



International Journal of ChemTech Research CODEN (USA): IJCRGG ISSN : 0974-4290 Vol.6, No.3, pp 1725-1728, May-June 2014

ICMCT-2014 [10th – 12th March 2014] International Conference on Materials and Characterization Techniques

Investigation of Surface Texture Generated by Magnetic Field Assisted Abrasive Finishing

T. C. Kanish*, P. Kuppan, S. Narayanan

School of Mechanical and Building Sciences, VIT University, Vellore 632014, India.

*Corres.author: tckanish@vit.ac.in

Abstract: In this paper, an attempt has been made to characterize the surface texture generated, during Magnetic Field Assisted Abrasive Finishing (MFAAF) of SS316L material. The changes in surface texture generated are studied by using surface roughness profiler, Atomic Force Microscopy (AFM) and Scanning Electron Microscopy (SEM). The deep cutting marks left by grinding process have been removed and replaced by a new surface texture generated during MFAAF process. It is also observed from the AFM and SEM images that the peak surface profiles produced by grinding process have been sheared off by the abrasives. This leads to tiny material removal in the surface. It is also evident from the micrographs that the indentation and rotation of the magnetic abrasive flexible brush have formed circular lays during MFAAF.

Keywords: Magnetic field assisted abrasive finishing; Surface roughness; AFM; SEM; SS316L; Surface topography.

Introduction

Conventional finishing process like grinding and lapping apply uncontrolled high pressure on the work piece, which may cause micro cracks and substantial normal stresses. To overcome these drawbacks of conventional finishing processes magnetic field assisted finishing process have been developed. Magnetic field assisted abrasive finishing (MFAAF) uses the magnetic abrasive particles under a magnetic field to finish the surfaces of the work piece with controlled forces [1]. Due to the irregular geometry of magnetic abrasive flexible brush, detailed investigation is required for understanding the nature of surface generated during MFAAF process. Few researchers [2, 3] have studied the process characteristics and mechanism of surface generation, chip formation and forces acting on the surface during MFAAF process. It is found that most of the researchers have analysed the process mechanism from macroscopic point of view using the roughness profiles. Only a very few works have been published on the microscopic analysis of surface textures generated during MFAAF [4]. Hence, this paper presents the analysis of surface texture generated during MFAAF process for SS316L material using surface roughness profiles, AFM and SEM images for understanding the basic behaviour of the process at micro/nano level.

Experimental details

An electromagnet assembly was fabricated and fitted to the spindle of Computer Numerical Controlled vertical milling machine to conduct the MFAAF experiments. The details of experimental setup were explained in Kanish et al. [5]. The experiments were planned using the Taguchi design of experiments technique. The process parameters and their levels were selected from pilot experiments and literature [2, 6]. The selected variable process parameters and their levels for the present study are as follows: voltage supplied to the electromagnet (A) at levels of 18, 20 and 22 V; machining gap (B) at levels of 1.5, 1.75 and 2.0 mm; rotational speed of electromagnet (C) at levels of 270, 405 and 540 rpm; and abrasive size (D) at levels of 400, 800 and 1200 mesh. The other parameters like feed rate (50mm/min), finishing time (15min), grain size of iron particle (300 mesh), total amount of magnetic abrasive particle (10 g) and mixing ratio (80% Fe, 20% SiC abrasive) were kept constant for all the experiments. The work material selected for this study is a non-magnetic material, austenitic stainless steel grade 316L.

The experiments were conducted as per the Taguchi L9 orthogonal array. The obtained experimental results were fed in to Minitab statistical software for analysis. The percentage improvement in surface roughness ($\%\Delta R_a$) increases with the increase in voltage, rotational speed and abrasive size, whereas increase in machining gap has negative effect. To understand the behavior of abrasive finishing process, the surface roughness profiles alone do not reflect the interaction of cutting edges of abrasives. Therefore the corresponding AFM and SEM micro graphs of the work piece surface before and after the MFAAF process were also studied and reported.

Results and Discussion

Surface roughness profile analysis

The Figure 1 depicts the surface profiles obtained before and after MFAAF process for the optimal values of process parameters by using Mahr brand surface roughness tester equipment with martalk instrument having driving unit GD120. It is evident that the maximum peak height (Figure 1 a) has been reduced by the MFAAF process (Figure 1 b). The peaks obtained by the grinding operations were sheared off by indentation and rotation of MFAAF process. It is also found that a high level of surface finish, $R_a = 0.087 \mu m$ is obtained at the optimal cutting condition (A3B1C3D3).



Figure 1 Surface roughness profile

Atomic Force Micrographs

To understand the surface textures generated by MFAAF process, AFM images were taken (by NanoSurf Easy Scan2 instrument) before and after the MFAAF process and depicted in Figures 2(a) and 2(b) respectively. The figure 2(a) shows the AFM image of the work piece showing the periodic peaks and valleys (ranges from 921 nm to -1.14μ m), pits and digs obtained by grinding process. It is observed from figure 2(b) that the peaks have been sheared off to a much smaller height in the range of 150 nm by MFAAF process.



Figure 2 Atomic Force Micrographs

Scanning Electron Micrographs

Scanning Electron Micrographs of the surface generated before and after MFAAF process at the optimal cutting conditions is shown in figures 3(a) and 3(b) respectively. To obtain the SEM images Carl Zeiss make FESEM-Supra 55 instrument was used. Figure 3(a) shows the grinding marks with periodic peaks and valleys. From the figure 3(b), it is observed that the grinding lays peaks were removed and new surface texture is achieved by the magnetic flexible abrasive brush (MFAB). It is also evident that during MFAAF process the material was removed by indentation and rotation of abrasive particles. Due to localized higher pressure on the abrasive particles, micro-scratches are clearly visible in the surface texture generated by MFAAF process (Figure 3(b)).



Figure 3 Scanning Electron Micrographs

Conclusions

Based on the above investigations, the following conclusions are drawn:

- i) The normal magnetic force and relative motion induced on the abrasive particle leads to indentation and shearing action respectively. This helps to improve the surface roughness.
- ii) The minimum surface roughness (Ra) value of 0.0807 μ m is obtained at the optimum cutting conditions (A3B1C3D3). It is also found that the % ΔR_a obtained (80.28 %) at the optimal levels is higher than the values obtained during L9 experiments.
- iii) It is evident from the AFM and SEM images that the grinding peak marks on the workpiece surfaces are sheared off to nano-meter level by MFAAF process and a new surface texture is generated.

References

- 1. Jain V.K., Magnetic field assisted abrasive based micro-/nano-finishing, Journal of Materials Processing Technology., 2009, 209, 6022–6038.
- 2. Mulik R.S. and Pandey P.M., Magnetic abrasive finishing of hardened AISI 52100 steel, International Journal of Advanced Manufacturing Technology, 2011, 55 (5-8), 501-15.
- 3. Dhirendra K Singh., and Jain, V.K., Experimental investigations into forces acting during a magnetic abrasive finishing process, International Journal of Advanced Manufacturing Technology, 2006, 30, 652-662.
- 4. Dhirendra K Singh, Jain V.K, Raghuram V and Komanduri R., Analysis of surface texture generated by a flexible magnetic abrasive brush, Wear, 2005, 259, 1254-1261.
- Kanish T.C, Kuppan P, Narayanan S, Experimental investigations on magnetic field assisted abrasive micro finishing of austenitic stainless steel 304L, Advanced Materials Research., Vol. 584 (2012), pp 192 – 196.
- 6. Dhirendra K Singh, Jain V.K and Raghuram V., Parametric study of magnetic abrasive finishing process, Journal of material processing technology, 2004, 149, 22-29.
