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Fractal Structures as Possible Abstractions of the Size and Site-distribution Approximants of Interphase Boundaries Configurations on the Surface of Composites

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Annotation *– The opportunity of the fractal structures presentations as a possible abstractions of the size and site-distributions of phases and a possible approximants of the interphase borders configurations onto surface of the compositional coatings was discussed. Some fractal structures can be used when interpreting the probable mechanism of surface formation of the anti-frictional coating and the dynamics of its changes in the process of friction and wear.*

In accordance with the concept of synergy of the properties of solid phases and lubricating component of the composite coatings (CC) the model which takes into account the influence of chemical and phase composition, microstructure characteristics of solid phase components coating and the configuration and characteristics of interphase boundaries on tribological properties of surfaces was developed (1-3). Qwazi-crystal structure in 2D space in these works are regarded as a possible approximants of the size-distribution of ultrafine particle phases and a possible abstractions of the configurations of interphase boundaries at the surface of antifrictional CC (4).

Synergetic model for tribological surface property P of homogeneous CC is based on while taking into account the nano-structural parameter k_N and the $k_{g,S}$, characterizing the qwazi-fractal character of the configuration of interphase boundaries (2): $P = \alpha P_{sol} + (1 - \alpha) P_{lub} + \delta_P (P_{sol} - P_{lub})$, were the relative value of the synergic effect is $\delta_P = 2(1 - \alpha) \alpha^2 [1 + k_N + \alpha k_{g,S})]$, the α is denotes the volumetric fraction of the phases of CC solid component.

For different CC the fact that amount of parameters ($k_N + \alpha k_{g,S}$) can be set in the range from 0.03 to 0.08 and characterizes the volumetric fraction of nanoparticles (or micro-particles) of the solid phases in the friction zone was established (4-10). Some features of the configuration of interphase boundaries are taken into account by a parameter $k_{g,S}$ allowing considered solid phases in the border zone as a conditional lubricant. Both parameters are describe the formal reduction of the concentration of the solid phase CC components.

In the case of substantial deviations of the borders interphase configuration from smooth everywhere differentiable curved surface can be considered its as a fractal. The cross-section of micro-particles with such surface - confined fractal lines, which can be approximated by fractals with different generators (11-19).

Fractal structures based on triangular generators Kokh by homologue series K(2(n+1)/(n+2)) and K(2(3n-1)/3n), rectangular generators by series K((n+4)/(n+2)) and K((4n +1)/(2n +1)), generators-meanders of series K((6n +2)/(2n +2)) and ((10n-2)/(2n +2)) and two species of meander-like generators of series K(6n/2n), where n = 1, 2, 3 ... ∞, have been analysed. On some trigonal or tetragonal two-color Kepler-Shubnikov nets using the method of iterative modular design the deterministic fractal structures with different diagnostic lakunar spectral characteristics were obtained (4 – 6). Spectral characteristics of the apparent deterministic hybrid fractals - complex fractal structures with two or more point or linear generators into 2D space were analyzed, too.

In general, the dimension of fractal structures Dim F can be determined from the ratio of $\mathrm{Dim}\, F = d + \ln(1 \pm k\Delta)$, where d is the topological dimension of the fractal, Δ - relative deviation of topological dimension d of the lacunar fractal element from its topological dimension, $\Delta = |(d-d')/d|$; k - share of this deviation from the maximum possible value. Depending on the dimensionality of space in which formed the fractal with certain genetic charakteristik ({(d-1)+} or {d-}) the parameter k will take definite values. For example:

1D space: for I(n/(n+m)){0+} and C(n/(n+2m)){1-} kinds of fractal structures the parameter k = 1.

2D space: for $MF_{K(1/l)}${Pg}{1+} and $F_{N\{Pg\},i,k}${2-} kinds of fractal structures the parameter k = 1 or 1/2.

3D space: for $MF_{K(1/l)}${Ph}{1+} and $F_{N\{Ph\},i,k}${2-} kinds of fractal structures the parameter k = 1, 2/3 or 1/3.

Fractals of the 2D space can be considered as a possible approximants of the configurations of interphase boundaries and the side-distribution of phases onto surface of antifrictional CC during their formation and subsequent friction and wear. To identify structures with required characteristics (fractal dimension D, as lacunar size-and site-distributions, etc.) it is necessary the next four steps:

1) experimentally identify the main micro-structural characteristics of micro-particles of all phases (size-distribution and site-distribution onto surface);
2) to construct a set of appropriate fractal structures, formally satisfying to the above characteristics, using the next diagram "fractal dimension – parameter of the lakunar element";
3) to determine the most probable fractal structures of the resulting set in accordance with the selection criteria;
4) to calculate level manifestations of tribological properties of CC taking into account the characteristics of those structures and based on comparative analysis with the corresponding experimental values identify the most probable fractal structure.
Thus, the identified a fractal structure can be used when interpreting the probable mechanism of surface formation of CC and the dynamics of its changes in the process of friction and wear.
It is necessary to note, the global principles of the possible structural states formation from fractal components, taking into account the semi-group properties of the multitude of corresponding generators were formulated in (12). All spatial components of the all possible structural states of deterministic modular structures of composite materials with nano-dimensional component into 3D space, in particular (fff), (rff), (ffn), (rrf), (fnn) and (rfn) classes were described (13-19). The possible states of the distribution of the modular structure of crystalline, nano-dimension and fractal objects onto surface and into volume of anti-frictional composite coatings and options for the nature of their site and size-distributions were described (20-23).

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