Experimental Investigation and Analysis of Nano Surface Finish in Lapping Process Using Nano Abrasives

[1]Ramkumar R, [2]Nishanth S, [3]Balaji V

[1, 2, 3] Department of Manufacturing Engineering, College of Engineering Guindy, Anna University, Chennai

Abstract: **Recent developments in lapping process have opened up new avenues for finishing of hard and brittle materials with nano surface finish, high tolerance and accuracy. Instead of using super abrasives such as diamond and CBN for achieving nano surface finish, conventional abrasives such as alumina and silicon carbide can be reduced to nano level to obtain nano surface finish. The properties of abrasives at nano-level are also studied.**

Keywords: **ball milling, nano-abrasives, surface roughness.**

I. INTRODUCTION

Lapping is a finishing process, in which material removal takes place due to relative motion between the work piece, loose abrasive grains, and the lapping plate. This process is used in achieving finer surfaces and closer fits, correction of minor imperfections, and maintaining close tolerances. An investigation is conducted to determine the effect of abrasive particle size on the type of surface generated by flat lapping. Lapping has extensive applications in high precision manufacturing industry and is capable of providing high finish and accuracy of form without complex setup.

II. LITERATURE REVIEW

From the literature, it was found that diamond abrasives are used for achieving surface finish in nanometre range. Tam et al [1] used 30um diamond abrasive for lapping of reaction bonded silicon carbide (RB-SiC) and achieved a surface finish of 0.11um. Diamond abrasive of 20um resulted in surface finish of 0.048um and diamond abrasive of 10um resulted in surface finish of 0.021um. Deshpande [3] surface finish depends upon the type and size of abrasives used.

Figure 1: Table top lapping machine

Table 1: Specification of lapping machine

Manufacturer	Speed Fam
Model	Table top machine
Speed	70 rpm (constant)
Lapping weight	1 kg, 115mm diameter and 18mm thickness
Conditional Ring	130mm outer diameter 115mm inner diameter
Lap material	Cast iron

Lapping Machine:

Lapping machines vary extensively depending upon the manufacturer. Speed Fam has designed a set of instruments that are specifically designed for universal lapping and polishing applications. The specifications of lapping machine are shown in table 1.

Workpiece Material:

Mild steel is the most common form of steel because its price is relatively low while it provides material properties that are acceptable for many applications. Low carbon steel contains approximately 0.05–0.25% carbon.

III. SYNTHESIS OF ALUMINIUM OXIDE NANO-ABRASIVES

The reduction of abrasives from micro level to Nano level was done with the help of planetary ball milling machine. Planetary ball mills are smaller than common ball mills and mainly used in laboratories for grinding sample material down to very small sizes. A planetary ball mill consists of at least one grinding jar which is arranged eccentrically on a so-called sun wheel. The direction of movement of the sun wheel is opposite to that of the grinding jars (ratio: 1:-2 or 1:-1 or else). The grinding balls in the grinding jars are subjected to superimposed rotational movements, the so-called Coriolis forces. The difference in speeds between the balls and grinding jars produces an interaction between frictional and impact forces, which releases high dynamic energies. The interplay between these forces produces the high and very effective degree of size reduction of the planetary ball mill. For every one hour the powder is stirred to avoid conglomeration.

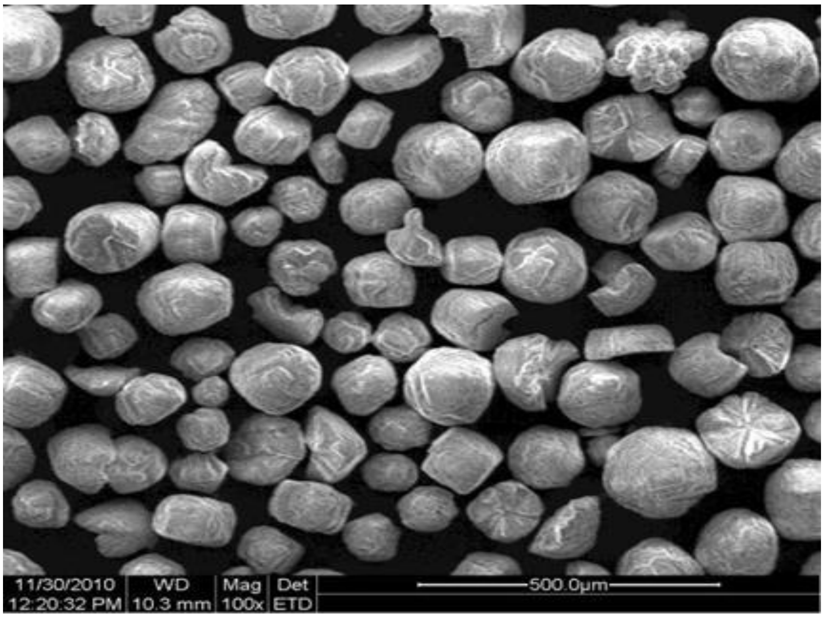


Figure 2: SEM image of Al_2O_3 micro abrasives

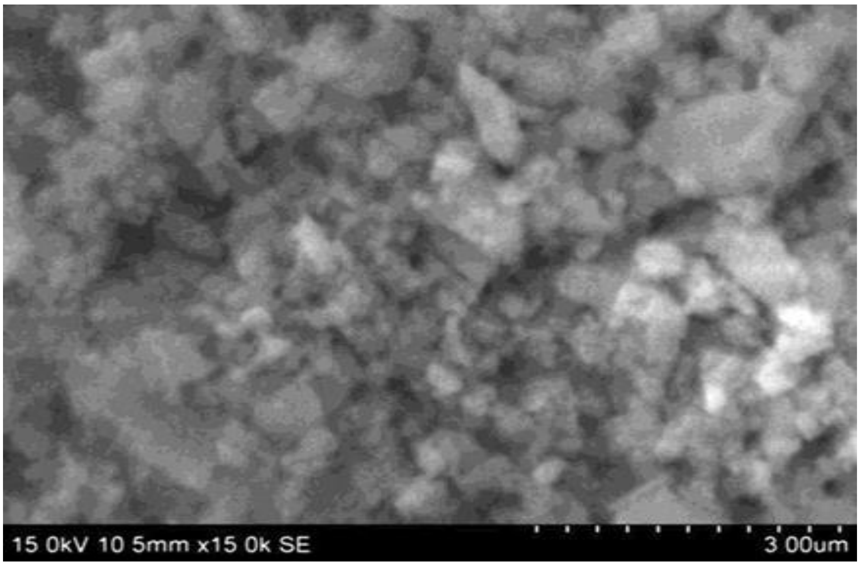


Figure 3: SEM image of Al2O3 nano abrasives

Figure 4: Planetary Ball Milling Machine

Table 2: Specification of planetary ball milling machine

Time	20 hours
Balls	23
Ball material	Tungsten carbide
Diameter of ball	10mm
Capacity of jar	300 gms
Speed	300 rpm
Motion	Planetary

IV. SURFACE ROUGHNESS TESTER

Mitutoyo's SJ-400 portable surface roughness tester was used for the measurement of surface roughness. The specifications of the equipment are in table 3.

Figure 5: Surface roughness tester SJ 400

Table 3: Specifications of roughness tester

Measuring	0.05, 0.1, 0.5, 1.0mm/s
speed	
Vertical	20X to 100,000X Auto
magnification	
Horizontal	1X to 1,000X Auto
magnification	
Stylus	Diamond, 90º / 5µmR
	(60º / 2µmR: low force type)
No of	36
parameters	
standards	ISO,DIN,ANSI,JIS.
Return speed	0.5,1,2mm/s
Measuring	4mN/0.75mN
force	

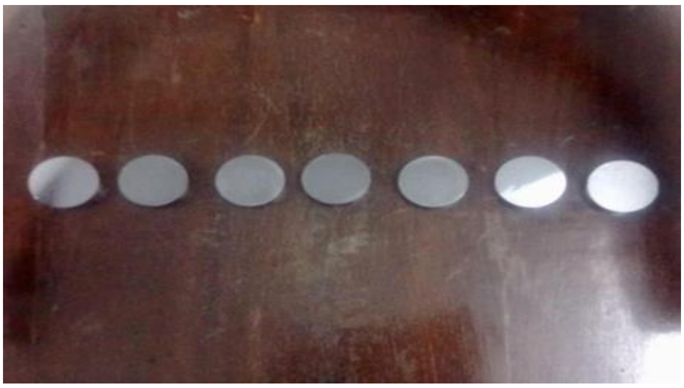


Figure 6: Mild steel specimens

V. RESEARCH METHODOLOGY

Initially the mild steel was turned and parted off into small specimens using conventional lathe. Then the specimens were grounded using surface grinder for initial surface finish. After, the specimens were taken for lapping process using micro-sized and nano-sized abrasives.

VI. RESULTS AND DISCUSSIONS

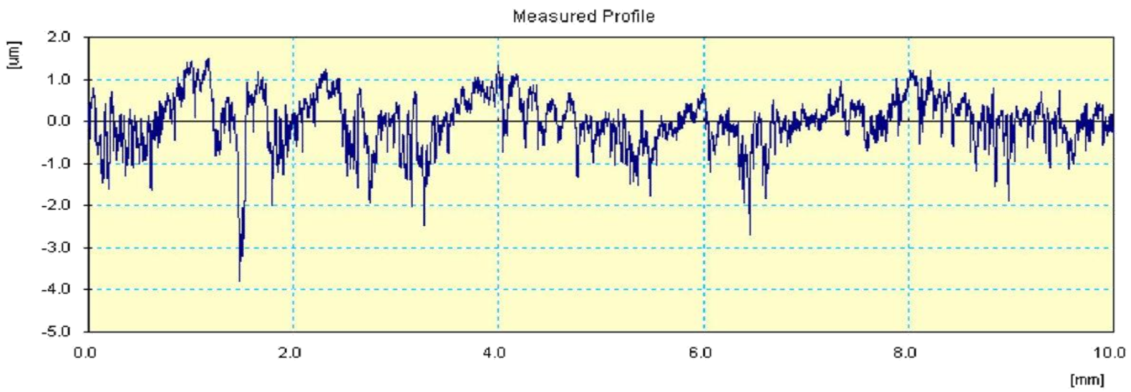
Initially the work piece was grounded with help of surface grinder and the average surface roughness was found to be 0.41um (410 nm). After that the same work piece was lapped for thirty minutes (30 min) in a single-sided lapping machine with aluminium oxide micro-abrasives (average particle size is around 60um) and the average surface roughness was found to be 0.19um (190 nm). Finally, the same work piece was lapped for fifteen minutes (15 min) with the help of aluminium oxide nano-abrasives and the average surface roughness was found to be 0.07um (70nm).

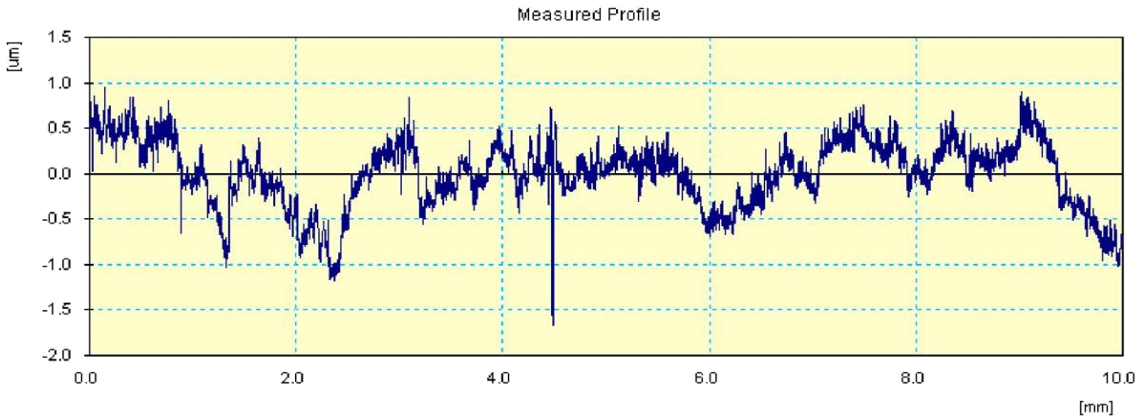
VII. CONCLUSION

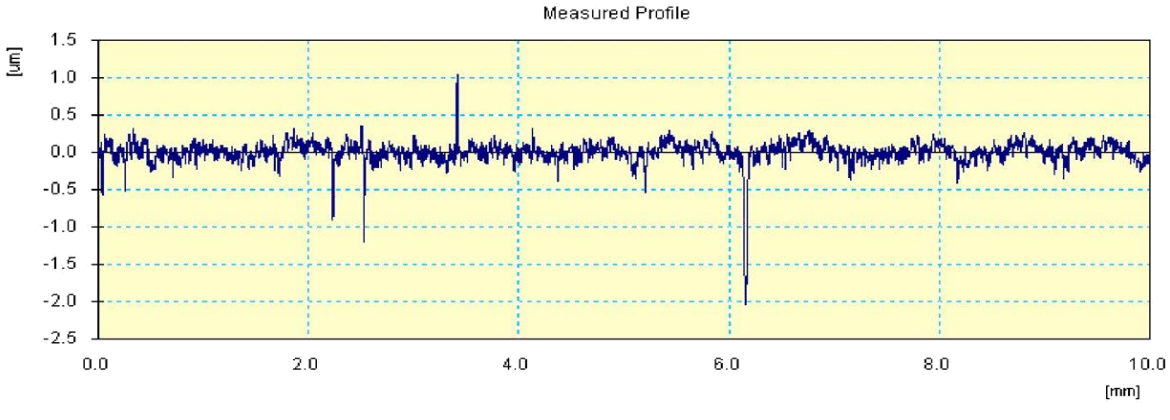
As the surface finish obtained was less than 100nm, average surface roughness of 70nm is considered to be nano-surface finish. Because of high surface finish in the order of nanometre range, the friction between the mating parts can be reduced to a great extent which in turn increases the overall efficiency of a system.

Future Work:

Behaviour of different nano sized abrasives, recharging of abrasives and analysing the properties of recharged abrasives will be studied.







REFERENCES

[1] H.Y.Tam, H.B.Cheng and Y.W.Wang (2007) "Removal rate and surface roughness in the lapping and polishing of RB-SiC opticalcomponents", Journal of Material Processing Technology, 192-193, 276-280.

[2] W.J.Zong, D.Li, K.cheng, T.Sun, H.X.Wang and Y.C.Liang (2005) "The material removal mechanism in mechanical lapping of diamond cutting tools", International Journal of Machine Tools and Manufacture, 45, 783-788.

[3] Lalit Suhas Deshpande, Shivakumar Raman, Owat Sunanta and Casmir Agbaraji (2008)"Observations in the flat lapping of stainless steel and bronze", Journal of Material Processing Technology", 265, 105-116.

[4] S.Prabhu and B.K.Vinayagam (2009) "Analysis of nanosurface generation of lapping process using multiwalled carbon nanotubes (MWCNT)" International Journal of Nanotechnology and Applications, 3,35.-42.

[5] S. Kalpakjian and S. Schmid (2009) "Manufacturing processes for Engineering materials", Pearson education.

[6] V.C, Venkatesh and Sudhir azim "Precision Engineering ".

[7] "Analysis on Lapping and Polishing Pressure Distribution"G.Q. Caib, Y.S. Lub, R. Caib and H.W. Zhengb.

[8] "Technological Advances in Fine Abrasive Processes"(2006)R. Komanduria, D.A. Luccaa and Y. Tani, a Mechanical & Aerospace Engineering, Oklahoma State University, Stillwater, OK, USA

[9] "A study on recycling of abrasives in abrasive water jet machining"M. Kantha Babu and O. V. Krishnaiah Chetty, Manufacturing Engineering Section, Indian Institute of Technology Madras, Chennai 600 036, India.