CRACK GROWTH IN CAST IRONS UNDER STATIC AND CYCLIC LOADING

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The presence of internal stress concentrators excerts a strong influence on the materials behaviour in the field of mechanical stresses, crack initiation and propagation. Successful experimental investigation of the mentioned processes can be performed using cast irons, whose structure consists of metallic matrix and graphite inclusions, differing in their mechanical properties.

Tests were performed on cast irons with lamellar, globular and vermicular graphite. Chemical composition is given in Table. The following matrix structures were obtained due to heat treatment: ferrite, ferrite-pearlite, spheroidized pearlite and lamellar pearlite. Fracture toughness data were obtained from slow bending of precracked 12 mm thick specimens. Acoustic emission signals were recorded during testing.

Fracture of all tested irons, except pearlite irons with globular graphite, takes place due to subcritical crack growth. Acoustic emission method was used to determine the value of stress intensity factor K_s at the moment of the main crack start. Fracture toughness of ferritic, ferritic-pearlitic and spheroidized pearlitic irons decreased with the change of the graphite shape from globular to vermicular, and, further, to lamellar (Fig. 1). Obtained results and literature data analysis show (1), that fracture toughness - tensile strength (K_Q-σ_{UTS}) dependence for cast irons consists of two intersecting bands - an ascending section presenting peculiarities of fracture of cast irons and a descending one, common for steels (2). Three areas - A, B, C - are distinguished on the plot, where the crack growth character is different within each area. In region A fracture of cast irons takes place by subcritical crack growth irrespective of the micromechanism of fracture of the metallic matrix. In region B fracture of cast irons may happen along two mechanisms: subcritical crack growth and/or spontaneously. In region C spontaneous fracture predominates.

Fatigue crack growth investigations showed, that the minimum resistance to fatigue fracture was exhibited by

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grey irons (Fig. 3a). As established, fatigue crack growth rate, including threshold ΔK_{th} values is insensitive to the structure of the metallic matrix in irons with vermicular graphite (Fig.3b). Maximum effect of the matrix structure on resistance to fatigue crack growth is observed in irons with globular graphite (Fig. 3c). The $\Delta K_{th\ eff}$ values, determined from crack closure measurements variate over the range of 3.5 ... 6.0 MPa$\sqrt{m}$. This is connected with a considerable crack tip blunting and branching when the crack comes across the graphite inclusions.

REFERENCES

(1) Romaniv, O.N., Tkach, A.N. and Yus'kiv, T.Ya., Fiz.Khim.Mech.Mater, No.5, 1988, to be published (in Russian)

(2) Romaniv, O.N., "Fracture Toughness of Structural Steels", Metallurgia, Moscow, 1979, 176 p. (in Russian)

Chemical comp. (wt%)	Grey irons	Nodular irons	Malleable irons
C	3,22	2,44	3,35
Mn	0,69	0,42	0,74
Si	3,13	1,37	3,14
Cr	0,19	<0,05	–
Ni	–	–	0,41
Cu	–	–	0,40
Mg	–	–	0,048

Table.

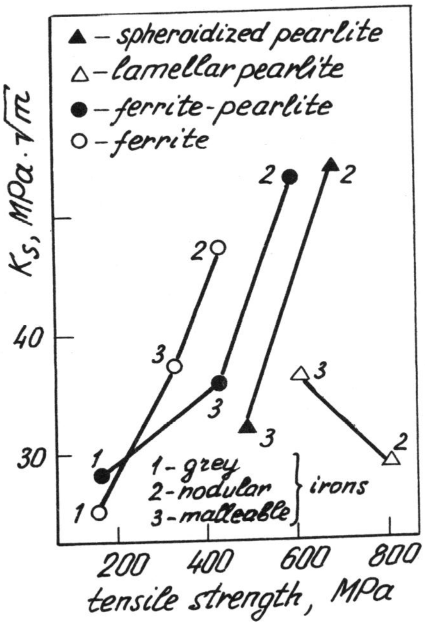

Fig.1. Fracture toughness K_s and strength σ_{UTS} dependency on the graphite shape and matrix structure

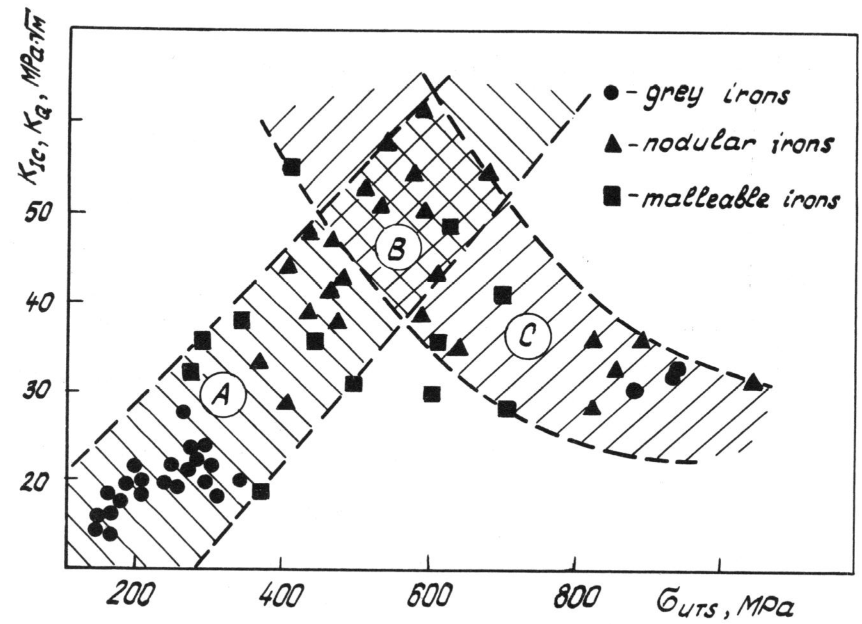

Figure 2. Relationship between K_Q and σ_{UTS} in cast irons.

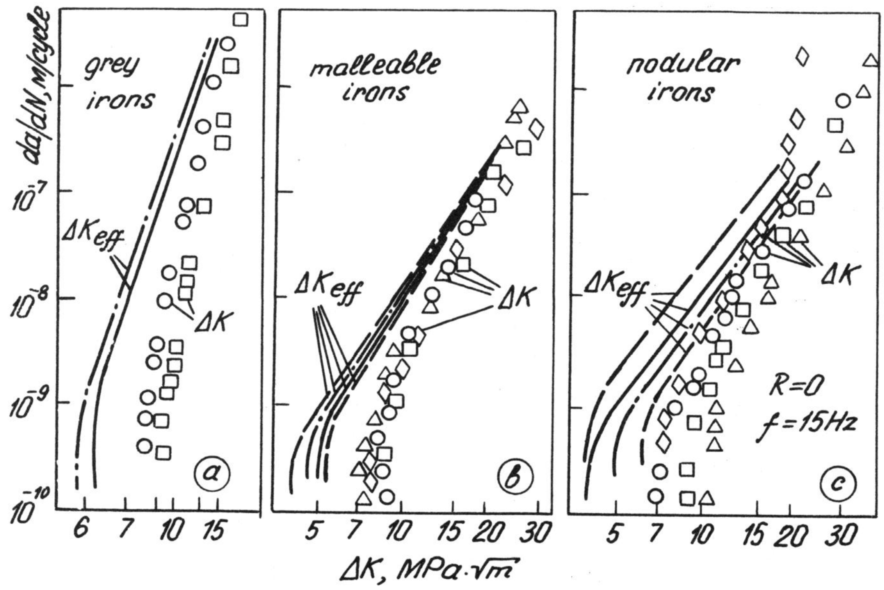

Figure 3. dl/dN vs ΔK and dl/dN vs ΔK_{eff} for irons with ferrite (——, ○), pearlite-ferrite (—·—, □), spher. (- -, △), lamell. (— —, ◇) pearlite.