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DEVELOPMENT IN MACHINING TECHNOLOGY

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This study aims to provide the recent advances in machining for modern manufacturing engineering, especially CNC machining, modern tools and machining of difficult-to-cut materials, optimization of machining processes, application of measurement techniques in manufacturing, modeling and computer simulation of cutting processes and physical phenomena.

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PREFACE

Machining is one of the most popular technique to change shape and dimensions of the objects. Machining operations can be applied to work metallic and non-metallic materials such as ceramics, composites, polymers, wood.

Cutting tools have been used since ancient times to remove excess material from forgings and castings. Nowadays, metal cutting became one of the primary manufacturing processes for finishing operations. In the last few years we have observed a rapid development in automation of manufacturing processes, especially in automatic control systems. Progress in cutting stimulates a significant increase in the metal removal rate and achieving high accuracy in terms of dimensions and shape of machine parts. New materials, which play the key role here, are used to produce cutting tools.

To meet today's high demands concerning accuracy and efficiency of the manufacturing process of machine parts, it is necessary to use computer methods for designing of technological processes.

This study aims to provide the recent advances in machining for modern manufacturing engineering, especially CNC machining, modern tools and machining of difficult-to-cut materials, optimization of machining processes, application of measurement techniques in manufacturing, modeling and computer simulation of cutting processes and physical phenomena.

Wojciech Zębala

PART 3

Non Traditional Machining

Chapter 3.1

FRACTAL ANALYSIS OF THE STRUCTURE OF GEOMETRICAL SURFACE AFTER EDM

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Cracow University of Technology, Poland

Abstract: *The intensive development of advanced technologies show the essential influence of the structure of geometrical surfaces (SGP) on usable values of elements. The parametral opinion of surface in result to use of computer aided of analysis surface in three-dimensional arrangement (3D) can be inference about state this surface, the prognoses the propriety of exploational articles as well as to serve of optimization of cutting parameters. The opinion of row of additional parameters the structure of geometrical surfaces (SGP) is possible it is to serve of utilization the technique of computer aided of analysis painting as well as size what "fractal dimension".*

Keywords*: 3D analysis, structure of geometrical surfaces (SGP), fractal analysis*

1. Introduction

Term "fractal " come from Latin '*fractus*', which means - "broken," "partial ". It marks object, whose parts are similar to the whole object (object self similar). Mathematicians define "fractal", as a set which possesses non-trivial structure in every scale. This set is self similar, what makes describing it in language of traditional Euclid's geometry difficult, if not in exact than in stochastic or approximate sense. Example of two-dimensional "fractal" according to [1] is represented by (Fig. 1)

a) b)

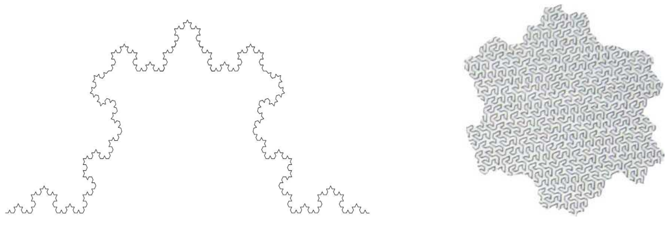

Fig. 1. Examples of two-dimensional “fractal” [1]. a) Koch’s curves, b) Gosper’s curves

Function Weierstrassa - Mandelbrota is the most popular description of surface or profile. It is expressed by the following fomula(1):

$$z(x) = G^{D-1} \sum_{n=n_1}^{\infty} \frac{\cos(\gamma^n x + \phi_n)}{\gamma^{(2-D)n}} \tag{1}$$

where: ϕ_n - random phase,

γ - coefficient of scale.

Round applying of “fractal” many controversies have grown, however tests are lasting till now [7]. First of all, one question should be asked: is it possible to use application of “fractal on every surface? It the aim of description of breakthroughs or different free or internal surfaces the fractal methods are used. They allow in many cases on distinction of the breakthroughs with different morphology, but they have to possess the same value of parameter R_L(Fig. 2). The processes of cracking in microscopic scale possess the accidental character, which is particularly useful in application of fractal analysis [2]. In literature there are also notes about the fractal description of surface after EDM, gridding and also the waste [1].

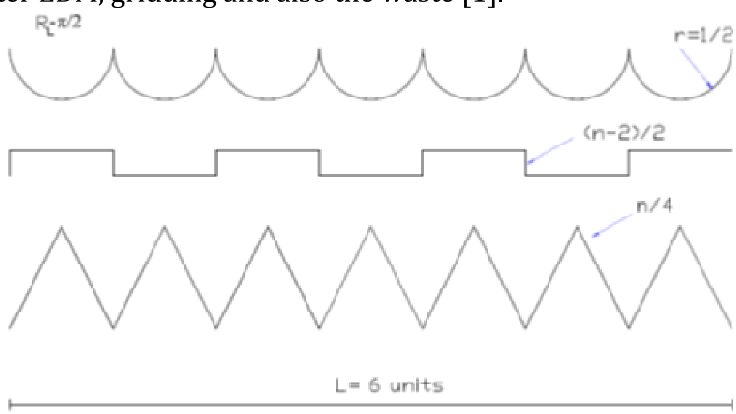

Fig. 2. Model profiles with equal coefficients R_L [1]

According to authors [2,5] “fractal” can be divided into two groups:

- non-stochastic (not accidental),
- stochastic (accidental).

Not stochastic “fraktal” belong to mathematical objects, formed by next iterations. Example of this type of formation of the “fractal” is the Sierpiński’s triangle (Fig. 3).

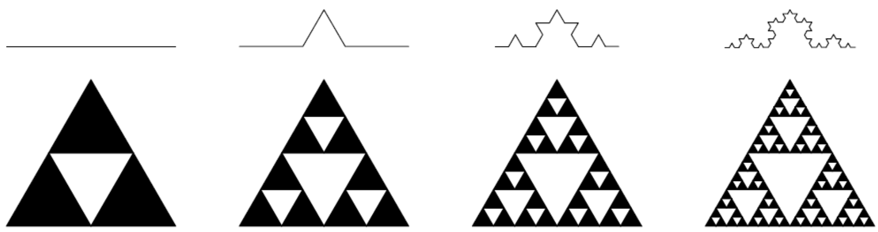

Fig. 3. Non-stochastic “fraktal” in Sierpiński’s triangle

In the second case, stochastic objects (accidental), which are not “fractal” often appear in the nature. They possess some characteristics, as (thickness), which diminishes in wide range linearly together with increasing, if we will show it on doubly logarithmic graph.

The basic technique of delimitation of dimension is the construction of the doubly logarithmic graph, dependence of length of line of profile from increase of (the resolution) or the size of measuring step. It represents the equation (2) of the straight line with negative direction coefficient the *c*.

$$\log[L(x)] = c\ \log x + b \tag{2}$$

where: *L(x)* – length of profile dependent from size of measuring step x,

c – direction coefficient of straight line connected with fractal dimension D.

Author [2,5] quotes several methods of delimitation of length of line of profile. The method of bowstrings is one of them (stepper, Divider Method or Commpass Method) - profile is replaced by bowstrings with solid length. Initial and final points should be identical for different measuring steps (Fig. 4,5).

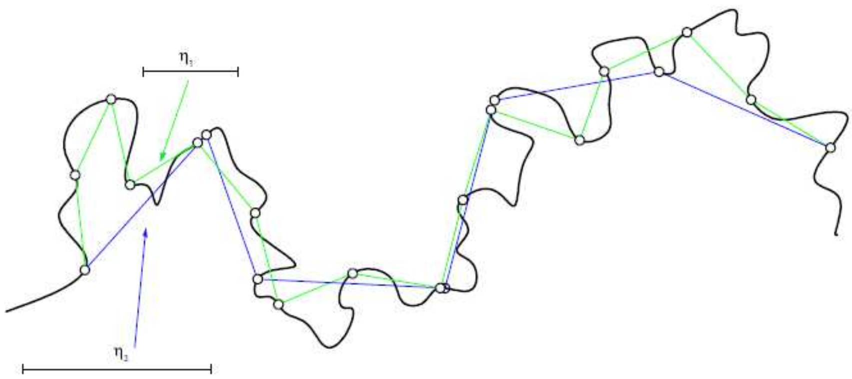

Fig. 4. The interpretation of curve by using a broken line with different lengths of measuring step η [5]; *b* - the scale factor = 2μm, η - broken lines of different lengths measuring step

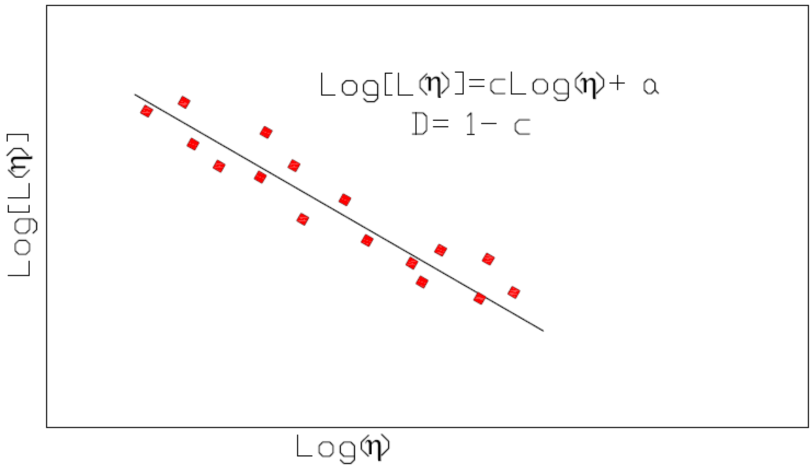

Fig. 5. The delimitation of the fractal dimension by the method of bowstrings [2]

Different method of measurement of length of the line – is done by putting the square meshes with different lengths of side (*Box - Counting Method*). In this way the pictured function on graph represents the number of squares (the size of square mesh) cut by profile of breakthrough (Fig. 6).

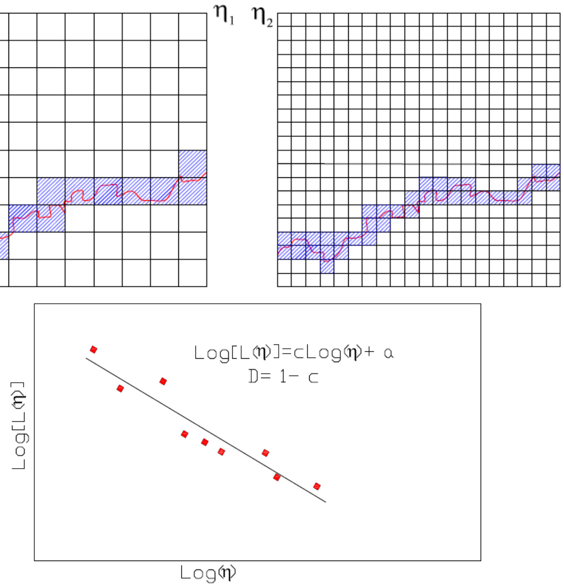

Fig. 6. Delimitation fractal dimension method *Box – Counting* [2]

2. The computer analysis of an image of Structure of Geometrical Surface (SGP)

To delimitation of fractal dimension of structure of geometrical surface (SGP) the computer techniques of computer analysis of an image are used[6]. The computer analysis – it is the process of processing of information, where the picture is the entrance data and outputs have different forms (the numbers, board of numbers, decision, text, etc.)

The processing of image – it is the process of processing of information, where the data are the entrance information and also outputs in figure of image.

Computer systems, which serve to this aim, have considerable superiority over man with regard to: the speed of analysis, resistance on fatigue. Because of it such systems according to [2] found wide use inter alia in:

- science about materials(the opinion of size of grains),
- medicine (the analysis of image from CAT scanner),
- criminology (comparison of finger prints),
- remote sensing (satellite and air images),
- control of quality,
- automatic sorting correspondence and others.

Filters

Filters serve to cleaning of the signal from different kinds of hums, accidental disruptions developed in studied timing. Filtration usually is done by removal of values, which are too large or too small. The idea of process of filtration according to [2] be introduced on (Fig. 7).

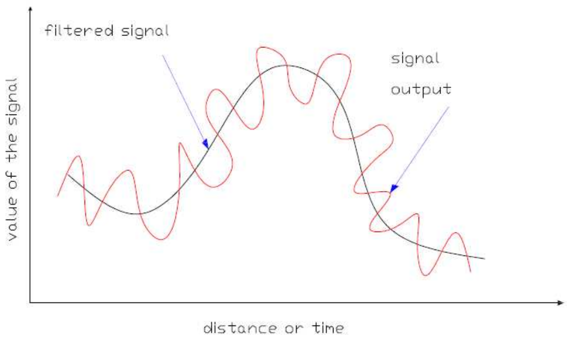

Fig. 7. Idea of process of filtration [2]

3D Analysis of spatial image

By 3D analysis it is possible to receive precise information about size, shape and spatial position in analysed object [6]. Thanks to this type of investigations we get true shapes and distribution in spaces of studied material (Fig. 8)

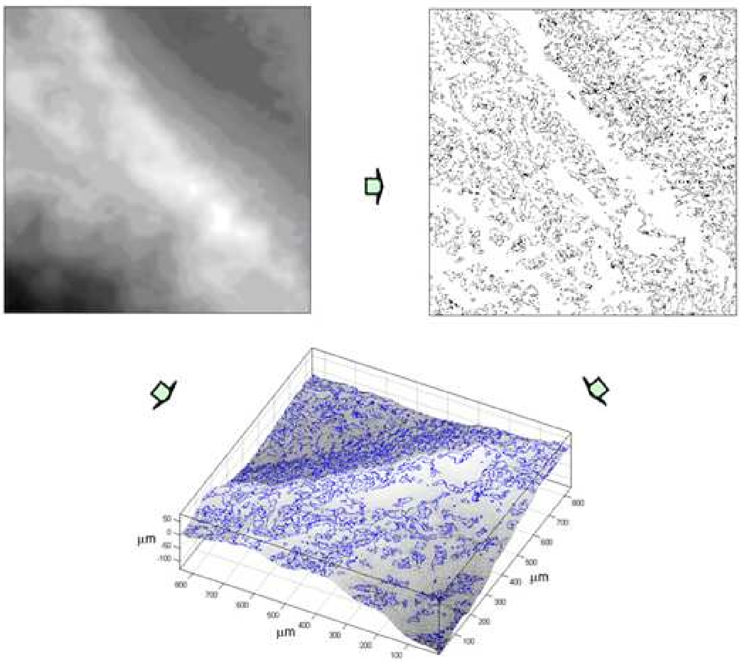

Fig. 8. 3D image of size grains

Aphelion (Fig. 9) it is advanced platform, which serves to processing of image.

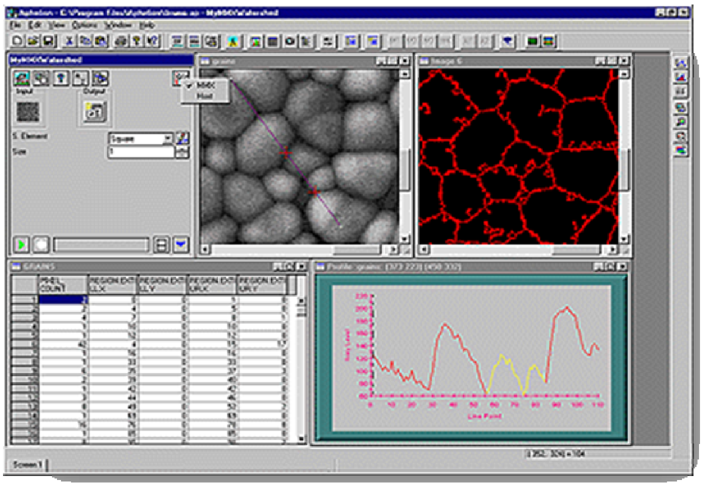

Fig. 9. The panel of Aphelion programme

The Aphelion is the software to processing of image and quantitative analysis, which serves to quick prototyping of application as well as development of new techniques of illustrating. Images analysed in Aphelion can be binary, grey, or colourful.

Delimitation of fractal dimension by Box - Counting method

The basic technique of delimitation of dimension is the construction the doubly logarithmic graph, dependence of length of line profile from increase of (the resolution) or the size of measuring step. This analysis was introduced in form of graphs (Fig. 10 - 16). For basis of delimitation of fractal dimension measuring step even size 2 μ m was accepted.

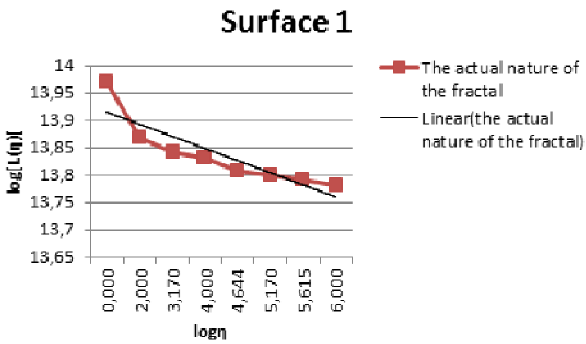

Fig.10. Fractal dimension on surface 1

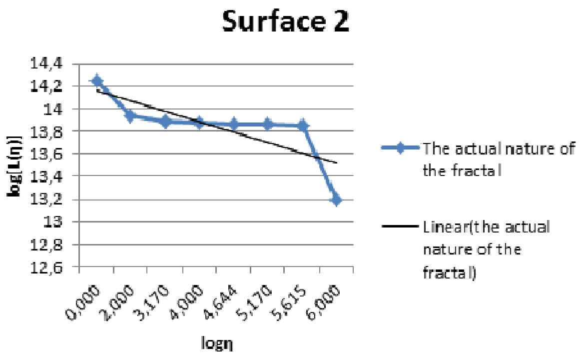

Fig.11. Fractal dimension on surface 2

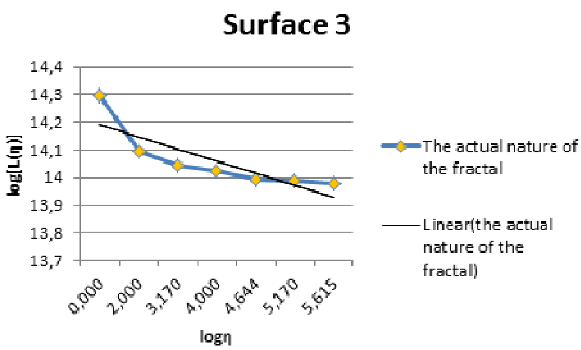

Fig.12. Fractal dimension on surface 3

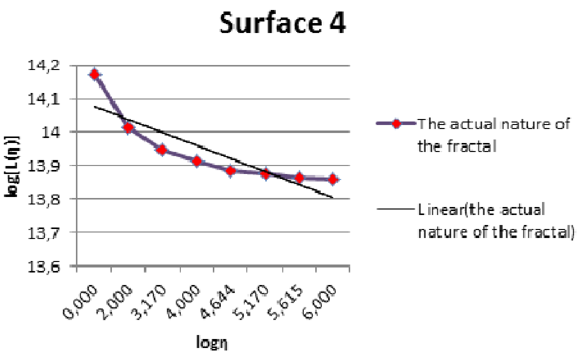

Fig.13. Fractal dimension on surface 4

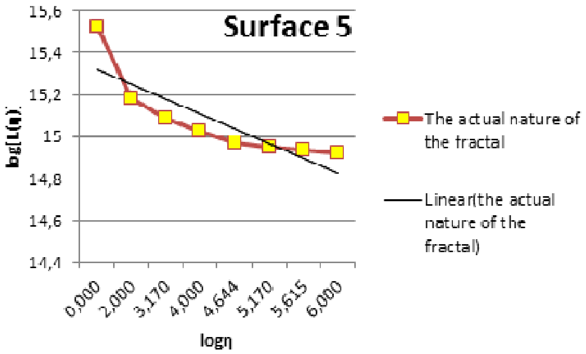

Fig.14. Fractal dimension on surface 5

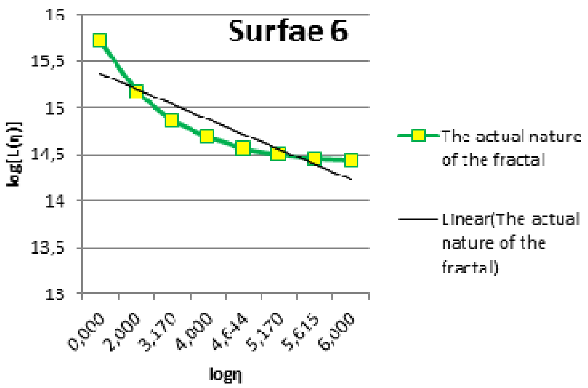

Fig.15. Fractal dimension on surface 6

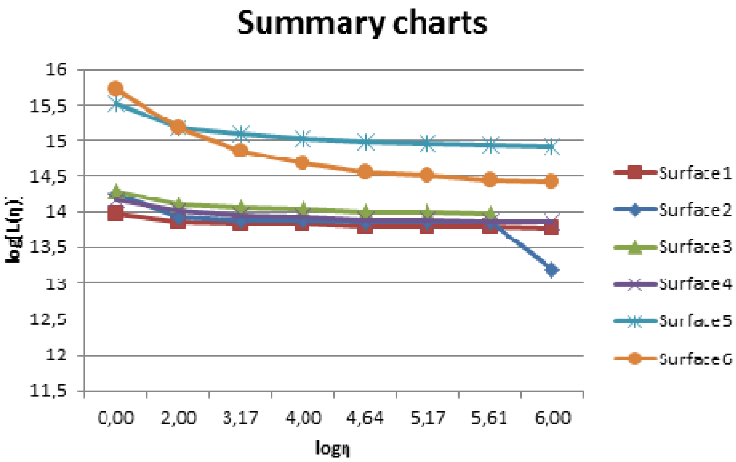

Fig. 16. Fractal dimension of six studied surfaces

Each surface has been subjected to various processing parameters (Table 1).

Table 1. Values of processing parameters

Nr.	*Iz* [A]	*Ir* [A]	Impulse time *Ti* [µs]	Pause time *To* [µs]	Reference voltage *Uz* [V]
1	3	1	29	10	65
2	3	5	160	16	50
3	3	9	290	29	42
4	3	15	600	29	32
5	3	25	1600	40	30
6	3	40	25000	100	30

3. Conclusion

Analysis of results shows that with changing parameters of processing, the fractal dimension contains in compartment 0.60 ÷ 1.69. The change of conditions of processing causes the change of value of fractal dimension and position graph in received arrangement of reference.

The choice of length of measuring step is the decisive problem. In conducted investigations it was the value of 2 µ m. Suitable selection of this value is dependent from the SGP shaped on the surface as well as computational possibility of computer equipment.

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