiments are conducted to investigate the effect of burnishing force and number of passes on the surface hardness and surface roughness of the Ti-6Al-4V.

**Keywords :** Residual stress, Surface roughness, Hardness.

## 1. Introduction

Vibratory Burnishing causes work hardening and creation of beneficial compressive stresses in the surface layers which, in turn, increase the micro hardness, wear resistance and fatigue strength of the surface layer of the component. Hardened and highly polished steel rollers are brought into pressure contact with a softer work piece. As the pressure exceeds the yield point of the work piece material, the surface is plastically deformed by cold-flowing of subsurface material. Vibratory roller burnishing is a metal displacement process. Microscopic “peaks” on the machined surface are caused to cold flow into the “valleys”, creating a plateau-like profile in which sharpness is reduced or eliminated in the contact plane. The burnished surface will therefore resist wear better than the abraded surface in the metal-to-metal contact, as when a shaft is rotating in a bushing.



**Fig. 1** Vibration burnishing Mechanism [1]

Vibratory roller burnishing helps users to eliminate secondary operations for substantial time and cost savings, while at the same time improving the quality of their product. Vibratory roller burnishing is a method of producing an accurately sized, finely finished and densely compacted surface that resists wear. Hardened and highly polished steel rollers are brought into pressure contact with a softer work piece. As the pressure exceeds the yield point of the work piece material, the surface is plastically deformed by cold-flowing of subsurface material.

Malleswara Rao J. N. *et al.* [1] carried out studies on the effect of Vibratory roller burnishing on surface hardness and surface roughness on specially fabricated mild steel specimen. In Vibratory roller burnishing, a hard roller is pressed against a rotating cylindrical work piece and parallel to the axis of the work piece. Dinesh Kumar *et al.* [2] studied about improving surface finish and hardness for M S cylinder using Vibratory roller burnishing. High surface finish is required for proper working of the machine parts with long life. Khalid. S. Rababa *et al.* [3] carried out studies on effect of Vibratory roller burnishing on the mechanical behavior and surface quality of O1 alloy steel which enhances the mechanical properties and micro hardness of the surface of O1 steel using the Vibratory roller burnishing process.

P. Zhang, J. Lindemann *et al.* [4] carried out studies on effect of Vibratory roller burnishing on fatigue properties of the hot-rolled Mg–12Gd–3Y magnesium alloy and found the influence of

RB on the high cycle fatigue properties of the Mg–12Gd–3Y alloy was investigated because it is a substitute of aluminum so consider a fatigue property and find conclusions can be drawn: Anish P. Borkar *et al.* [5] investigated on single Vibratory roller burnishing tool by modifying and controlling the burnishing force. Burnishing is cold working process where hard roller are being pressed against irregular surface, so that surface finish and the Jignesh R. Patel *et al.* [6] studied the role of enhancement of the surface roughness and surface hardness of the of C20 carbon steel using the Vibratory roller burnishing process. In globalization manufacturing processes the both physical and mechanical property are importance so we have studied and find best suitable parameter in minimize input parameter like force, feed, and Speed with using RSM method in Minitab16 and best result gain with burnishing tool which manufacture with new design which cover Lean manufacturing, J-I-T concept with easily assemble and disassemble for small and large scale industries and minimize tool manufacturing cost. Mr.Ashwin Joshi *et al.* [7] conducted experiments on cylindrical Aluminum alloy (Al-6061) workpiece and has been burnished using different machining parameters [Speed, Feed, and Depth of Penetration and Number of passes.]. In a single Vibratory roller burnishing process, a hardened and polished roller is penetrated against a revolving cylindrical workpiece.

Saeed Saki Entezami *et al.* [8] studied by designing and manufacturing a burnishing tool and then the surface roughness studied by changing effective parameters influencing on burnishing such as rotation speed, feed and roller force of burnishing and roughness of initial surfaces. A. Lewandowski *et al.* [8] studied about when processing EN GJSFP 450-10 ductile cast iron. The L18 Taguchi robust plan was used to optimize the processing conditions. The application of this method allowed determination of optimal conditions taking into account the conditions of pre-turning and burnishing.

## 2. Methodology of Investigation

Brief description of the methodology followed during the course of this study is as follows;

- i. Carry out the Literature regarding the effect of Vibratory roller burnishing and on surface enhancement by referring journals, books and related documents.
- ii. Carry out the design calculation for roller diameter and thickness.
- iii. Carry out modeling using solid edge software.

- iv. Carry out fabrication of burnishing tool and hydraulic cylinder with hand pump arrangement.
- v. Carry out fabrication of fixture for the tool to fit to the lathe specification.\
- vi. Carry out testing on surface hardness and surface roughness.
- vii. Carry out microstructure testing of aluminium alloy 6061 by scanning electron microscope.
- viii. To analyze effect of burnishing on the aluminium alloy 6061 specimen using Vibratory roller burnishing tool.

**2.1 Material Data, Preparation of Specimen for LPB.**

Error! Reference source not found. displays the results of an energy-dispersive X-ray spectroscopy (EDS) investigation performed on a machined, untreated Ti-6Al-4V test sample. The chemical composition and mechanical properties of Ti-6Al-4V are displayed in **Table 1** and **Table 2**, respectively.

**Table 1** Ti-6Al-4V material : Chemical composition

Elements (Wt.%)	C	Al	H	Fe	O	N	V	Ti
	0.029	4.99	0.0031	0.311	0.27	0.009	3.18	Remaining

The cuboidal specimens were created using a wire electric discharge machine (EDM) to cut a forged plate that was 300 mm by 200 mm by 5 mm into 25 tiny test coupons that were 10 mm by 10 mm by 5 mm. Using the process control parameters—burnishing feed, burnishing pressure, and burnishing passes—specimens were treated with LPB. Error! Reference source not found. displays cuboidal test samples both before and after the LPB treatment.

**Table 2** Ti-6Al-4V: Mechanical properties

Density (kg/m <sup>3</sup> )	Elastic Modulus (GPa)	Poisson’s Ratio	Ultimate Tensile Strength (MPa)
4428	109	0.29	1001

**3. Results and Discussion**

In this chapter the results obtained from basic experimental tests namely Surface Hardness from Micro Vickers Hardness tester, Surface Roughness test from Tally Surf meter, and micro structure comparison by Scanning Electron Microscope on all the considered specimens are tabulated, compared and discussed carefully in the following sections.

#### 4. Results.

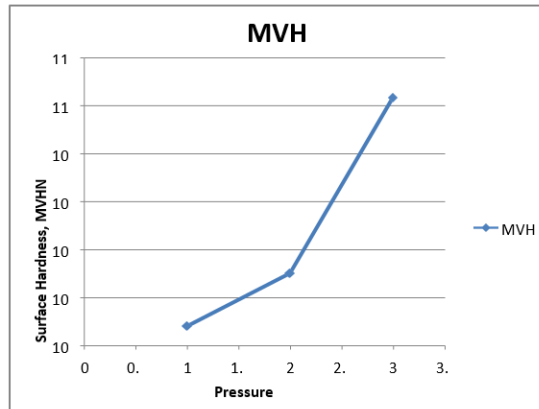
In this section the results obtained from various experimental tests are tabulated. The roughness, hardness, and microstructure of three given specimens before and after burnishing process are tabulated and compared as follows.

##### Effect of Burnishing on Surface Hardness.

Burnishing is carried out for the specimen keeping passes constant. The pressure is varied once for 20kg/cm<sup>2</sup> and another one for 30 kg/cm<sup>2</sup> force, hardness of the material; before and after burnishing is tabulated below in the table 6.1.

Table 3 Experimental results of surface hardness of the specimen before and after burnishing process

Sl. no.	Specimen	MVHN			Average (Hv)
		1	2	3	
1	Without Burnishing	98.8	101.4	101.3	100.8
2	20kg/cm <sup>2</sup> 3 passes.	102.0	102.8	104.2	103.0
3	30kg/cm <sup>2</sup> 3 passes.	108.6	111.5	110.8	110.3



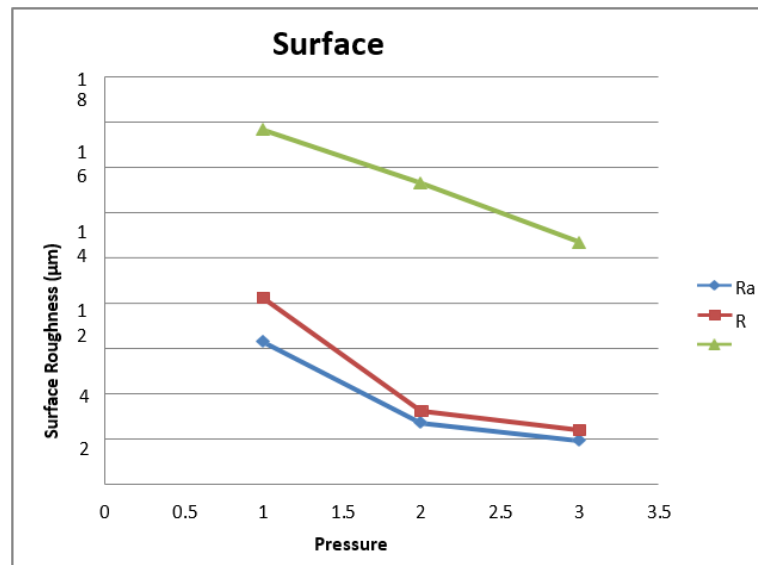
**Fig. 2** MVHN for 3 passes.

**i. Effect of burnishing on surface roughness.**

Burnishing is carried out for the specimen keeping passes constant. The pressure is varied once for 20kg/cm<sup>2</sup> and another one for 30 kg/cm<sup>2</sup> force, Roughness of the material before and after burnishing is tabulated below.

Table 4 .Experimental results of surface of the roughness specimen before and after burnishing process

Sl. no.	Specimen	Surface Roughness(μm)		
		Ra	Rq	Rz
1	Without Burnishing	6.28	8.24	15.67
2	20kg/cm <sup>2</sup> 3 passes.	2.692	3.23	13.3
3	30kg/cm <sup>2</sup> 3 passes.	1.910	2.39	10.68



**Fig. 3 Surface roughness for 3 passes.**

The obtained results of all the specimens were tabulated. It is observed that (from table 6.1) the hardness of the specimen has increased constantly with the increase in pressure. When 20kg/cm<sup>2</sup> has applied hardness is increased from 100.8 HV to 103 HV and when 30kg/cm<sup>2</sup> is applied hardness has increased from 100.8 HV to 110.3 HV.

From the table 6.2 results of all the specimens were tabulated. It is observed that the roughness of the specimen has decreased constantly with the increase in pressure. When 20kg/cm<sup>2</sup> is applied roughness (Ra) has decreased from 6.28µm to 2.692µm and when 30kg/cm<sup>2</sup> is applied hardness has increased from 6.28µm to 1.910µm.

## 5. Conclusions.

Conclusions are drawn based on the results obtained from experimental methods are summarized as follows:-

- 1) Vibratory roller burnishing method which is employed for surface modification of aluminium alloy 6061. This allows the high spots to be flattened out and the valleys filled in. It is a new concept in finishing Components. This process eliminates Grinding and honing which are costlier processes while improving the surface finish, surface hardness, wear-resistance etc.
- 2) After burnishing the surface of aluminium 6061 alloy, the hardness test was conducted by using micro Vickers hardness tester to measure hardness and compared with the hardness value of al 6061 alloy without burnishing. The results show

significant improvement in the surface hardness after burnishing process.

- 3) After burnishing the surface of aluminium 6061 alloy, the test was conducted by using tally surf meter to measure surface roughness and compared with the hardness value of aluminium 6061 alloy without burnishing. The results show significant improvement in the surface roughness after burnishing process.

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