# A Signal Processing Approach for the Analysis of Mechanism of Surface Generation in EDM

V.S.R.Murti*, P. Laxminarayana* and M. Krishna Reddy**

*Department of Mechanical Engineering
**Department of Statistics
University College of Engineering (Autonomous)
Osmania University, Hyderabad-500 007, AP, INDIA, e-mail: drvsrmurti@yahoo.com
Phone: (O) 040-7018951 Ext: 317, (R) 040-7173006, Fax: 040-7017065

## ABTRACT

For a superior analysis of mechanism of erosion and surface generation in EDM, the surface profile is analysed using a signal analysis technique namely its autocorrelation function. The correlation length thus evaluated and the roughness index Ra have been related to the erosive effect of electrical sparks and the resultant crater dimensions

***Keywords:*** Signal analysis, autocorrelation function, correlation length, sparks, crater dimensions.

## 1 INTRODUCTION

In electro discharge machining (EDM) the surface texture is the result of overlapping craters produced by erosion from randomly located high frequency electrical sparks. The roughness of EDM surfaces thus is a function of the diameter and depth of these spark craters. The conventional index of roughness is its average height (Ra) has the obvious limitation of absence of spatial characteristic of roughness profile. The surface finish analysis instrument produces an output signal which is time dependent corresponding to the surface profile i.e. a function of roughness height versus profile length. Therefore for the analysis of surface roughness a signal analysis approach has been adopted [1]. Auto correlation function (ACF) has been the most popular way of representing spatial information [2]. Treating the ordinates of the roughness profile as a time series its auto covariance function (ACVF), $R(\tau)$ and its normalized from ACF $\rho(\tau)$ have the following form[3].

$$R(\tau) = \underset{L \to \infty}{Lt} \frac{1}{L} \int_0^L Zx \,.Z(x+\tau).dx \qquad (1)$$

and $$\rho(\tau) = \frac{1}{\sigma^2} R(\tau) \qquad (2)$$

Where Z is the ordinate, L is the sample length, $\tau$ is the lag and $\sigma^2$ is the variance.

Electrodischarge machining (EDM) is associated with purely a random surface and the model that fits best the autocorrelogram is

$$\rho(\tau) = \exp.\ \left(-\frac{\tau}{\beta}\right) \qquad (3)$$

where $1/\beta$ is decay rate at origin of the ACF.

The ACF can discriminate between differing spatial structures by its decay properties[4]. The decay rate can also be represented by correlation length, the intercept where the ACF decays to zero and is a measure of average wave length of the signal. Since many of the auto correlograms do not decay to zero, the correlation length of the signal is measured at $\rho(\tau) = 0.1$ or 90 percent confidence limits.

## 2 METHODOLOGY

The steel specimens were machined on an EDM equipment with an iso-frequent pulse generator. The pulse voltage was held constant at 40 V and only the pulse current and frequency were varied as listed in table 1. The roughness profile was recorded on perthometer. Treating the digitized values of roughness ordinates as a time series, its ACF was estimated using the discrete value expression [5]

$$\rho(\tau) = \frac{1}{\sigma^2 (N-r)} . \sum_{i=1}^{N-r} Zi.Z(i+r). \qquad (4)$$

where N = Total number of ordinates and
r = lag number.

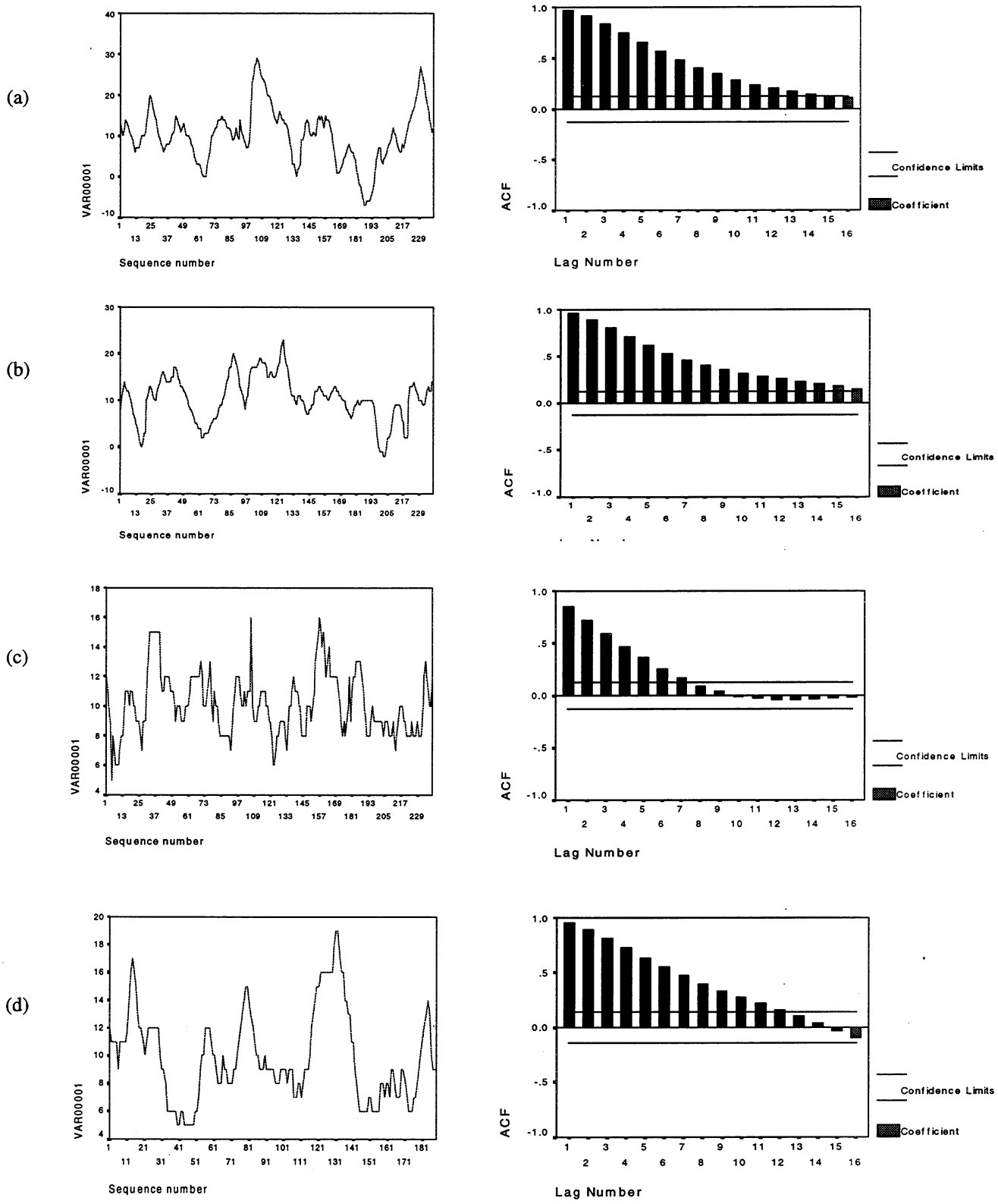


**Fig.1.** The digitized profiles and their auto correlograms (a,b,c,d) corresponding to s.no 1,2,3 and 4 respectively in table 1.



*Computational Nanoscience 2001, (www.cr.org),* ISBN 0-9708275-3-9.

**Table 1.** The roughness and the correlation length of roughness profiles at different pulse parameters.

| S.No. | Process parameters | | Roughness Ra (μm) | correlation length (μm) |
|---|---|---|---|---|
| | Current (Amps.) | Frequency (kHz) | | |
| 1 | 9 | 5 | 6.8 | 140 |
| 2 | 18 | 5 | 8.4 | 160 |
| 3 | 9 | 10 | 5.6 | 70 |
| 4 | 18 | 10 | 7.2 | 120 |

## 3 RESULTS AND DISCUSSION

The digitized roughness profiles and their autocorrelograms are shown in figures (a,b,c,d). The corresponding Ra roughness and correlation lengths are listed in Table 1 along with the process parameters. For the same pulse frequency, an increase in pulse current causes higher roughness and the correlation length. And for the same current, higher the frequency lower is the roughness and lower correlation length. The pulse energy is the product of its voltage, average current and pulse time. An increase in current or reduction of frequency produces corresponding increase in pulse energy which causes the crater size i.e. its diameter and depth to increase. The erosion in EDM occurs by melting and ejection of atomized liquid metal particles from the spot of spark impingement leaving behind a spherical crater. The final surface texture is the cumulative effect of such successive craters. Higher the depth of these craters, higher will be the roughness and larger the diameter, higher will be the correlation length. The former leads to higher Ra and latter to higher wave length. One can thus relate the spark crater diameter and depth to the pulse current and pulse time (reciprocal of pulse frequency). In the cases of constant pulse energy (at s.no.1 and 4 of the Table.1.) the roughness increases from 6.8 to 7.2 μm whereas the correlation length reduces from 140 to 120. This is interesting. Increasing current and reducing pulse time can be considered to have a corresponding effect on crater height and diameter. Or in other words though both pulse current and pulse time increase the size of spark crater the former has a prominent effect of increasing the crater depth whereas the latter increases the crater diameter. Since larger correlation length leads to a better surface texture, it is desirable to reduce the frequency of sparking to improve machining rate as well as surface texture. This is an important result which can be exploited for superior characteristics of machining in EDM.

## 4 CONCLUSIONS

1. The conventional roughness index Ra is indicative of roughness height alone. For analyzing the spatial features the correlation length obtained from auto correlogram is highly suitable for stochastic surfaces of EDM.
2. These studies establish a link between surface texture and pulse parameters in EDM. Higher current and pulse duration result in higher roughness height as well as spacings in the form of increased Ra and correlation length which is a measure of wave length.
3. The effect of pulse current is dominant on crater depth whereas pulse duration effects the crater diameter. Employing higher pulse times leads to better surface texture compared to increased current though both have similar effect on machining rate.

## REFERENCES


1. Connor,R.F.O. and Spedding,T.A. "The use of a complete surface profiles description for investigation of cause and effect of surface features" Int.Jl. Mach.Tools Manufacture V.32, 1992, pp147-154.
2. Peklenik, J. "Investigation of surface topology", Annals of CIRP, v. XV, 1967, pp381-385.
3. Box GEP and Jenkins, G.M., Time Series Analysis, forecasting and Control, Holden-Day, Sanfransico 1970.
4. Chatfield,C. "The analysis of time series" Chapman and Hall, London, 1980.
5. Sayles, R.S."The profiles as a random process" Rough surfaces (ed) J.R.Thomas longman, London, 1982.