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DIAGNOSIS ABILITIES OF ACOUSTIC EMISSION MULTI-CHANNEL SYSTEMS: EXPERIMENTAL SET-UP

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INTRODUCTION

The benefit of Acoustic Emission (A.E.) used as a non-destructive examination technique during proof testing of pressure vessels mainly depends on the ability of the systems to give an effective diagnosis of the health of the monitored structure. Till now most multi-channel systems are able to locate A.E. sources in large structures but the defect grading they provide still remains a major problem. To evaluate the diagnosis abilities of A.E. multi-channel systems applied to statically stressed heavy metallic structures, Association Vinçotte and the Laboratory of Strength of Materials of the Ghent University have set up an experimental program with the support of the Belgian Institute for the encouragement of the Scientific Research in the Industry and the Agriculture.

PROGRAM OF EXPERIMENTS

The program covers an extensive A.E. monitoring of wide test plates, some plain, some others welded, being pulled to rupture at temperatures below and above the Nil Ductility Transition temperature. The material of the plates is a quenched and tempered steel with an Ultimate Tensile Stress (U.T.S) of about 850 N/mm2. The plate size is 1000 x 800 x 50 mm. The test plates include stress raisers in form of through - thickness machined grooves, fatigue induced cracks, weld defects.

For the tests, each plate is welded to the $60\ 10^6$ N hydraulic tensile machine of the Ghent University, and instrumented with a 4 A.E. sensors location pattern. During loading at controlled strain rate, stress, strain and crack Opening Displacement (C.O.D) values are continuously recorded by the A.E. system. Moire photographs are taken during the tests. The A.E. system also records all sets of 4 analog A.E. signals validated for location purposes.

The mechanical and A.E. data are processed afterwards to give both individual and statistical evaluation of sources. The computer of the A.E. location system provides oscillation count, peak amplitude and energy measurements, Fourier spectra, and a set of distribution diagrams.

In a second phase, industrial pressure vessels will be monitored in the field during the hydraulic proof test with a 6 arrays location system. One channel per array is connected to an analog recorder.

A.E. EQUIPMENT

The A.E. 24 channels equipment necessary to meet the requirements of the hereabove program includes amongst others :

- Transducers with an optimum sensitivity in the 0.1 - 1 MHz frequency band and calibrated for frequency, temperature, and directivity.
- 4 parametric channels.

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- 6 Wave form recording channels including per channel : 1 log. amplifier, 1 5 MHz analog-to-digital converter, 4 K bytes buffer memory. Max. recording time : 0.8 ms at 5 MHz sampling rate.
- 64 K bytes core memory computer fitted with a real-time-multi-task operating systems and a FORTRAN V, Level 1 compiler
- 82 M bytes disk storage memory. Max. Storage capacity : 4 500 sets of 4 A.E. signals or 18 000 A.E. signals
- 750 K bytes floppy-disk program storage memory
- Key board and printer
- CRT display and hard copy unit.

Most parts of the system are assembled in 3 portable racks in order to make it movable in the field.

TEST PREPARATION

Before starting the experimentation, the noise level of the tensile machine, the cooling system and measuring instruments for stress, strain, C.O.D. and Moire measurements must be reduced to an acceptable level in the 0.1 - 1 MHz frequency range.

Noise in the tensile machine

A 1000 x 1000 x 100 mm St 37 steel plate was welded to the machine and tensile tests were monitored with a single channel A.E. DUNEGAN/ENDEVCO (D/E) 3000 system. D/E D 9201 Transducer was used. The sensitivity threshold was 2 dB above the electronical background noise. During successive loading, at levels below the previous maximum applied load (KAISER zone) a peak up to 3000 counts/s was recorded each 30 s at frequencies up to 300 kHz.

To avoid the interference of these signals with true A.E. signals, garde probes will be used with the multi-channel equipment. On the other hand actions are taken to lower the power of the extraneous A.E. sources.

Instrumentation noise

Before starting the tests on the 60 10^6 N machine, the experimental procedures will be developped on a 8 10^6 N machine. As a preliminary check a 1000 x 600 x 25 mm St 37 steel plate was welded to that smaller machine and stressed following the procedure described in the hereabove paragraph. The records show that the high activity arising when passing the previous maximum load is not detected any more if the sensor is attached on a machine head (90 mm thick). This effect is assumed to be due to the difference in thickness between the plate and the machine head, which provides a good acoustic barrier for surface waves.

CONCLUSION

The experimental set-up includes all devices presently available to analyse A.E. signals. The use of a specially powerfull tensile machine makes it possible to experiment in laboratory under conditions very similar to the proof testing of pressure vessels and large structures.