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ON THE MECHANISM OF PROPAGATION OF A BRITTLE FRACTURE IN STEEL

by

H.C. van ELST - W.L. KORBEE - C.A. VERBRAAK

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On the Mechanism of Propagation of a Brittle Fracture in Steel

H. C. van Elst, W. L. Korbee, and C. A. Verbraak

IN a recent paper,[1] one of us has presented some experimental evidence on the relationship between twinning and brittle fracture in steel.

From metallographic examinations of brittle fracture it could be derived that mechanical twins and microcracks are formed already in front of a running brittle fracture. A tentative explanation based on the evaluation of the statistical distribution of mechanical twins vs various angles to the fracture was given in the above mentioned paper. It was suggested that these twins are caused by stress waves emitted by a running brittle fracture.

With the aid of high-speed photography and the use of photo-stress sheet we are now able to study in more detail the propagation of a brittle fracture and the emittance of stress waves connected with fracture.

A typical example is given in Fig. 1. In this figure a running brittle fracture in an ordinary Thomas steel is shown. The experiment was performed on a Robertson apparatus and the stress waves caused by the fracture were made visible with photo-stress

H. C. VAN ELST, W. L. KORBEE, and C. A. VERBRAAK are Senior Scientist, Electrical Engineer, and Head of the Department for Basic Research, respectively, Metaalinstituut T.N.O., Delft, The Netherlands. This work is sponsored by EURATOM U.S. Joint R. and D. Board under Contract no. 068-61-11-RDN.

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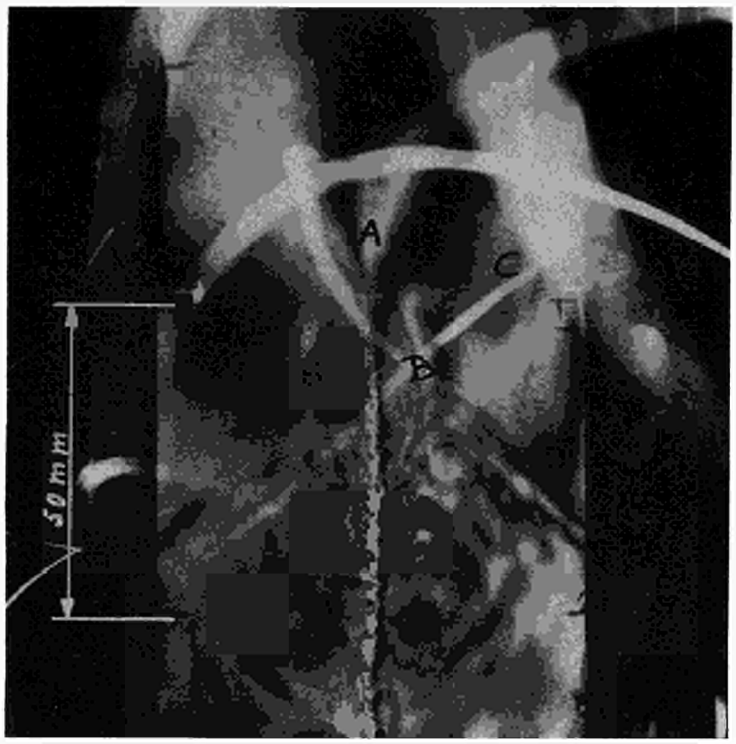

Fig. 1—Running brittle fracture in Thomassteel. Photograph obtained with a 1 μsec flash of 5 wattsec timed 150 μsec after the initiation of the fracture. Stress waves recorded with the aid of photo-stress sheet (1/8 in.) glued to the steelplate.

sheet glued to the steel plate. A 1 μsec flash of 5 wattsec timed 150 μsec after the initiation of the fracture was used in this experiment. From this photograph it can be concluded that stress waves apparently are not emitted continuously but rather intermittently by the running brittle fracture.

Three different stress waves emitted by the running fracture at successive times can be seen on the photograph. These were obtained as isoclinics, where the directions of the principal tensions were parallel and perpendicular to the fracture path (*i.e.*, the direction of polarizer and analyzer respectively). At *A* a stressfield is being built up at the tip of the running fracture, at *B* a stress wave can be seen that was emitted at an earlier time, whereas the stress wave at *C* was emitted at a still earlier time and is reflected already by the weld of the testplate.

It is too early yet to draw any definite conclusions. Taking into account, however, our former work we would suggest the following preliminary and tentative mechanisms of the propagation of a brittle fracture. The release of a stressfield at the tip of a running fracture starts a stress wave running with a velocity of nearly five times the velocity of the fracture itself. This stress wave may cause twinning and the formation of microcracks in front of the fracture until the energy of the stress wave is dissipated too much to form twins. In the area where twins and microcracks are formed the running fracture can now follow an easy path. As soon as the fracture approaches the end of this area a new stressfield will be built up, which on release starts a new stress wave and the same sequence is repeated. An extensive programme on the observation of running brittle fracture in various steels is now being performed in our Institute. More detailed description of the phenomena observed and also quantitative calculations will be published in due course.

[1]C. A. Verbraak: Brittle fracture and twinning in steel, *Materialprüfung*, 1961, vol. 3, no. 10, p. 383.

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