ECOLE NATIONALE SUPERIEURE D'ARTS ET METIERS - LILLE

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APPLICATIONS OF THE FRACTAL ANALYSIS IN THE CAS OF DYNAMIC FRACTURES

GENERAL ABSTRACT:

A fractal analysis can indicate the lengths characteristic of a rough surface and contribute to a better arrangement of the influence of the microstructure on the process of fracture. The surface roughness is a shape parameter that measures the average height of a given surface and depends on the scale of measurements.

By using both parameters of different characters, one can obtain more detailed information about a given fracture surface in comparison with the analysis by using only the fractal dimension.

TECHNICAL ABSTRACT:

The objective of my doctoral thesis Applications of the fractal analysis in the case of dynamic fractures is to underline the current stage concerning the application of the fractal analysis in the evaluation of the characteristics of materials, requested in a dynamic way.

I also present some theoretical and experimental contributions concerning the application of the fractal analysis in the case of dynamic fracture by shock on Charpy specimens.

INTRODUCTION:

There is some controversy in the literature about the nature of fracture surfaces, whether or not they are self similar or self-affine.

Mandelbrot was the first which had treated this problem for steel. First we find the results from the literature: conditions, materials, methods and the mechanical strain rates for determining the character of self similar or self-affine fractured surfaces.

We prove why a rough surface is self similar or self affine according to measure. Then we take diferent materials and we analyse the influence of materials through the self similar or the self affine character of fracture surfaces. Finally we see what it could be measured: the existing self similar or self affine for the fracture surface.

In these presentation we particularly try to prove in what a rough surface could be considered according to the technique of measure of the profile used, as self-affines or self-similars, after examination of different materials.

GENERALITIES

AUTOSIMILARITY

□ According to the literature the fracture surfaces which are formed in materials which are isotropic should be self-similar (glasses and fine-grained polycrystalline brittle materials).

□ We cannot correlate a given value of the fractal dimension with a specific microstructure, because fracture surfaces are "fractal" in statistical sense in a given length scale range, and their profiles are not mathematically rigorous fractal figures like "the Von Koch curve".

□ The problem is to estimate at intervals the fractal dimension of the fractured surfaces.

AUTOAFFINITY

□ Fractured surfaces are general self affines. The notion of auto-affinity was used at first to characterize the fractional brownien relief, presented by Mandelbrot.

$$(x, y, z) \rightarrow (bx, by, b^{\zeta} z)$$

ζ :indice de rugosité ou exposant de Hurst.

$$\zeta = 0.8 \pm 0.05$$

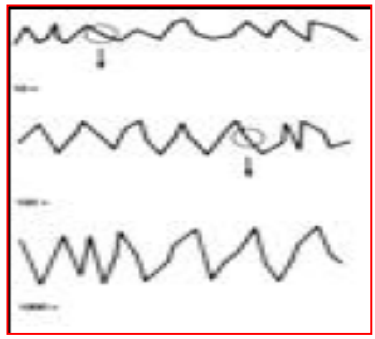
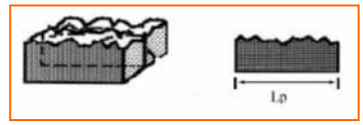


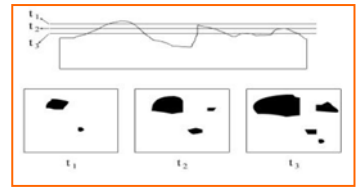
Fig.1. Fractal self-affine

The fractal dimension of a surface is not clearly a measurement of roughness as far as, it does not depend, contrary to the fractal dimension, to the change of scale of representation.

TECHNIQUES FOR GENERATION OF FRACTURE PROFILE



Vertical Section



Slit Island

The outlines of islands are the intersections of the fractured surface with a plan z=constant, they have the dimension Df-1 if the surface is itself self-affine of dimension Df.

There would be thus no correlation between the indication of roughness and any other physical parameter of the material.

1. Fractal. There is no strict definition or usage for the word "fractal" even among specialists. It is used as a generic noun, as a countable one and sometimes as an adjective. The term "fractal" was introduced by Mandelbrot to represent shapes or phenomena having no characteristic length. The origin of "fractal" is the Latin adjective "fractus" (broken). The English words "fractional" and "fracture" are derived from this Latin word.

2. Dimension. We live in a space with three dimensions: length, width, and depth. What we call dimension may sometimes be defined as the number of directions in which movement is allowed. Dimensions are consecutive integers: 0 (a point), 1 (a line), 2 (a surface), 3 (a volume).

3. Fractal dimension for a fractured surface represents the scale independent geometrical complexity of a given surface. In general, the higher the fractional part of the fractal dimension, the rougher the surface. We use "fractal dimension" as a generic term for dimensions that can take fractional values.

4. Surface fractal. A dense object with a fractal surface is called a surface fractal.

5. Mass fractal. If the object itself is fractal and hence also its surface.

6. Pore fractal. A dense object in which there exists a distribution of holes or pores with a fractal structure.

7. A self-similar surface looks the same at different a or it produces the same statistics, such as roughness. A self-similar surface appears self-similar, regardless of scale. At a magnification of 10x, a typical feature has a certain lateral and vertical size. If a section of this trace is selected and viewed at a higher magnification of 100x, then a typical feature has about the same lateral and vertical size as before. The process might be repeated at 1000x.

8. A self-affine fractal is only self- similar when expanded more in one direction than in another .

9. Slit Island= cutting paralel to the fracture surface

10. Vertical Section= cutting perpendicularly to the fracture surface