

THE MODEL CRACK GROWTH OF INTER-PORES IN SINTERED STEELS

Phd Ing. Cristina IONICI

University "Constantin Brâncuși" of Tg-Jiu, cfelix1967@yahoo.com

Abstract: The geometrical structure of sintered steel pores and their distribution is described in terms of fractals. The found correspondence between pore distribution and crack is examined. The fractal dimensions of crack generated from pores model (due to the simple proposed geometrical rule) and real fatigue crack are compared.

Keywords: sintered steel, pores and crack.

1. INTRODUCTION

At first we look for the suitable range of magnifications. For each picture we estimate (box-counting) fractal dimension for observed structure of pores. Next computer finds contours of all pores and once more we evaluate fractal dimension for contours solely. We seek for range of magnifications in which the above two fractal dimensions coincide. An example is shown in the fig. 1.

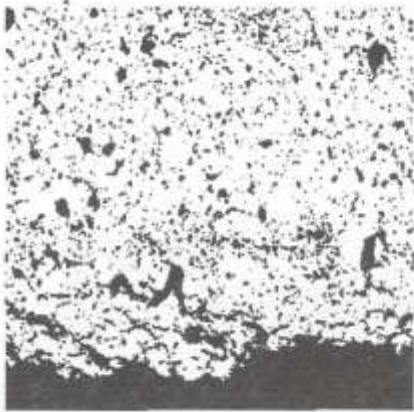


Fig. 1.a.

The observed pores and fatigue crack.

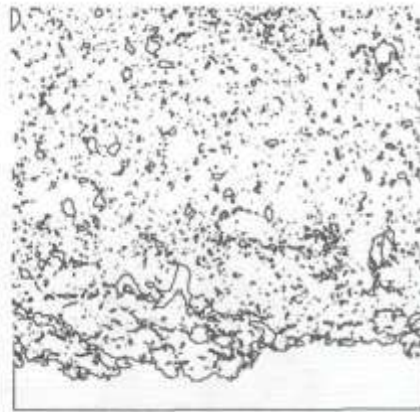


Fig. 1.b.

The pores and all defects used in fractal dimension estimation.

Then fractal dimension will depend on linear size of pores and their distribution solely but not on the internal structure of separate pores. Since details of individual pore form are not important we can model pores by points but the distribution of points should have the same fractal dimension as real structure.

Sintered steels are produced from powders and during technological process high pressures are applied. Therefore structure of grains, being dense packed, should be locally close to hexagonal one. In turn pores originate predominantly at surfaces of adjoint powder grains. In effect we expect the hexagonal structure to be visible also in spațial distribution of pores. At large macroscopic scale the pore distribution becomes uniform and hexagonal order is missing. In effect the fractal modeling pore structure should be composed with hexagonal cells. Each cell contains a fractal with dimension close to value obtained from experimental observations.

2. METHODE MODEL CRACK GROWTH IN SINTERED STEELS

We generate a crack according to simple geometrical rule, which does not favorize any length scale. Suppose that we have two clouds of defects with a single common point. Then a crack should run through this common point and inside a cloud of defects we approximate crack by straight segment. Under current resolution we treat the cloud of defects as uniform defect. Increasing magnification we notice that inițial cloud divides itself into smaller ones and we once more apply above crack form approximation. The procedure has been depicted in the fig. 2.

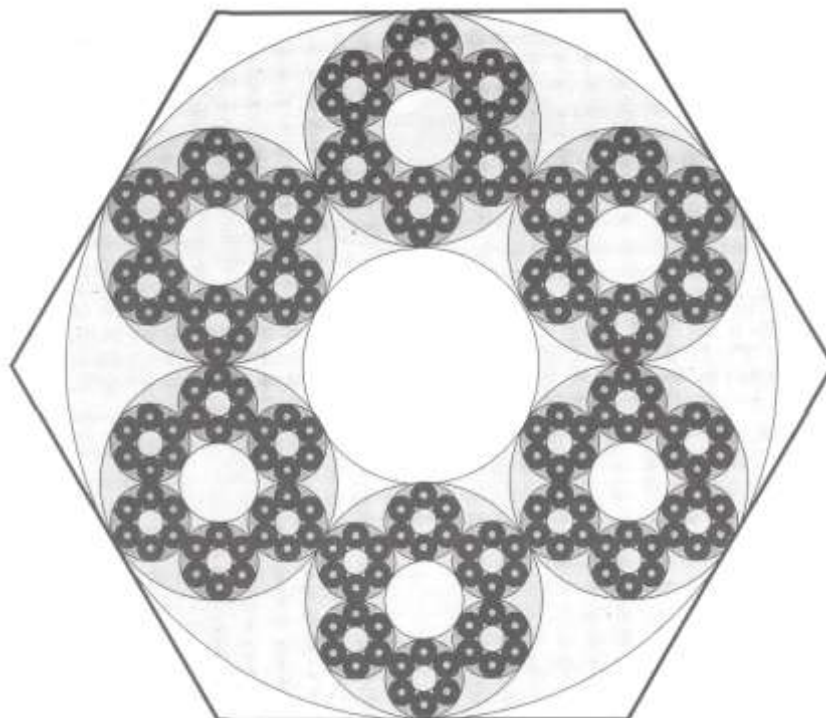


Fig.2. The intersection of the infinite sequence of defect structure inside.

3. RESULTS AND DISCUSSION

The model crack (in fact formed from von Koch type curve shown in the Fig. 4) has fractal dimension $\ln 5 / \ln 3 = 1.47$. At the same time fractal dimension of real crack equals 1.51. For both models: pore distribution and crack form, the model and experimental values of fractal dimensions nearly coincide. Model values are slightly smaller because our construction doesn't employ any overlapping. Moreover the dusts filling cells are very regular.

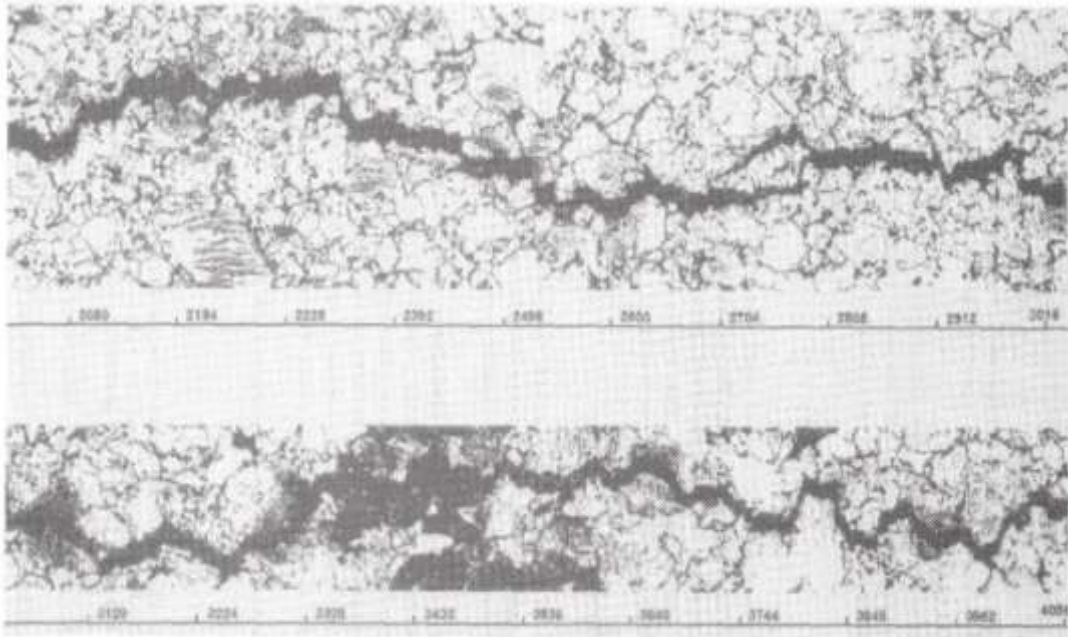


Fig.4. Fatigue crack in the steel

To estimate the characteristic linear size of cells we evaluate numerically the relative partition entropy of fractal defined in the same way as in the ergodic theory, or in the theory of dynamical system.

To compare the fig. 5 presents the observed fatigue crack in sintered steel from the work . Some fragments of observed pattern have form quite close to the constructed fractal model. The constructed models of pore distribution and cracks may be applied to study other important characteristics like stress intensity factor, the energy conserving cascade process examined in [3], [4].

4. CONCLUSION

The growing fatigue crack in sintered steel can be observed at many distinct length scales. At macroscopic level (large comparing to characteristic size of cell) the crack can be approximated by a smooth curve. No fractal character becomes visible.

At the opposite limit, at scale comparable to individual pores the crack contour is also quite close to smooth curve with relative low fractal dimension. Moreover there is no any correspondence between separate pores and fatigue crack form.

The crack form appears to be sensitive to the pore distribution solely. At the intermediate scale length when pores become points object there is close correspondence between fractal distribution of pores and fractal form of the final crack.

REFERENCES

- [1] L. O. Andrushchik—E. Dudrovâ—V. V. Kornjushin, et. al.: *Science of Sintering*, 24, 1992.
- [2] Lenei, F.V., Ansell, G.S.: *J. Met.*, 34 (2), 1982, p. 17-27.
- [3] M. Rybaczuk: The fatigue evolution of fractal defects in metals, *Third International Conference On Low Cycle Fatigue And Elasto-Plastic Behavior Of Materials*, Berlin FRG September 7-11, 1992, Elsevier London and New York 1992;
- [4] K. Falconer K.: *Fractal Geometry*, John Wiley & Sons, Chichester and New York;
- [5] R W. Goldsztein—A. B. Mosolov: Cracks with fractal surfaces, *WAN SSSR*, 319, 4;
- [6] R. W. Goldsztein—A. B. Mosolov: Fractal cracks, *PMM*. voi. 56, 1992;