COMPARISON BETWEEN GRINDING AND LAPPING OF MACHINED PART SURFACE ROUGHNESS IN MICRO AND NANO SCALE

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ABSTRACT

Micro and Nano surface finish has become an important parameter in semiconductor, optical, electrical and mechanical industries. In this work a comparison between two traditional finishing processes grinding and lapping was made. Machined parts surface roughness in micro and nano scale has been measured using two different devises in two different directions normal and perpendicular to the machining direction. Results show that the traditional finishing processes are not suitable for nano scale surface finish. There is a significant difference between the normal and perpendicular measured surface roughness in nano and micro scale.

***KEYWORDS**: Lapping, grinding, surface roughness, micro, nano scale.*

1.0 INTRODUCTION

Final finishing operations in manufacturing of precise parts are always of concern owing to their most critical, intensive labor and least controllable nature. In the era of nanotechnology, deterministic high precision finishing methods are of utmost importance. The need for high precision in manufacturing was felt by manufacturers worldwide to improve interchangeability of components, improve quality control and longer fatigue life [1]. Taniguchi [2] reviewed the historical progress of achievable machining accuracy during the last century. The machining processes were classified into three categories on the basis of achievable accuracy conventional machining, precision machining and ultraprecision machining. Ultraprecision machining are the processes by which the highest possible dimensional accuracy is achieved at a given point of time. This is a relative definition which varies with time. It was predicted that by 2000 AD, the machining accuracies in conventional processes would reach 1 μm, while in precision and ultraprecision machining would reach 0.01μm (10 nm) and 0.001μm (1 nm) respectively [2].

The study of micro and nano surface metrology is becoming common in industrial and research environments as structures and surface features become smaller and smaller [3,4,5,]. Scanning interferometry is becoming increasingly important in metrology analysis because of various factors such as ; the possibility of non-destructive measurement - no sample contact or preparations are required [6]; its accurate and quantitative surface characterization; the fast and convenient sample loading and set-up; the capability of measuring a wide range of materials; high resolution; highly repeatable measurements; fully automated measurement – ideal for process control; performing roughness and step height analysis within a single measurement; the possibility of surface coating measurement – film thickness and real surface roughness measurement. It can address many of the challenging measurement problems that exist when studying samples at the micro and nano scale [7]. These include the measurement of critical dimensions, heights, angles, surface roughness, solving etch rate/time problems, measuring stress gradients, etc [8].

Roughness is an important parameter for sample properties control. Various roughness ranges are normally studied in order to define the overall properties of the surface and one of the limitations to the analysis is the bandwidth of the measurement method [9]. It is very important to accurately evaluate the quantities values of surface roughness, to determine the possibility of their usage and quality of products, to measure the effective height of surface roughness, a scanning microscope is used [10, 11]. Comparing the surface roughness machined with traditional finishing, grinding and lapping in small scale can help in choosing the finishing methods used in production of small parts.

In this work a comparison between two traditional finishing processes, grinding and lapping was made. Machined part surface Roughness in Micro and Nano scale using two different devises was measured in two different directions normal and perpendicular to the machining direction. To show how suitable grinding and lapping is suitable in finishing parts in nano scale.

2.0 EXPERIENTIAL WORK

A set of experiments were carried out to compare the measurement results of micro and nano grinding surface roughness. Samples were processed implementing various methods and their surface roughness were measured using a special measurement device "Surfcorder SE 1200 fig(1) and a multi-microscopic scanner CMM-2000 fig(2)". During this experiment the main difficulty was the selection of samples' parameter. Initially they should be big enough to be stably mounted during the machining process, as well as fitting the space of measurement devices. In this case, we have used samples of steel 45 with dimensions of 10 mm in length, 8 mm in width and a thickness of 2 mm were used. These parameters were selected according to microscopic scanner capability. The workpice has been machined on a shaping machine then abrasive processing processes grinding or lapping were used. Silicon carbide 55C and grain size of 20 μm. were used in grinding and lapping.

Fig.1. Surfcorder SE 1200

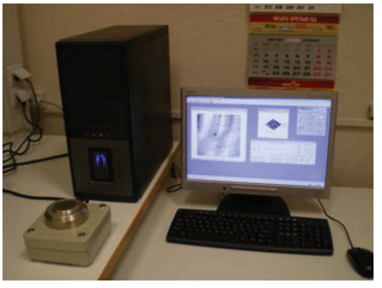


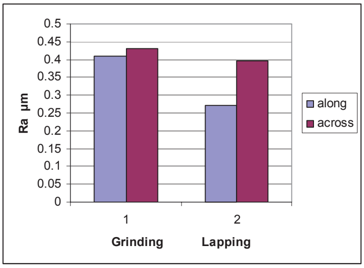
Fig.2. multi-microscopic scanner CMM-2000

3.0 RESULTS ANALYSIS

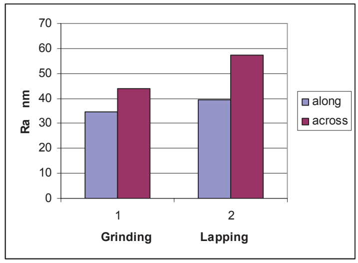
A "Surfcorder SE 1200" of Kosaka lab (Japan) was used to measure the micro surface roughness. To define the surface nano characteristics a scanning microscope was used "CMM 2000" manufactured by proton –MIET (Russia). The workpiece surface roughness (Rz) after shaping process of the profile-meter was 2,998 μm, in the direction of machining, and 3,311 μm perpendicular. This value shows the significant effect of shaping cutting tool. It is not possible to test it on the CMM-2000 scanner, as the resulted values of (Rz) are higher that allowed measurement rang (2 μm). The results of surface roughness after the abrasive processing with different direction are stated in the table (1) and the surface roughness in micro and nano scale after grinding and lapping process are given in Table (1)

Table 1: measuring surface roughness after abrasive machining in the different direction.

Process	Measurement Direction	Profile-meter «SURFCORDER SE 1200»		Microscope CMM-2000	
		Ra, µm	*Rz*, µm	*Ra*, nm	*Rz*, nm
Grinding	along	0.410	2.120	34.71	150.7
	across	0.431	2.577	43.88	-
Lapping	along	0.270	1.450	39.31	149.5
	across	0.395	2.152	57.38	-



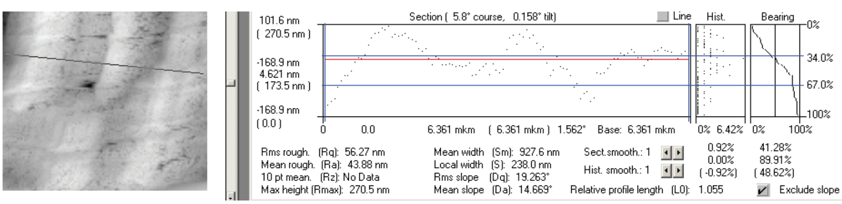
a)



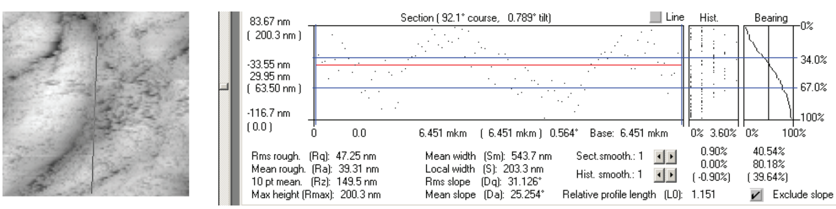
b)

Fig.3. Ra after grinding and lapping process. a) in micro scale, b) in nano scale

Fig (3) shown that in the micro surface roughness the lapping process has better surface than grinding, while in nano scale grinding process has better surface. Fig 4. Shows the results according to "CMM 2000" microscope



a) after grinding



b) after lapping

Fig. 4. the results according to "CMM 2000" microscope in nano scale left – scanned image ; right – profile measurements

The results of the surface roughness in nano scale which measured with CMM 2000 microscope and the scanned profile of the grinding and lapping surface show that the surface after grinding process is smother than lapping process.

The comparison between the grinding and lapping surfaces gives a different result in micro and nano, the lapping process is better in micro while the grinding in nano scale, the cutoff distance in measuring surface roughness may be the reasons of this result because in nano scale the cutoff distance very small about 2-4 nm while in micro 0.8-1 mm.

4.0 CONCLUSION

The present work has led to the following conclusions:
The surface roughness by the two devices has qualitative value, Quantities comparisons is not possible to define in nano scale surface roughness because it differs from one place to anther on the machined surface. Lapping process gives better surface than grinding in micro scale, while in nano scale the grinding process is better. Measuring direction has an effect in the micro and nano surface roughness. The research result shows that the traditional finishing processes it not suitable in nano scale machined part.

5.0 ACKNOWLEDGEMENTS

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