Characterization and Generation of Machined Surfaces

M. UCHIDATE [1], T. SHIMIZU[2] and A. IWABUCHI[2]

[1]*Research Fellow of the JSPS, Iwate University*
4-3-5 Ueda, Morioka, Iwate 020-8551, JAPAN
[2]*Department of Mechanical Engineering, Iwate University*
4-3-5 Ueda, Morioka, Iwate 020-8551, JAPAN

In this paper, electrical discharge machined (EDM) surfaces machined with various machining parameters are characterized and simulated. Three-dimensional surface topography of EDM surfaces are measured by a stylus instrument. Surface topography is characterized with auto-correlation coefficient and height probability density functions. Then, EDM surfaces are modeled and computer-simulated by using the non-causal 2-D auto-regressive model. Simulation results show that EDM surfaces are characterized well by a few parameters.

Keywords : Electrical Discharge Machining, Surface Topography, Simulation

1. INTRODUCTION

Texturing technique is applied on the cylinder bore surfaces, the disk surfaces of HD drive, etc. to optimize tribological performance. In most cases, the machining parameters of texturing is determined by tribological experiments. Recently, tribo-simulation techniques such as direct simulation are being improved to reflect real situations. Thus, it can be expected that optimum surface topography is designed with aid of the simulation techniques in the future. In that case, it is required that machine operators control surface topography for desired radius of curvature, summit density, void volume for oil-pit etc. In this paper, we attempt to apply a new database technique using some parameters and surface topography model to electrical discharge machined (EDM) surfaces as a first step.

2. EXPERIMENT

A small hole drilling EDM, K1CS-4 (Sodick Co., Ltd), was used for machining. Carbon steel, SKD 11, was machined by copper electrode. Peak current, I_p and pulse duration, τ_p, were controlled as I_p = 17, 35, 47, 53 and τ_p = 6, 12, 18, 24, 30, respectively. Surface topography was measured by a stylus instrument.

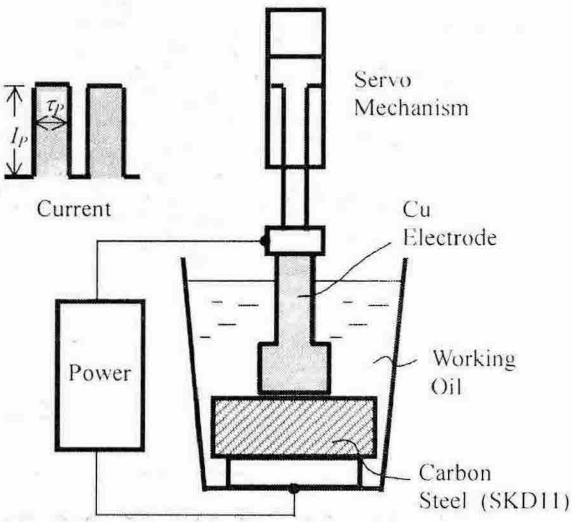
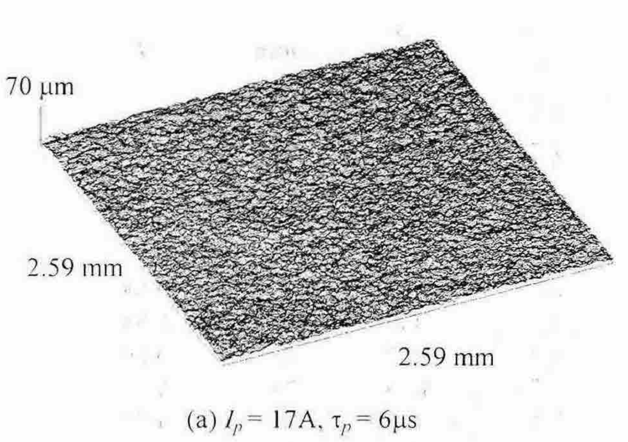
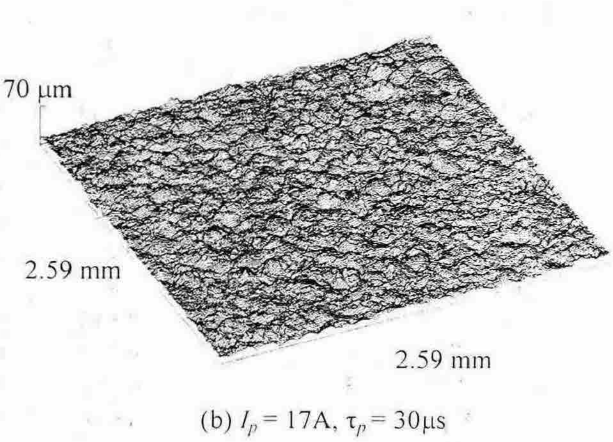


Fig. 1 Electric Discharge Machine



(a) I_p = 17A, τ_p = 6μs



(b) I_p = 17A, τ_p = 30μs

Fig. 2 EDM surfaces

3. RESULTS

Two examples of EDM surfaces measured by the stylus instrument are shown in **Fig.2**. Root mean square deviation, Sq, and correlation distance, β, increased as increasing of I_p and τ_p. The relationship among Sq, I_p and τ_p was expressed as follows.

$$Sq = -9.48\times10^{-4}\tau_p^{\,2} + 4.46\times10^{-4} I_p^{\,2} + 2.86\times10^{-4}\tau_p I_p + 2.14\times10^{-2}\tau_p + 3.87\times10^{-3} I_p + 1.47 \tag{1}$$

And the relationship between β, I_p and τ_p was as follows.

$$\beta = -1.64\times10^{-5}\tau_p^{\,2} + 7.36\times10^{-6} I_p^{\,2} + 1.46\times10^{-5}\tau_p I_p + 8.29\times10^{-4}\tau_p - 2.67\times10^{-4} I_p + 2.50\times10^{-2} \tag{2}$$

The non-causal 2-D AR model which is expressed as following equation is applied [1] based on eqation (1) and eqatiion (2).

$$z_{xy} = \sum\sum_{(i,j)\in D} \phi_{ij} z_{x-\Delta x\cdot i,\, y-\Delta y\cdot j} + a_{xy} \tag{3}$$

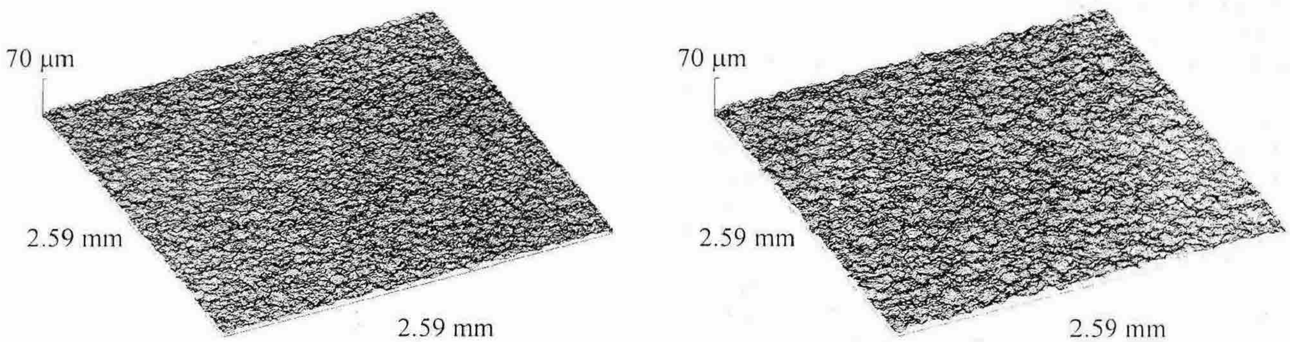
Examples of generated surfaces are shown in **Fig.3** and evaluated parameters are shown in **Table 1**. It can be seen that parameters of EDM and the generated surfaces agree well.

4. CONCLUSION

EDM surfaces were able to be characterized some parameters and surface topography data with the same parameters were generated by using the non-causal 2-D AR model.

5. REFERENCE

[1] Uchidate, U., Shimizu, T. and Iwabuchi, A., "Generation of Three Dimensional Surface Topography Using Non-Causal Two Dimensional AR Model," Int. Tribol. Cof. Nagasaki 2000, pp. 223-228, 2001.



(a) I_p = 17A, τ_p = 6μs (b) I_p = 17A, τ_p = 30μs

Fig. 2 Generated surfaces

Table 1 Evaluation results based on slope and significant summits of surface topography

Machining parameters	Kind of surface (M : EDM surface G : Generated surface)	Mean slope ξ	Mean height hs μm	Standard deviation σs μm	Areal density ηs 1/mm²	Mean nearest distance $d$min μm	Dispersion index q
(a) I_p = 17A,	M	**0.104**	**2.59**	**1.73**	**3.02×10²**	**40**	**0.70**
τ_p = 6μs	G	**0.105**	**2.62**	**1.72**	**2.89×10²**	**41**	**0.71**
(b) I_p = 47A,	M	**0.156**	**4.17**	**3.09**	**2.61×10²**	**42**	**0.68**
τ_p = 6μs	G	**0.158**	**4.05**	**3.08**	**2.48×10²**	**43**	**0.68**
(c) I_p = 17A,	M	**0.112**	**2.87**	**2.36**	**2.34×10²**	**44**	**0.67**
τ_p = 18μs	G	**0.117**	**3.00**	**2.28**	**2.47×10²**	**43**	**0.68**
(d) I_p = 47A,	M	**0.133**	**6.51**	**4.20**	**90.7**	**72**	**0.68**
τ_p = 18μs	G	**0.144**	**6.81**	**4.38**	**88.7**	**73**	**0.69**
(e) I_p = 17A,	M	**0.091**	**4.24**	**2.73**	**86.0**	**75**	**0.70**
τ_p = 30μs	G	**0.090**	**4.19**	**2.46**	**1.01×10²**	**71**	**0.72**
(f) I_p = 47A,	M	**0.155**	**7.96**	**5.30**	**75.6**	**75**	**0.65**
τ_p = 30μs	G	**0.167**	**7.92**	**5.72**	**81.4**	**75**	**0.68**