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DYNAMIC PROPERTY AND CONSTITUTIVE MODEL OF THE PERFORATED CASING STEEL 32CrMo4 IN THE PERFORATION CHARGE

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ABSTRACT

To enhance oil output of low yield well, a composite perforating charge is often used to extend oil outlet, see Fig.1. In general, the perforated casing in the perforation charge suffers higher strain rates and elevated temperatures during practice uses, therefore the dynamic mechanical property of the perforated casing at all times attracts researchers and engineers interest.

In the present paper, the perforating charge tests are conducted to understand the dynamic properties of the perforating casing. Several strain gauges are adhered to surface of the perforated casing made from 32CrMo4 alloy steel to measure the function relation between of strain rates and corresponding practice explosive pressure. Through these simulating testing, the variation of the strain rate is obtained, see Fig. 2. Based on practice strain rates that the perforated casing suffers, uniaxial compression tests of 32CrMo4 alloy steel are performed with the cylindrical samples, using a CSS44100 electromechanical universal material testing machines and the split Hopkinson bar technique. True strains exceeding 80% are achieved in these tests, over the range of strain rates from 0.001/s to about 3,000/s, and at initial temperatures from 294K to 573K. The typical testing results are shown in Fig. 3.

To obtain a constitutive model characterizing this steel, based on Johnson-Cook model framework, these experimental data are used to estimate the parameters in this model, and the model predictions are compared with the experimental results, as shown in Fig. 4 .

Finally, the finite element method(FEM) is utilized to evaluate residual strength of the perforated casing. The stress distributions are obtained and analysed, see Fig. 5.

Some major conclusions are as follows: 1) the variation of strain rate of the perforated casing is from 10^2/ s to about10^4/s during practice use; 2) flow stress of 32CrMo4 alloy steel depends on strain rates and temperatures, 3) based on experimental data, the parameters of Johnson-Cook model is obtained, the model predictions are in good agreement with the experimental results over a wider range of temperatures and strain rates; and 4) using Johnson-Cook model, computational FEM of the perforated casing is created, the strength of the perforated casing can be effectively analysed and evaluated.

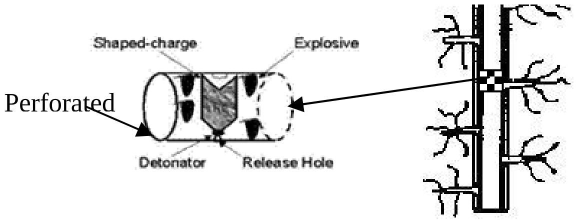

Fig.1 A combined perforation charge and its perforated casing for low yield oil well

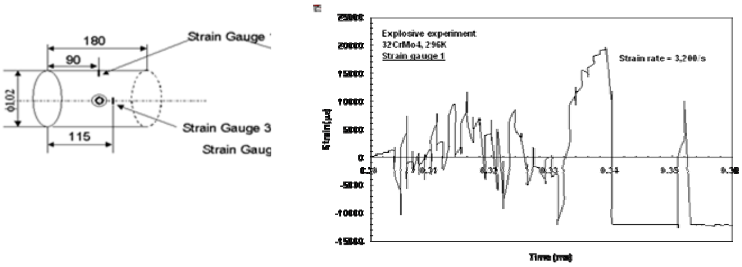

Fig.2 Strain rate change of 32CrMo4 alloy steel during practice explosive tests

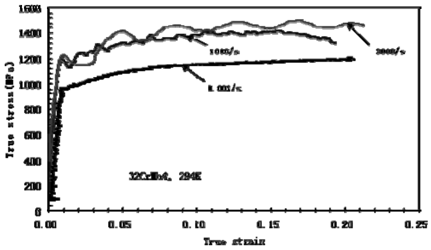

Fig.3 Effect of strain rates on flow stress at an initial temperature 294K

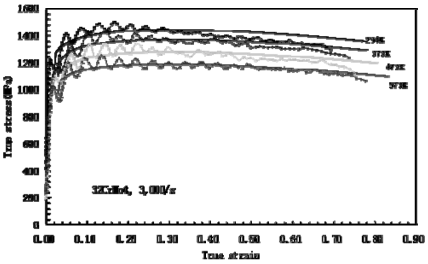

Fig. 4 Comparison of model predictions with experimental results

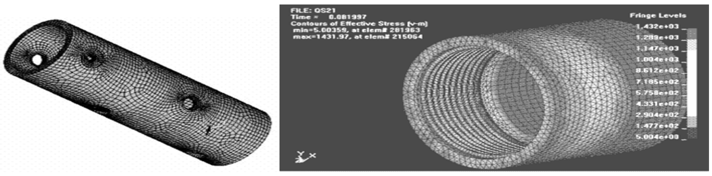

Fig. 5 Computational mode and results for the perforated casing

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