Markovian Style Analysis of Aging Pipeline Remaining Life

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Abstract

Reliable assessment of the remaining life of pipeline systems (PS) with defects, modeled as a distributed system, plays a crucial role in solving the problems of their integrity.

Residual life is a *random* time of transition of the pipeline from its current condition to a critical or limiting condition.

In this paper authors propose a methodology which allows estimating the time (remaining life) of transition of a PS from its current state to a critical condition, based on available information on the sizes of growing set of defects found during an in line inspection (ILI) and verification or direct assessment (DA).

PS with many actively growing defects is a physical *distributed* system, which transits from one state to another. This transition finally leads to (conditional) failure of its components, each component being a defect. Such process can be described by a Markov process.

The degradation of the PS (measured as monotonous deterioration of its failure pressure) is considered as a non-homogeneous pure death Markov process (PDMP) of the continuous time and discrete states type. Failure pressure is calculated using one of the internationally recognized pipeline design codes: B13G, B31Gmod, DNV, Battelle and Shell-92.

The PDMP is described by a system of non-homogeneous differential equations, which allows calculating the probability of stay of defects failure pressure in each of its possible states. On the basis of these probabilities the conditional remaining life of defects is calculated, i.e. the time from the last ILI or DA to the moment of conditional failure - until the moment of time $t = t_f$, which is the *random variable*, and at this time the failure pressure $P_f\left(t_f\right) \le K \cdot P_{op}$, where $P_f\left(t_f\right)$ is the failure pressure of pipeline defect, P_{op} is the operating pressure and *K* is the strength safety factor. The developed methodology was successfully applied to several real life cases, which are presented and discussed.