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AN ACOUSTIC EMISSION CALIBRATION DEVICE

J A Parker

UKAEA, Reactor Engineering and Materials Laboratory, Risley, Warrington

ABSTRACT

The acoustic emission pulse count rate obtained from steel specimens is critically dependant upon the sensitivity of the system. It is therefore necessary to know the sensitivity of acoustic emission systems if a meaningful comparison between the results for different experiments is to be obtained. In this paper a calibration device is described that generates a fast rise time thermal stress pulse of known amplitude in the specimen by passing a current pulse, 320 nsec long and up to 100 amps amplitude, through a point contact formed by an electrode and the specimen surface.

INTRODUCTION

When making acoustic emission measurements on steel specimens, the measured pulse count rate depends upon the size of the acoustic emissions and the overall sensitivity of the acoustic emission system, including losses in the specimen, transducer sensitivity and discriminator level. It is clearly impossible to compare meaningfully different acoustic emission measurements if the relative sensitivities of the systems are unknown.

The most direct method of measuring the overall sensitivity of the system is to use a calibration device to inject a simulated acoustic emission of known amplitude into the specimen. The common practice of electrically pulsing a piezo-electric transducer is not a satisfactory calibration, due to the variation in the acoustic coupling between the specimen and the transducer.

SPECIFICATION

The most important requirement of a calibration device is that it must be capable of injecting a stress pulse of reproducible amplitude into the specimen, although it is not necessary to know its amplitude absolutely. In order to simulate an acoustic emission, the stress pulse should have a fast rise time and originate from a point source. A rise time of 1 μsec should allow the calibrator to be used on acoustic emission systems up to 500 KHz. For ease of use, the injected pulses should be repetitive, with a repetition rate adjustable between say 10-100 pulses per sec and an amplitude adjustable to give detected signals between 0 and 40 db above the background electrical noise of the acoustic emission system (20 μV pp for the REML system).

POSSIBLE CALIBRATION DEVICES

Since it is difficult to make a reliable consistent acoustic coupling between two solids, only devices that were capable of directly injecting a stress pulse into a specimen were considered. Of the four devices that were examined at REML, a 'point contact' device was the most satisfactory. Briefly the other devices were:

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Particle impact

Firing a small particle, 0.06 cm or less in diameter, at the specimen generates a stress pulse in the specimen about 1 μsec wide. While methods were developed to fire a single small particle at a specimen repetitively, the amplitude of the stress pulse varied from impact to impact and the device was difficult to handle, due to the small size of the particle.

Capacitor pulser

A mica dialectric capacitor, in which part of the specimen surface forms one electrode is electrically pulsed and the resulting force on the electrodes generates a stress pulse in the specimen. The disadvantages were that the pulser had to be 1 cm or more diameter, hardly a point source, and there was some evidence of a drift in the amplitude of the stress pulse, probably due to changes of the dialectric.

Spark discharge

A capacitor was charged up to a voltage of 6-12 KV and was then discharged by means of a rotating switch through a spark gap formed by an electrode and the specimen surface. An acoustic pulse is generated in the gap and travels through the air to the specimen. The stress pulse injected into the specimen had a reproducible amplitude and a rise time, measured using a capacitor transducer, of 0.7 μsec. It was, however, not possible to vary appreciably the amplitude of the stress pulse. The combined effect of varying the applied voltage from 6-12 KV and the gap from 0.05-0.2 cm only change the amplitude of the detected signal by 5 db.

POINT CONTACT DEVICE

The 'point contact' calibration device consists of a point contact formed by an electrode and the specimen surface, through which a short electrical discharge is passed. The resulting transient local heating of the specimen surface results in a thermal stress pulse being generated in the specimen surface.

In order to obtain a well defined junction, the point contact was formed by loading an 0.318 cm diameter steel ball bearing on to the specimen surface and the junction resistance was monitored by passing a dc current through the junction and measuring the resulting voltage drop. A short duration current pulse of known shape and amplitude was obtained from the delay line pulse generator shown schematically in Fig 1. The 50 Ω delay line was charged via a resistor until the breakdown voltage of the spark gap was exceeded, when the delay line was discharged through a 50 Ω resistor, of which the 'point contact' formed part. The resulting rectangular current pulse had a rise/fall time of 10-20 nsec, a duration of 320 nsec and a repetition rate of up to 30 pulses per sec at the maximum current of 100

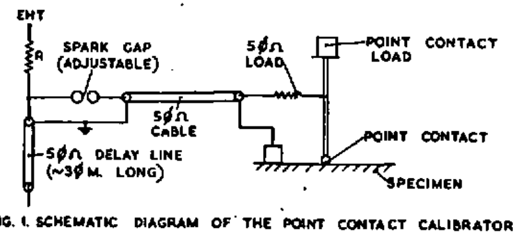

FIG. 1. SCHEMATIC DIAGRAM OF THE POINT CONTACT CALIBRATOR

amps. The amplitude of the current pulse was varied by varying the spark gap, while the repetition rate was independently controlled by an oscillator which 'set' a flip flop to 'enable' the EHT, while the leading edge of the current pulse was used to 'reset' the flip flop, so inhibiting the EHT. A convenient feature of the system is that the device actually placed on the specimen only consists of the point contact and the 50 Ω load resistor. The load resistor must, however, be non inductive and capable of handling the power involved, up to 0.5 MW in the present system. The present system uses a straight 14 cm length of resistance wire to meet this requirement.

Experimental results

The 'point contact' device was mounted on a 10 x 10 x 56 cm steel specimen and the resulting stress pulses were detected by an REML 190 KHz acoustic emission system (1). The resistance of the junction was monitored using a 100 mA bias current and the shape and size of the discharge current were measured by monitoring the voltage generated across the 50 Ω load resistor with an oscilloscope.

Initially, the resistance of the point contact was very variable, presumably due to oxide films. However, on passing a discharge through the junction, the resistance fell by two or more orders of magnitude to a reasonably constant 6 mΩ. Figs 2 and 3 show the effect of discharge current and junction resistance on the amplitude of the detected signal in terms of the ratio β, where β is defined as the ratio of the electrical energy dissipated in the junction to the peak to peak amplitude of the detected signal.

DISCUSSION

The 'point contact' device appears to be an effective device for generating a stress pulse in a metal specimen. The source of the stress pulse is the locally heated region which will be approximately the size of the point contact, estimated as about 6×10^{-3} cm diameter from elastic theory (2), so it is a true point source.

The rise time of the stress pulse will be approximately the sum of the duration of the discharge, 320 nsec, and the time the stress pulse takes to cross the source, probably less than 20 nsec, giving a total of 340 nsec, well within the 1 μsec target.

Figs 2 and 3 show that within the resolution of the

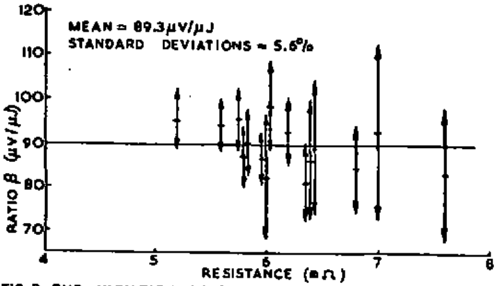

FIG. 2. THE VARIATION OF DETECTED SIGNAL WITH POINT CONTACT RESISTANCE

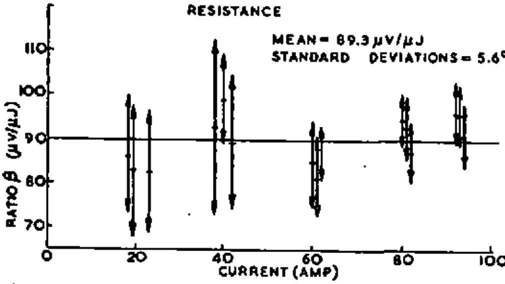

FIG.3 THE VARIATION OF DETECTED SIGNAL WITH DISCHARGE CURRENT

present measurements, the ratio β is independant of the discharge current and junction resistance, meaning that the amplitude of the stress pulse is proportional to the electrical energy dissipated in the junction. Thus by monitoring the resistance of the junction, it is possible to compensate for changes in the point contact, up to 20% for the results in Fig 2, by adjusting the amplitude of the discharge current, thus obtaining a stress pulse with a reproducible amplitude, which is the fundamental requirement for a calibrator.

The range of adjustment of the stress pulse amplitude, 10–38 db above background (20 μV pp) and repetition rate, 0–30 pulses per sec, are not significantly different from those suggested in the specification, 0–40 db for amplitude and 10–100 per sec for repetition rate, and could be increased by using a higher charging voltage and current.

CONCLUSIONS

The 'point contact' calibration device is a point source of fast rise time stress pulses, which are a good approximation to acoustic emissions.

The amplitude of the stress pulse is proportional to the electrical energy dissipated in the junction. Thus, provided the resistance of the junction is monitored, stress pulses with a reproducible amplitude can be generated.

The amplitude and repetition rate of the stress pulses are readily varied, which should make the device convenient to use.

REFERENCES

(1) P G Bentley, D G Dawson, J A Parker. Instrumentation for Acoustic Emission, 1973. UKAEA TRG Report 2482(R). (2) F P Bowden, D Tabor. The Friction and Lubrication of Solids, 1954. Oxford Clarendon Press.