LONG-RUNNING DUCTILE FRACTURE OF HIGH PRESSURE GAS PIPELINES

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Abstract

Long-running fractures have been observed in high-pressure gas pipelines. The phenomenon of ductile fracture propagation is very complex: it is multi-disciplinary, involving interaction of gas dynamics with fracture mechanics and large plastic deformation of the pipe wall and the surrounding backfill.

The dissertation is concerned with a study of ductile cracks, propagating at a constant speed, by means of an energy balance approach. Various aspects of the problem will be studied. The main aim is to improve on previous energy balance analyses of the problem.

Ductile cracks are accompanied by a large amount of plastic deformation of the pipe wall. In particular, the pipe-wall displacement is very large and of the order of one pipe radius. Various energies involved in the fracture propagation process (such as work done by the gas, kinetic energy of the pipe wall, energy dissipated in plastic deformation of the pipe wall, etc) depend strongly on the mode of pipe wall deformation and in particular on the geometry of the deformed pipe wall. The major theme of the present work is a proper consideration of the pipe-wall deformation during the propagation of a ductile crack.

Axial stretching is considered to be the prime mode of deformation of the pipe wall. It is shown that this deformation mode can be adequately described by two parameters which define the pattern of the pipe-wall mid-surface stretching. A shell theory approach is then used to obtain the deformed geometry of the pipe wall in terms of these two parameters. In particular, physical models of the deformed pipe wall are constructed in order to study the large displacement of the pipe wall.

Various energy terms are evaluated in terms of the same two deformation parameters. It is shown that the plastic stretching of the pipe wall provides the main energy dissipation mechanism. An energy balance equation is then developed in terms of the two deformation parameters, which links the major variables involved in the fracture propagation process.

Though a minimisation technique, the two deformation parameters are then eliminated. This finally leads to the development of a new crack arrest criterion.