# NEW TRENDS IN BEHAVIOR INVESTIGATION OF HANDLED PARTICULATE MATERIALS

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*Summary: A behavior investigation of particulate materials plays an important role by the behavior prediction of particulate materials with their transport, handling and storage. This properties, their prediction followed processing is a highlight to ensure a free-flowability of this particulate materials in transport systems. Property investigations, e. i. particle morphology, creation of a surface patterns focus with a perfect estimation of a dependence of this properties on important aspects ensuring a permanent and continual material flow in transport systems no matter with material structures.*

*Key words: Particulate materials, morphology, surface patterns*

## 1. INTRODUCTION

Usually, the process of transport, handling and storage of a powder on a vibrating system is developed with a notable effect of creating harmonic patterns. The harmonic patterns are characterized by a very unstable structure called "cannibalizing" [1] by which one cell is changed to another cell and a scut of the cell is trenched on another cell. Definitely, it is almost impossible to say that the phenomenon is desirable or not in the powder processing.

The utilization of the phenomenon is to self-organizing of particulate structures and their mathematical description for understanding of a particulate material behavior. The used theory to powder structure description is Fractal theory and need to say, that the structure can be theoretically found both large particles (micro scale) and small particles (nano and sub micro scale) for the powder consisting nano particles in its size distribution.

## 2. HARMONIC PATTERNS OF POWDERS

### 2.1 Harmonic Patterns versus Fractals

The created structure is mathematical similar to fractal: term often used for an element that by the measure change shows signs as its enlargement exposure. So it is possible to say, that Fractal theory is applicable for powders considering a certain input conditions, e.g. oscillation frequency, mechanical-physical properties, morphology, size distribution, etc. The theory can be used for mathematical modeling of a surface structure of a powder very closed to observed structure by harmonic vibration (Fig. 1).

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Source: [1]

Fig.1 - Surface harmonic patterns of a powder by a vibration transport

Using artificial intelligence (AI) considering a input and output conditions it is possible to create an interactive mathematical model of a powder structure caring signs itself very close to a structure created by the vibration transport of a powder. The mathematical description is developed using a computational procedure for Julian [4] and Mandelbrot mathematical set [5]. Even that the structure looks very difficult to description, the mathematical description for the structure description is very elemental. An element base for the Julian set [4] creation as well as Mandelbrot [5] is Fractal geometry equation [4] derived as

$$z_{n+1} = z_n^2 + C \tag{2.1}$$

where

C is a complex constant,

$z_n$ is a point of the complex plane,

then

$$z_1 = z_0^2 + C \tag{2.2}$$

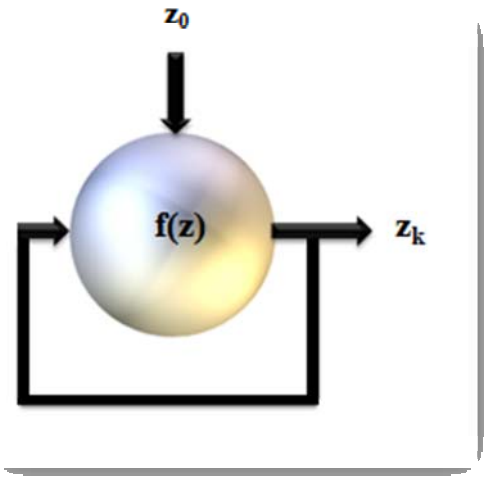
$$z_2 = z_1^2 + C$$

$$z_2 = \left(z_0^2 + C\right)^2 + C$$

$$z_3 = z_2^2 + C$$

$$z_3 = \left(z_1^2 + C\right)^2 + C$$

$$z_3 = \left[\left(z_0^2 + C\right)^2 + C\right]^2 + C$$



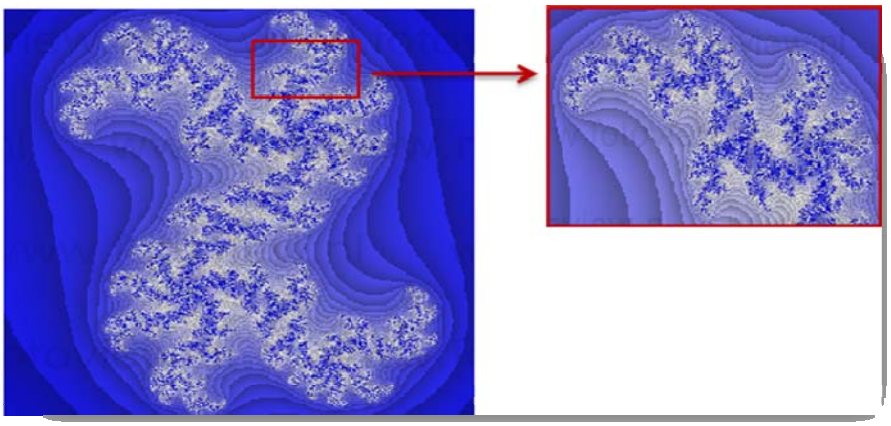

Source: [2]

Fig.2 - Iteration calculation of the point laying in the Julian set

Equation (2.1) covers all real numbers and more complex operator derived as:

$$i^2 = -1 \qquad (2.3)$$

For the mathematical explanation and description is necessary to know if the equation is divergent or convergent by initial conditions $z_0$ (a fix point) and constant C (an arbitrary constant). Taking account of the above-mentioned fact, it is possible to generate a structure having specific similarity properties. It means, that the structure is characterized by a similar shape by its magnification as the initial system (Fig. 2). There is strong analogue between powder/bulk solid and Fractal. Using mathematical software it is possible to derive needed shape of powder structure creating by a vibration transport in a specific range. The mathematical model is a similar to needed structure of a powder (Fig. 3).



Source: [3]

Fig.3 - Surface harmonic patterns modeled using an artificial intelligence for C =0,4-0,2i

## 3. CONCLUSIONS

Generally speaking, the created surface structures of powder by a vibration transport are possible to describe using fractal theory. That is the way to understanding and studying of creation of surface structures to application to industry.

Surface harmonic patterns can be very precisely craft with artificial intelligence using the known relation (2.1). Due to change in the appropriate parameters, we get a wide range of fractal-like real surface structures, as can be seen in (Fig.3).

The study of this issue can lead to a complete elimination of negative effects (aspects) due to the formation of surface structures of powdery materials, particularly for transport vibration, thus streamlining the process in the transport, handling and storage process.

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