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Evaluation of the Tribological Parameters of Three-dimensional Surface Topography with Various Property

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In this paper, the relationship among the 3-D surface topography parameters are studied. Several surface topography parameters that are important in tribology are calculated against various surface topography data. 3-D surface data with desired properties are generated by using the non-causal 2-D auto-regressive (AR) model. The non-causal 2-D AR model is a random 3-D surface topography model that can generate 3-D surface topography data with specified parameters.

Keywords : Surface Topography, Simulation, AR Model

1. INTRODUCTION

Recently, direct simulation techniques such as FFT-method, multilevel summation method etc. have been suggested to understand tribological phenomena and optimize tribo-performance.

Authors have studied random 3-D surface topography model that can generate 3-D surface topography data with desired parameters to investigate effect of surface topography in tribo-simulations.

But the relationship between the specification parameters and other parameters such as radius of curvature, summit density etc. has not shown systematically.

In this paper, some important 3-D surface topography parameters of various surface topography are calculated. Then the relationship among them is discussed.

2. SURFACE TOPOGRAPHY MODEL

Random 3-D surface topography data are generated by using the non-causal 2-D AR model. It has shown that this model can generate 3-D surface topography data with desired properties [1]. The non-causal 2-D AR model against surface height data, $\{z_{xy}\}$, is expressed as follows.

$$z_{xy} = \sum_{(i,j)\in D}\sum \phi_{ij} z_{x-\Delta x\cdot i,\, y-\Delta y\cdot j} + a_{xy} \quad (1)$$

$$D = \{(i,j)\,|\,(1 \le i \le m, j = 0) \cup (-m \le i \le m, 1 \le j \le n)\} \quad (2)$$

Where, $\{\phi_{ij}\}$ is AR parameter which represents the spectral properties of $\{z_{xy}\}$. $\{a_{xy}\}$ is the noise component which is the origin of the randomness of the surface. Δx and Δy are sampling intervals in the x and y direction, respectively. m and n are order of AR in the x and y direction, respectively. The schematic diagram of the non-causal AR model is shown in **Fig. 1**.

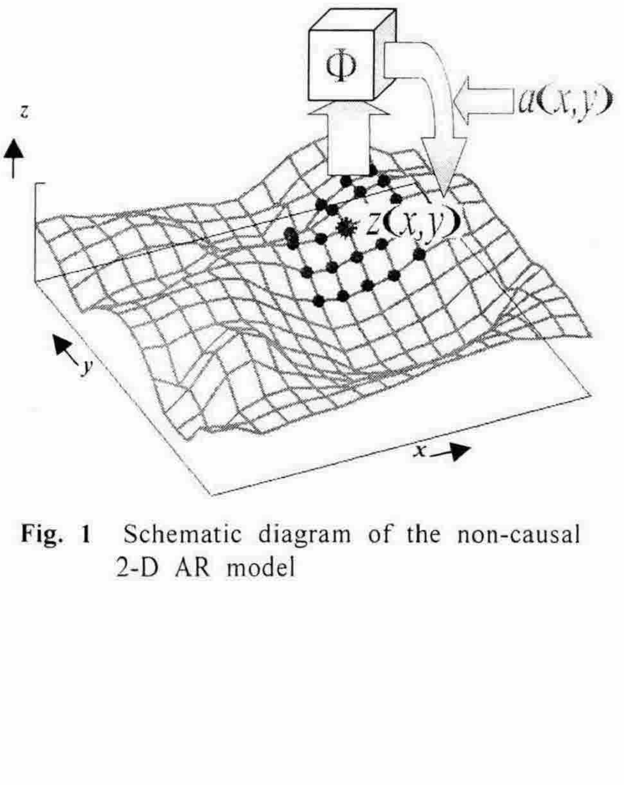

Fig. 1 Schematic diagram of the non-causal 2-D AR model

Specification parameters to generate 3-D surface topography data are shown in **Table 1**. βx, βy and w are parameters of auto-correlation coefficient which is expressed as follows.

$$C(\tau_x, \tau_y) = \exp\left[-\left\{(\tau_x/\beta_x)^2 + (\tau_y/\beta_y)^2\right\}^w\right] \quad (3)$$

Where, τx and τy are the lags in the x and y direction, respectively. Correlation distances is the measure the distance among summits and valley. Power index is a parameter which

Table 1 Specification parameters for 3-D surface topography generation

ACC	βx	Correlation distance (x)
	βx	Correlation distance (y)
	w	Power index
HPDF	Sq	Root mean square deviation
	Ssk	Skewness
	Sku	Kurtosis

is related with mixture of short period component and long period component. In the case of isotropic surface, $\beta x = \beta y$ ($= \beta$). The parameters of height distribution are root mean square deviation (=Sq), skewness (=Ssk) and kurtosis (=Sku). In the case of normal (Gaussian) distributed surfaces, Ssk = 0 and Sku = 3.

3. RESULT

Examples 3-D surface topography generated by using the method described above are shown in **Fig. 2**. Specification parameters are $\beta x = \beta y = 2, 4, 6, 10\Delta(\Delta = \Delta x = \Delta y)$, $w = 0.9$, Sq = 1, Ssk = 0 and Sku = 3. It can be seen that the method using the non-causal 2-D AR model is able to be generate various 3-D surface topography with different parameters.

Probability distribution functions of the radius of curvature of some sets of generated surface topography are shown in **Fig. 3**. The distributions shift toward larger radius and become flat with increasing of τ.

The relationship between τ and normalized summit count plotted on log-scale graph is shown in **Fig. 4**. Where, normalized summit count was calculated as the total summit count divided by the data number. The graph shows that summit count decrease logarithmically with increasing of τ.

4. 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.

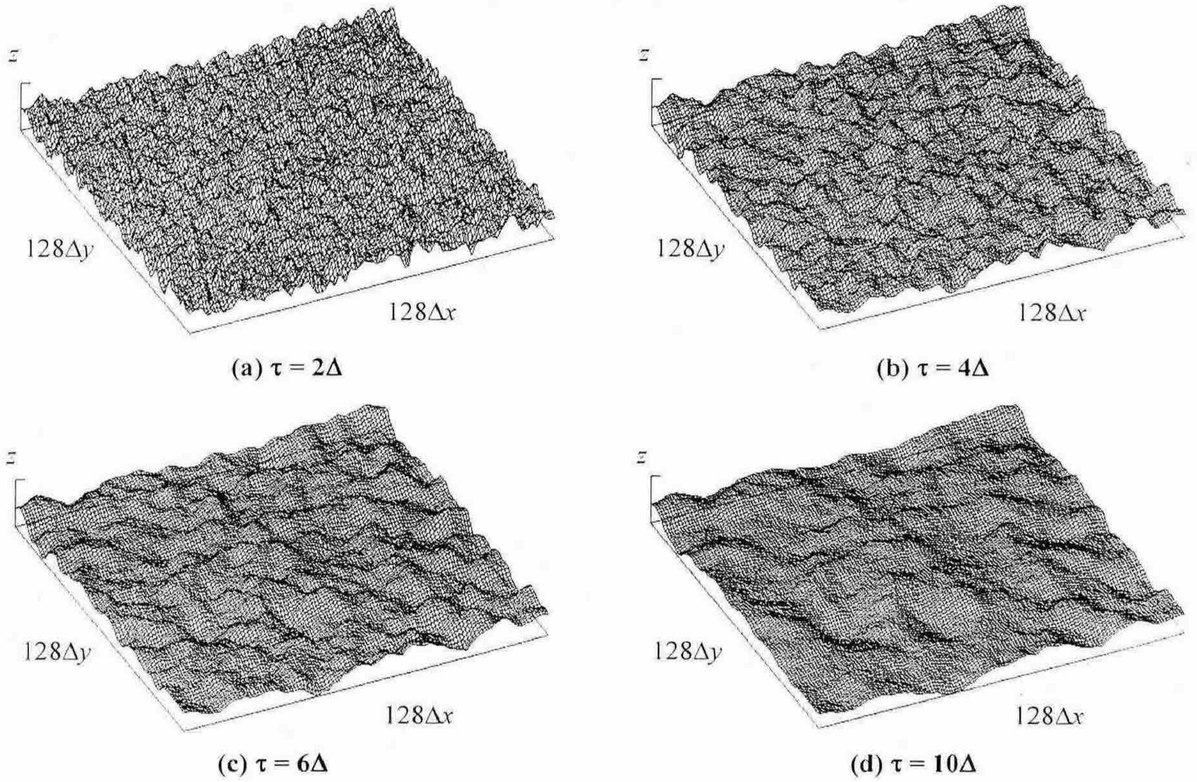

Fig. 2 Examples of generated surface topography

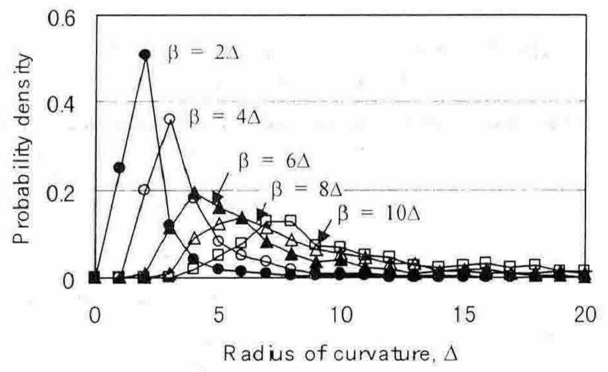

Fig. 3 Probability density functions of radius of curvature of the generated surfaces

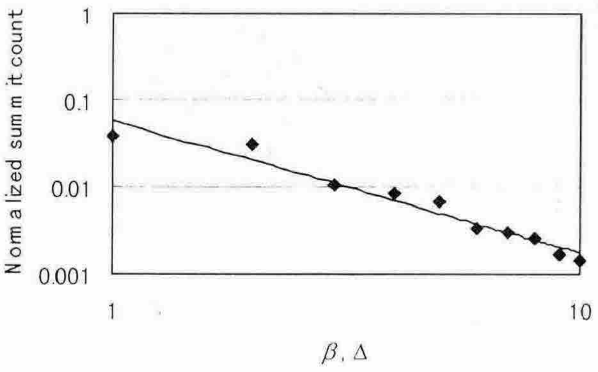

Fig. 4 Relationship between the correlation distance and the normalized peak count