FRACTURE MECHANISM STUDY - CAN QUANTITATIVE FRACTOGRAPHY HELP ?

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INTRODUCTION

Fractographic documentation is usually an important part in many works dealing with fracture mechanism research. Unfortunately the fracture surfaces are predominantly only qualitatively analysed. It causes the loss of possible information. It is due to the lack of proper methods for easy and efficient quantitative description of fracture surfaces. To make things worse there exists no universal method, applicable in all the fracture modes and cases. In the paper an algorythm is proposed for the efficient application of quantitative fractography.

METHODOLOGY OF QUANTITATIVE FRACTOGRAPHIC ANALYSIS

There are many methods used in quantitative fractography (1),(2). To choose (or create) the proper one the following procedure is recommended:

1. Analyse the fracture mechanism (how the microstructure can affect the fracture process). This can be done on the basis of literature study, own experience or preliminary experiments.
2. Analyse the possible fracture surface configuration resulting from the fracture mechanism (for example small inclusions can cause formation of numerous, small dimples in the ductile fracture mode).
3. Choose or create the measureable quantity characterizing the features choosen in point 2. (for example the dimple size can be described by the mean dimple intercept length while the fracture surface area is not sensitive to the changes in dimple size).
4. Evaluate the choosen quantity and analyse the results.

The proposed procedure has one important adventage: it allows to avoid unnecessary measurements, done in order to evaluate badly choosen parameters. It is very important because fractographic measurements are usually laborious and expensive.

Note (1),(3) that in general quantitative fractography cannot be applied for the evaluation of fracture toughness parameters, like stress intensity factors or J-integral. Fractographic analysis is useful predominantly in fracture growth, fatigue fracture or creep study.

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EXAMPLE OF APPLICATION

Let us analyse the effect of matrix properties on nodular cast iron fracture behaviour. The following model was proposed (4): in the case of brittle matrix, it is assumed the fracture surface is of minimum possible area (graphite-matrix interface is omitted because of its poor cohesion). On the contrary, in the case of ductile matrix the crack should go through the graphite nodules and the crack path is determined according to the principle: the next nodule is the nearest one (see Figure 1).

The predicted differences are not clearly visible in real fracture surfaces (see Figure 2 and 3). Therefore a new parameter R(A) was introduced (5). The boundary values of R(A) were theoretically evaluated (4) and compared with the values obtained from experiments:

Matrix	Predicted	Measured
brittle	$1.00 < R(A) < 1.62$	$1.13 < R(A) < 1.65$
ductile	$1.62 < R(A) < 4.00$	$2.52 < R(A) < 4.26$

These results indicate that the proposed fracture process model is in good agreement with experiments. Without the use of fractographic analysis it is very difficult.

SYMBOLS USED

$$R(A) = 2\,\frac{\text{area fraction of graphite in fracture surface projection}}{\text{volume fraction of graphite in the nodular iron}}$$

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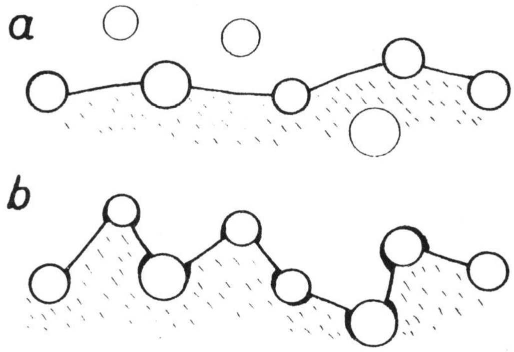

Figure 1. Model of crack path in the nodular iron with: brittle matrix (a) and ductile matrix (b).

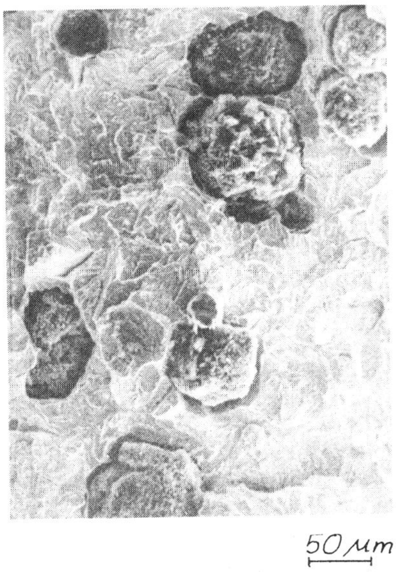

Figure 2. Fracture surface for cast iron with brittle matrix.

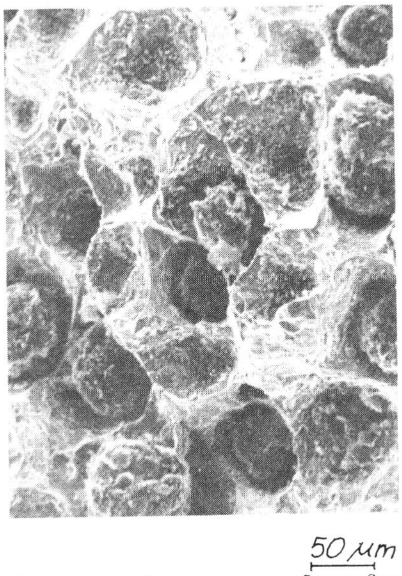

Figure 3. Fracture surface for cast iron with ductile matrix.