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Residual Life of Pipeline with Volumetric Surface Defect in the Weld Zone

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The present paper investigated the influence of volumetric surface defects located near the weld on the strength and residual life prediction of pipelines. The analysis procedure developed in this study combines the results of an experimental investigation of the stress-strain state and the durability of a full-scale model with finite element analysis. The results of the study revealed that it is necessary to take into account the features of the relative position of the defect and the weld as well as the features of the weld joint material when the residual life of a pipeline is evaluated.

INTRODUCTION

The environment in which main and technological pipelines are operating is characterized by a high loading level and a nonstationary stress-strain state. This creates the prerequisites for low-cycle fatigue failure in the zones of stress concentration, among which volumetric surface defects (VSDs) are most frequent. An engineering procedure has been developed by the Paton Welding Institute to assess the low-cycle fatigue strength of pipelines in the presence of volumetric surface defects, and its validity has been experimentally confirmed (Yukhimets et al., 2005). The main steps of the procedure are:

1) calculating the maximum deformations on the defect surface on the basis of its geometrical parameters and the pressure in the pipeline;

2) finding the allowable number of cycles of load variation observed during operation on the basis of the data regarding the Stress-Strain State (SSS) in the damaged zone and the cyclic properties of the pipe material; and

3) determining the residual life of the pipeline through a comparison of the allowable number of cycles with their number during the previous period of service.

However, the question regarding the application of this procedure to the case of a defect located in the vicinity of the weld is still open as it is anticipated that the results of the calculations made without consideration of the interaction of stress raisers, such as a VSD and a weld, can turn out to be nonconservative.

This paper presents the results of the cyclic hydraulic testing of a full-scale pipe sample with D530 × 8 dimensions and model surface depressions simulating corrosion damage. The results were analysed through an evaluation of the properties of the material, namely the static and cyclic strength, in the characteristic zones of the welded joint (WJ) from a full-scale sample. At the stage of experimental preparation, finite element modeling (FEM) calculations were used to study the features of the stress-strain state of a VSD located close enough to a seam weld.

PRELIMINARY INVESTIGATIONS

An investigation of the mutual influence of stress raisers in the form of a weld and a VSD was performed through the use of a geometrical model of a straight welded seam pipe, whose D530 × 8 dimensions (outside diameter $De = 530$ mm and wall thickness $h = 8$ mm) corresponded to the nominal dimensions of the full-scale sample. The geometrical parameters of the weld of the model pipe (Fig. 1) approximately corresponded to the actual dimensions of the weld of the full-scale pipe (Table 1), while the radius of transition $R = 0.5$ mm corresponded to the arithmetical mean value of butt welds of low-alloyed steel (Trufiakov, 1990).

Calculations were performed through the use of the defect in the form of a half-ellipsoid surface depression with the following

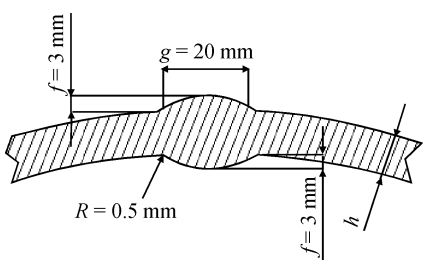

Fig. 1 Main geometrical parameters of the weld of the design model

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