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Thesis Abstract

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Thesis Title

14 pt

Time-dependent Failure at Mechanical Damage in Pipeline

Thesis Summary

Most of failures in gas pipelines occur at mechanical damage by construction works. Although the failures due to monotonic pressure increase have been well studied, time-dependent failures at mechanical damage have been hardly clarified. In this study, hydrogen stress cracking (HSC) due to cathodic over-protection and fatigue failure caused by pressure fluctuations were investigated for damaged pipes.

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Chapter 1 summarizes the background and previous studies.

Chapter 2 describes HSC at a surface defect of pipeline. Three-point bending tests for pipe materials under cathodic protection revealed that HSC occurred only when current density was greater than 1 mA/cm^2 and applied Crack-tip Opening Displacement (CTOD) was larger than a critical value.

Chapter 3 describes fatigue failure at a gouge in a dent of pipeline. Fatigue tests for pipes having a gouge in a dent demonstrated low-cycle fatigue associated with initial ductile crack growth and high-cycle fatigue due to pressure fluctuations; the fatigue failure modes were dependent on fracture toughness of pipes, defect size and pressure conditions. A threshold for low-cycle fatigue was predictable using the parameter Q, a function of fracture toughness and defect size. High-cycle fatigue life was a function of the dent depth, gouge depth and hoop stress amplitude in a power law manner.

Chapter 4 describes ductile crack initiation at a gouge in a dent of pipeline. Three-point bending tests for prestrained pipe materials clarified that plastic deformation reduced fracture toughness (CTOD), in particular, for low toughness pipe materials. The reduction of fracture toughness therefore enhanced ductile cracking as described in Chapter 3.

Chapter 5 describes a non-destructive evaluation (NDE) technique for plastic strain. Magnetic Barkhausen noise (BHN) was measured for prestrained pipe materials. Magnetic field necessary for BHN emission increased with increasing prestrain. This indicated that the present technique enables us to conduct an NDE of mechanical damage in pipeline.

Chapter 6 summarizes the results of this study.