A COMBINED NUMERICAL / EXPERIMENTAL INVESTIGATION OF INFLUENCE MICROSTRUCTURE ON FRACTURE TOUGHNESS MICROALLOYED STEEL

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This paper has shown study of the influence of microstructure low-carbon microalloyed steel type 22G2CB hardened with different velocity (20-140 C/s) on fracture toughness in process of crack initiation and stable crack growth. Type of steel and used cooling velocity was very convenient to produce large variation of microstructure. Each type used heat treatment (figure 1) afected on material behaviour within the fracture process. The microstructure consisted of ferrite and pearlite (in slow velocity) to martensite in high velocity of cooling. Tensile properties R02 ,Rm , A5 and calculated factors B , n as a function of cooling velocity has been shown on figure 2. Experimental tests were conducted on 3 point bent specimens. Values of load P, clipe gauge displacement Vc, specimen deflection q and crack growth Δa were monitored and recorded during each test. The last value Δa was measured by electrical potential drop method. The crack extension Δa was the basic input to the finite-element crack growth computer simulation . The calculation are repeated for five different material microstructure representated by material parameters B i n for the Ramberg-Osgood relation. A finite-element model of the crack tip region using 8-noded isoparametric elements in which the part of nodes are initialy collapsed to common point

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according Shih et al (1). As the load is increased, nodes are shifted as long as a crack growth is about 1.5 mm. Process of crack-tip blunting and growth has been observed using metalographic and fractographic techniques. Experimental results are presented which suggest that parameters based on J-integral, Crack Tip Opening Angle and Tearing module dJ/da are viable characterizations of crack initiation and stable crack growth. Observation based on microscopy and finite-element investigations shown that crack initiation is not only characterizable by critical value of JIc (figure 3). Paper (2) has shown that stable crack growth is characterisable in terms of "R" curve which is unique relation between J and crack growth Δa. The dJ/da appears to be not relatively constant in investigation range of crack growth and depended of microstructure of tested steel (figure 4). The microstructure in which martensite and bainite are presented , the toughness was increased by the deformable bainite , which like a crack arrestor . It can also increase the resistance of fracture by deforming and blunting crack. But upper bainite was found to be most brittle structure even ferrit-pearlite. The degree of agreement finite-element model and direct measure of crack extension for different microstrocture was quite good.

REFERENCES

(1) C.F.Shih, H.G.de Lorenzi, W .R .Andrews "Studies on Crack Initiation and Stable Crack Growth " ASTM STP 668 pp. 65-150.

(2) A.Bochenek"Investigation of Fracture Toughness in Stable Crack Growth" XI Polish Phisical-metallurgy Conf. Czestochowa 1893 pp 94-100

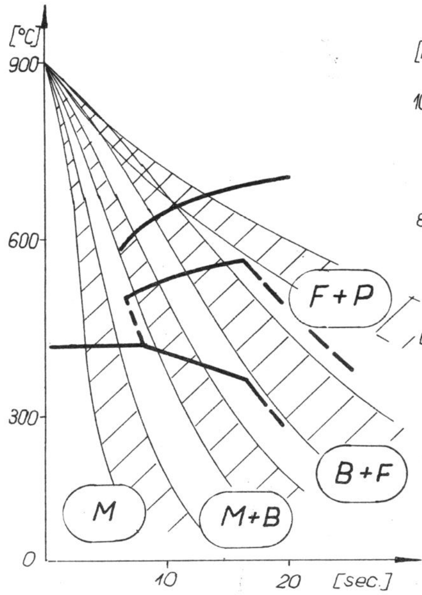

Fig.1 Cooling curves on 22G2CB CCT-Diagram

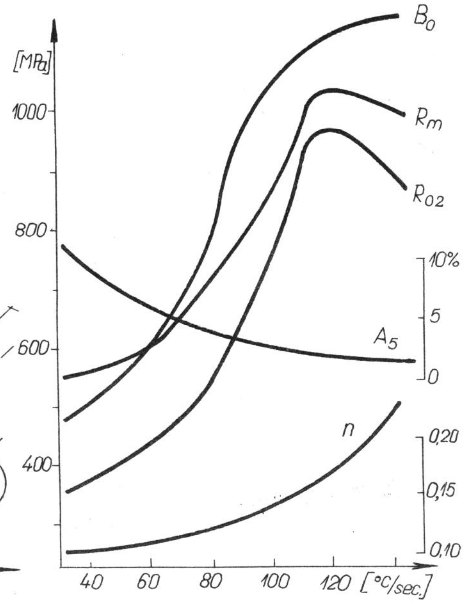

Fig.2 Tensile properties as a function cooling velocity

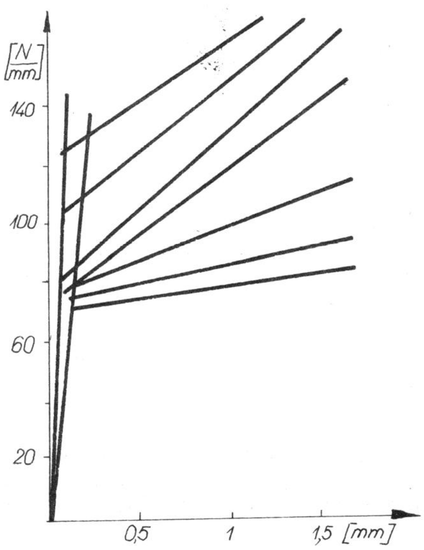

Fig.3 JIc and "R" curves of investigated steel

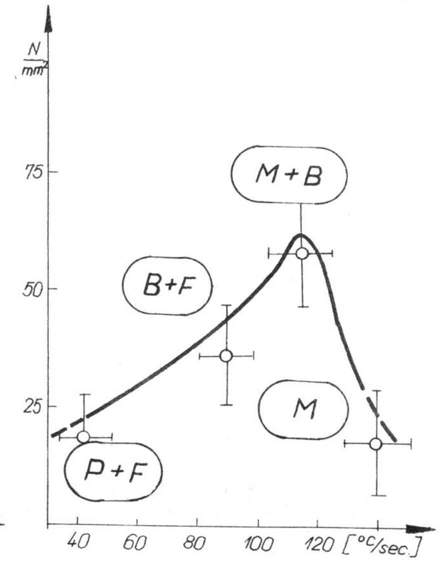

Fig.4 dJ/da in relation of microstructure