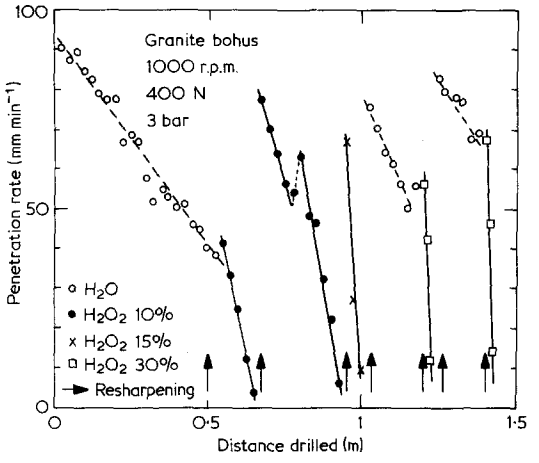

Figure 2 Effect of water, or various concentrations of hydrogen peroxide on the rate of performance loss of diamond impregnated drill bits. Vertical arrows indicate periodical redressing of the bit.

the efficiency of heat transfer and the temperature of the diamond. To achieve such an effect would not require the additive to be present in large quantities. Rhodes and Bridges [5] boiled water on the surface of a tube through which was flowing hot mercury. They found that film boiling is promoted by making the surface less wettable by, for instance, coating it with a film of wax or by adding very small quantities of oleic acid or mineral oil to the water. By contrast, the addition of sodium carbonate or sodium chloride restored nucleate boiling. The two latter chemicals *inter alia* have been said by Rehbinder [6] to improve the rate of penetration when rock drilling.

(3) Finally, the chemical nature of the additive should not be ignored insofar as it can directly influence the degradation of the diamond. Fig. 2 shows some results we have obtained using hydrogen peroxide as a drilling additive. Here, the disastrous effects of this powerful oxidizing agent are quite clear, and it is not necessary to look further for the cause of the loss in drill performance (in fact, we did consider the possibility that the oxygen bubbles liberated during drilling could have interfered with the heat transfer process: we are grateful to Professor Nabarro for a suggestion to drill with soda-water, which showed this effect to be insignificant).

In conclusion, therefore, we feel that while the effect of the environment on the performance of the drill is well established, the precise factors which influence the blunting of the diamonds are less clear. We have suggested three possible independent ways in which the environment could affect the wear of the diamonds, and others will no doubt emerge in time. Which of the mechanisms will be dominant in any given situation must depend on the conditions and additives employed.

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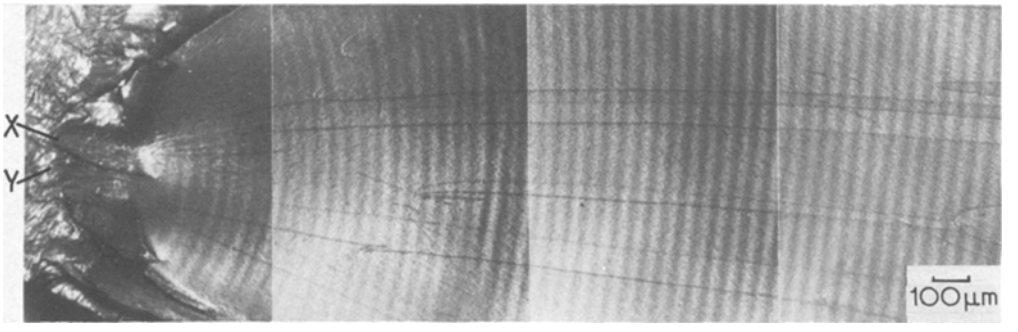
Velocity measurement by ultrasonic fractography for cracks in glassy polymers

Although high speed photography seems to have been most widely employed to determine the velocity of cracks (v_f) running in solids, its spatial resolution is not high enough to locate the exact position of narrow crack tips. The use of resistance grid methods [1, 2] makes it possible to measure v_f electrically. In this case, however, there still remains the doubt as to whether the electric signal generated really coincides with the crack tip arrival at the designated point.

Kerkhof [3, 4] showed that the ultrasonic fractography technique he developed is superior to the methods stated above both in spatial



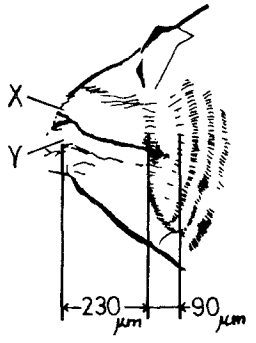


Figure 1 A typical example of ultrasonic-modulated fracture surface of PMMA.

resolution and reliability of v_f determinations for inorganic glass. This technique was then applied to crystalline materials [5], but has rarely been applied to viscoelastic materials because of serious wave damping.

In the present study we have succeeded in making distinct ultrasonic traces on fractured surfaces of polymethylmethacrylate (PMMA) by using a high power oscillator (maximum output, about 600 W). The oscillator consisted of a 100 W high frequency generator and a linear amplifier, to which a Y-cut quartz element with resonance frequency of 3.6 MHz was connected. The element was cemented with epoxy resin to a water-cooled aluminium transmitter. The other side of the transmitter was cemented with the same adhesive to a single-edge cracked tensile specimen on the opposite side of the crack. The quartz element was set to oscillate in the direction of the tensile load axis. The direction of maximum principal stress in front of an advancing crack was thus modulated by the 3.6 MHz transverse waves, and periodic artificial Wallner lines, so-called ultrasonic lines, were produced on the fractured surfaces. Fig. 1 presents a typical example of ultrasonic lines on a fractured surface of PMMA. From the quantities such as wavelength of the lines, wavelength and frequency of ultrasonic waves and inclination between propagating directions of the crack and waves, we estimated v_f as a function of crack length, as shown in Fig. 2. The spatial resolution in this measurement was of the order of a wavelength of the ultrasonic lines, i.e., about 50 μm in the case of Fig. 1. One may see in Fig. 1 that the crack started from the two points X and Y almost simultaneously and slowly grew to a distance of about 230 μm. Then instability set in. The static fracture behaviour suddenly changed to a dynamic one within a further advance of only 90 μm. We denote the crack velocity immediately after the transition as v_{fc}, and v_{fc} in the case of Fig. 1 may be seen as high as 185 m sec^{-1}.

By measuring v_{fc} and the static load to initiate fracture one can obtain a relationship between v_{fc} and the critical stress intensity factor K_{IC} at the moment when instability occurred. Fig. 3 compares our results concerning the v_{fc} versus K_{IC} relations with those of Hoagland *et al.* [6]. It should be mentioned that in our case K_{IC} was calculated after Brown *et al.* [7], and Hoagland

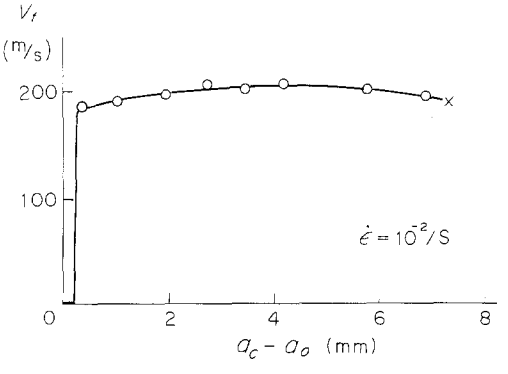


Figure 2 Measured fracture velocity (v_f) of the specimen in Fig. 1 as a function of advanced crack length ($a_c - a_0$).

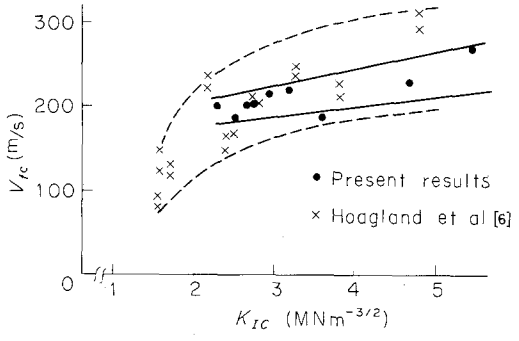


Figure 3 A comparison of K_{IC}–v_{fc} relationships.

et al. used the resistance grid method [1] to measure v_f. Fig. 3 shows that the amount of scatter in plotted values can be reduced by using the ultrasonic fractography method. Experimental details and further fracture mechanics study of propagating cracks in connection with ultrasonic fractography will be published elsewhere.

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Increased fracture toughness of brittle materials by microcracking in an energy dissipative zone at the crack tip

The influence of microcracking on the fracture toughness of brittle materials, especially of ceramics, has been discussed recently in the literature [1–5]. In our paper we shall deal theoretically with the question of under which conditions microcracking would result in an increase of toughness. Our theory is based on experimental results presented by Claussen *et al.* [6, 7]. They examined composites fabricated from Al_2O_3 and unstabilized ZrO_2 powder. The fracture toughness of these composites has a significant maximum in dependence on the volume fraction of ZrO_2 particles. In the optimum case the toughness can be increased by a factor between 2 and 3 in comparison to that of the Al_2O_3 matrix. It is hypothesized by Claussen [7] that this increase results from small matrix microcracks absorbing energy by controlled propagation.

The first attempt to explain theoretically this toughning phenomenon was made by Buresch [8, 9]. In his papers, however, an effective fracture criterion similar to the Dugdale–Barenblatt criterion is used. That is a problematic approach because that criterion presupposes homogeneous stresses within the microcrack zone near the crack tip, which precludes taking into account the direct interaction of the main crack with microcracks.

In our paper another approach will be used. We shall set up a more detailed energy balance of increasing and decreasing effects of microcracks on fracture toughness. Energy variations methods will be used, because they enable us to avoid a detailed calculation of stress and strain distributions. The theoretical model may be explained by Fig. 1, where the tip of a two-dimensional plane crack in an infinite body is shown. When the material is loaded, microcracking occurs in a certain region in the vicinity of the crack tip. The characteristic length of this region, say r_D, depends on the applied load; it will be determined