Entropy Approach to Assessing Deteriorating Pipeline Residual Strength

S.A. Timashev[1]**, A.V. Bushinskaya**[2]

[1] Science and Engineering Center "Reliability and Safety of Large Systems and Machines" Ural Branch, Russian Academy of Sciences, Ekaterinburg 620049, Russia, timashevs@cox.net

[2] Science and Engineering Center "Reliability and Safety of Large Systems and Machines" Ural Branch, Russian Academy of Sciences, Ekaterinburg 620049, Russia, bushinskaya@gmail.com

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Abstract

The paper describes a novelty approach to estimating the entropy of the residual strength of pipeline system (PS) with many actively-growing defects. Examples of practical application of this methodology are presented.

The process of PS degradation (decrease of failure pressure of the defects) 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 possible range of change of failure pressure (FP) of defects is divided into M non-overlapping intervals. Thus, the structure of FP is a discrete set of states $I_i\left(i=1,..,M\right)$. The probability of this state is the value of $P_i\left(t\right)=P\left\{P_f\left(t\right)\in I_i\right\}$, where $P_f\left(t\right)$ is the FP for the defect.

The probability $P_i\left(t\right)$ is a measure of definiteness of occurrence of event $P_f\left(t\right)\in I_i$. The measure of uncertainty of state I_i is the value of [$-\ln P_i\left(t\right)$], which is called partial entropy and characterizes this state only.

In the associative-structured approach to the process of degradation of residual strength the entropy of the residual strength of the defect is

$$H_d\left(t\right)=-\sum_{j=1}^{M}P_j\left(t\right)\ln\left[P_j\left(t\right)\right]$$

Since entropy is a measure of uncertainty, it has the greatest value at equiprobable distribution, when all the probabilities $P_i(t)$ are equal, i.e., when uncertainty is greatest. The moment of time at which entropy is maximal can serve as an analog of the *conditional remaining life* (*warning* time of failure) of the defect. This approach has a potential of performing the role of early diagnostics of pipeline failure.