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SIMULATION OF REAL CROSS-SECTIONS OF PARTICLE POPULATION

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ABSTRACT

Effective use of a model of structure discretized by means of the finite element method for estimation and description of linear characteristic of materials, requires genarating plane cross-sections of structure with the possibility to control stereological parameters. In this work an outline for procedure of computer simulation of cross-section of structure containing particles of the second phase is presented.

Keywords: simulation of structure, plane cross-sections

INTRODUCTION

Modelling the size and shape of cross-sections of matrix grains or a structural component, specially for estimating nonhomogeneity of material has been discussed by Adrian et al. (1983), and Malinski et al. (1983). The methods modelling the second phase are characterized by special selection of dissecting planes (Adrian et al. 1983). However, the method of generating the second phase particles, described by Jeziorski et al. (1987) may be used if the analytical form of a function describing the particle surface is known. The lack of such data leads to excessive simplifications resulting from assuming the known equations of surfaces (sphere, ellipsoid, etc).

The purpose of this study is to formulate a model of flat section of structure containing a second phase particles by determining a function modifying the shape of sections obtained in the result of dissecting spheres, randomly distributed in space, by an arbitrary plane (Jeziorski et al. 1987).

THE FUNCTION OF CROSS-SECTION SHAPE

The concept of this analysis is to adapt the method described by Wittmann et al. (1985) for determining the function correcting the cross-section shape, obtained on the basis of experimental data, from an exemplary population of cementite particles considering a random factor. The principle of this method is founded on measuring the cross-section radius length in the tested population of particles versus orientation angle θ (Fig 1). The origin of local coordinates connected with i-th cross-section coresponds with its grawity centre.

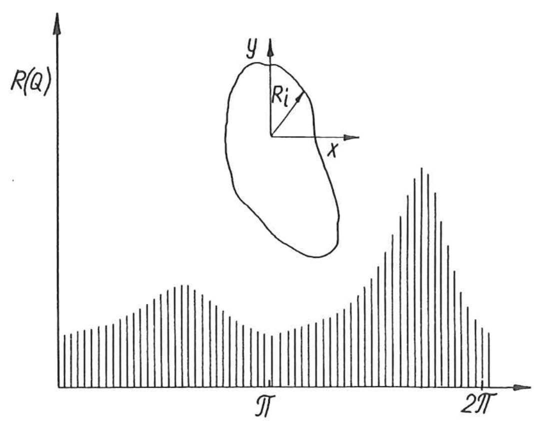

Fig. 1. Change of cross-section contour into function in polar coordinates.

In order to determine a function correcting the length of R, resulting from the method of dissecting spheres, the transformation of results founded on subtracting the value of radius of a circle described in cross-section Rw and dividing the difference obtained by R_W has been applied. The values $(R-R_W)/R_W$ are presented graphically in Fig. 2.

On the basis of the results presented in this figure it has been observed that the following function:

$$\frac{\Delta R(\theta)}{R_W} = \begin{cases} \dfrac{A_1 \sin(\theta)}{(1+B_1) - \sin(\theta+C_1)} & 0 \le \theta < \Pi \\[2ex] -\dfrac{A_2 \sin(\theta)}{(1+B_2) + \sin(\theta+C_2)} & \Pi \le \theta < 2\Pi \end{cases} \qquad (1)$$

is a good approximation of experimental points. One should expect that the numerical values of coefficients A_i, B_i, C_i $i=1,2,$ being constant for k-th cross-section and containing information on the second phase morphology, appear with a certain frequency depending on the phase type and its history. Some exemplary values of these coefficients are shown in table 1.

Table 1. Morphological parameters of cross-sections from tests on cementite particles population.

Lp	A_1	B_1	$C_1*\Pi$	A_2	B_2	$C_2*\Pi$
1	0.20	0.15	0.40	0.25	0.25	0.25
2	0.35	0.70	0.10	0.24	0.35	0.20
3	0.60	0.55	0.10	0.20	0.20	-0.05
4	0.15	0.30	-0.10	0.60	1.60	-0.10
5	0.10	0.20	0.05	0.50	1.30	0.10
6	0.14	0.18	-0.05	0.25	1.00	0.10
7	0.12	0.15	0.05	0.50	0.50	-0.50
8	0.08	0.10	-0.05	0.07	0.10	0.15
9	0.09	0.35	0.22	0.31	0.84	0.17
10	0.41	0.66	0.04	0.16	0.48	0.09

In Fig. 3 the empirical frequency distribution for the appearance of certain values of constants from Eq. (1) is shown. The results presented in Fig. 3, have been used for determining the parameters of random number generator. Some exemplary cross-sections generated by the programme are shown in Fig. 4. The fundamental stereological indices concerning the second phase particles are input parameters for the simulating programme.

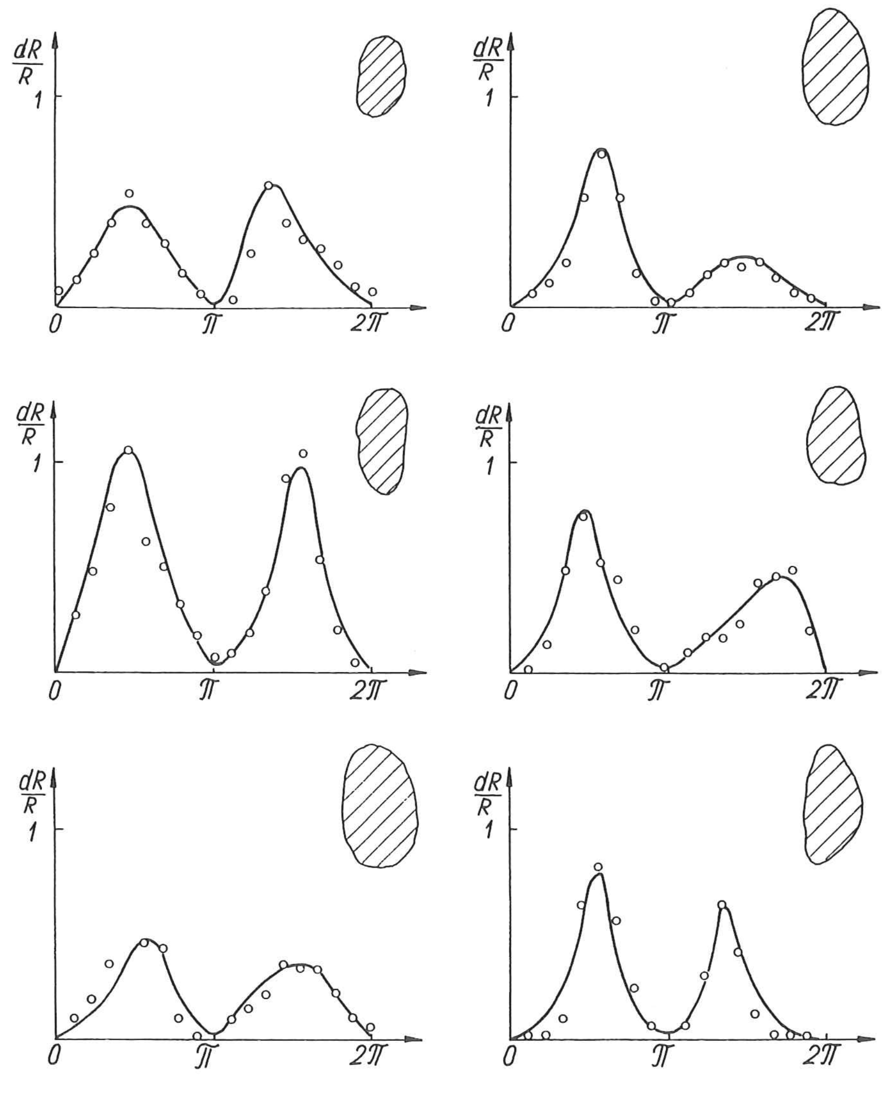

Fig. 2. Empirical values of $\Delta R/R_w$, approximating curves and simulated shape of cross-section.

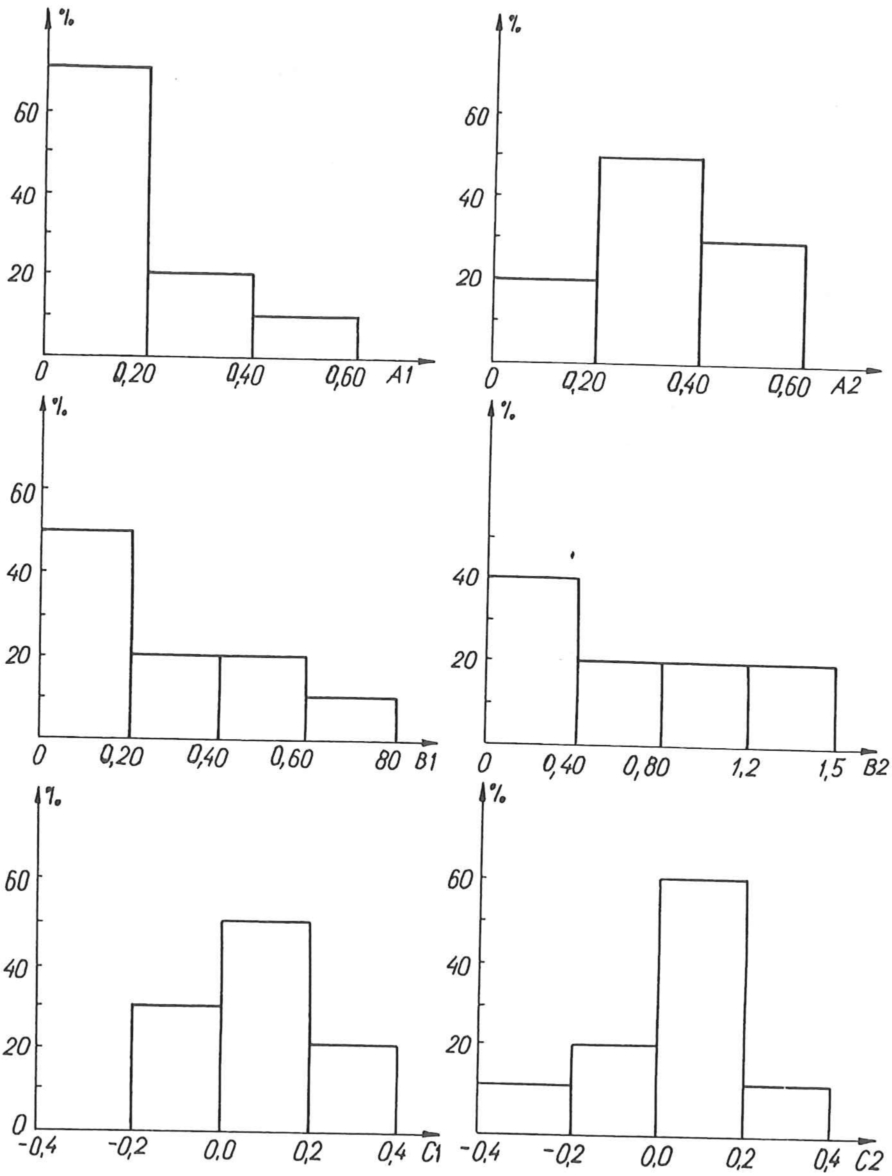

Fig. 3. Frequency distributions of constants A_i, B_i, C_i, i=1,2, in equation (1).

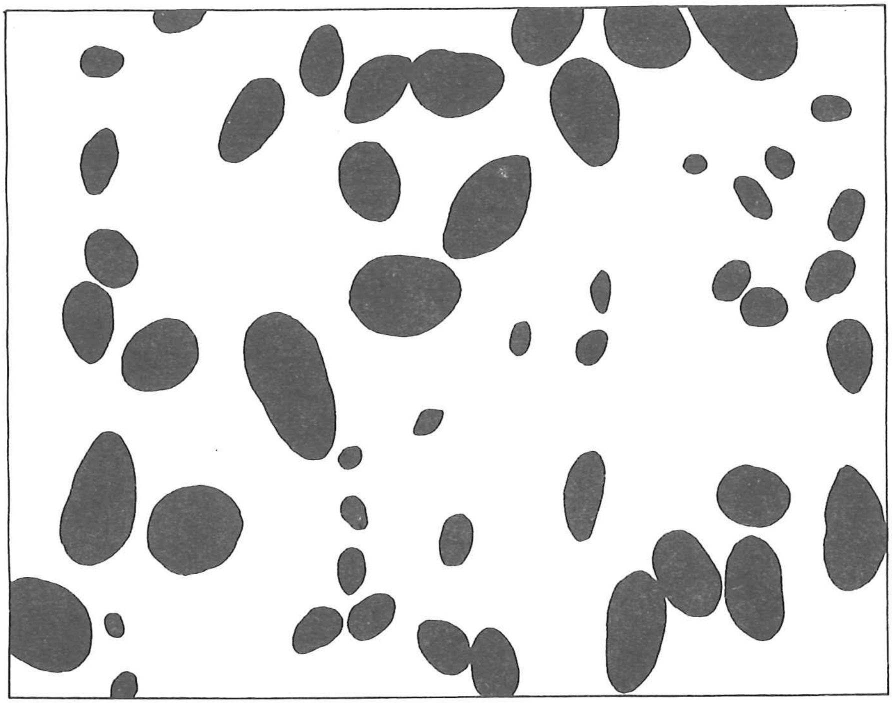

Fig. 4. Generated cross-section of phase.

CONCLUSIONS

The quantitative agreement between stereological parameters of the tested cementite particles population and population obtained from computer simulation has been obtained. To simulate cross-sections of any phases the measurements of cross-section radius necessary for calculation of coefficients of A_i, B_i, C_i (i=1,2) in Eq.(1) are required. However, the criterion for the minimum number of measurements satisfying the adequancy of the derived equation has not been determined.

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