Residual Strength Calculation & Residual Life Prediction of General Corrosion Pipeline

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Abstract

General corrosion is of the primary reason that causes the pipeline to failure. Researching the residual strength and residual life of general corrosion pipeline is the main measure to conduct the pipeline integrity management, and has great significance to ensure the safety of pipeline transportation. The calculation of the residual strength of even corrosion pipeline under the combined effects of internal pressure and axial force was discussed according to the Tresca yield criterion in elasto-plastic fault mechanics, when the defected size is given，the maximum permissible operating pressure under the defect and the calculation formula for the residual strength of corrosion pipeline are given. On this basis, reliability-based residual life prediction of the corrosion pipeline was developed.

Nomenclature

D	Inner diameter of pipe	h	Wall thickness of pipe
E_w	Weld coefficient	P	Operation pressure inside the pipelines
F	Axial force in the pipeline section	S	The material allowable stress
η	Design coefficient	σ_s	Minimum yield strength
ν	Poisson ratio	P_{max}	The maximum operation pressure
σ_{Z1}'	The axial stress of pipeline wall under the inner pressure in assumed conditions		
σ_{Z1}''	The axial stress of pipeline wall, under the inner pressure in operation conditions		
σ_{Z1}	The axial stress of pipeline wall under the inner pressure	σ_Z	The axial stress of pipeline
σ_{Z2}	The axial stress of pipeline under the axial load	σ_θ	The hoop stress
P_{hc}	The yield pressure of the current corroded pipeline	$f(\sigma_{ij})$	The stress function in the yield state
P^c_{max}	The allowable maximum working pressure of the axis direction	φ	The safety coefficient
P^θ_{max}	The allowable maximum working pressure of the ring direction	σ_w	The operating pressure of pipeline
σ_{rs}	The residual strength of general corrosion pipeline	$\Phi(\cdot)$	Standard normal distribution function
t	The residual life of general corrosion pipeline		

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1. Introduction

If symbols are used extensively, The oil and gas pipeline always serves in a complicated environment, such as the inner pressure, the axial load and bending load, which causes the pipe to be in a complex stress state [1]. According to the morphological characteristics of the corrosion defects of pipeline, the corrosion defects can be divided into three categories: general corrosion, local corrosion, pitting corrosion [2]. Among which, general corrosion is the primary failure form. So it is very necessary to deduct a deeply research on residual strength and residual life of the oil and gas pipeline, with general corrosion under complex stress state. Oil and gas pipeline always works with high toughness and complex forced situation, therefore, the elastic-plastic behavior of the pipeline must be considered, and conduct analysis based on the elastic-plastic fracture mechanics. The calculation of the residual strength of even corrosion pipeline under the combined effects of internal pressure and axial force was discussed according to the Tresca yield criterion [3] in elasto-plastic fault mechanics, when the defected size is given，the calculation formula for the residual strength of corrosion pipeline are given. On this basis, reliability-based residual life prediction of the corrosion pipeline was developed.

2. The residual strength calculation process and mathe- matical model

2.1. Calculation process

Residual strength is of the ultimate bearing capacity of the structure before the internal crack damage. Residual strength calculation can determine whether the pipeline can meet the safe operation requirements of carrying capacity with the current corrosion state and quantify it, so as to make sure the maintenance and the safety of pipeline under a scientifically supervise. Based on the specification sizes of the oil and gas pipelines and related mechanical model assumptions, residual strength calculation process of general corrosion pipeline are given, as shown in figure 1.
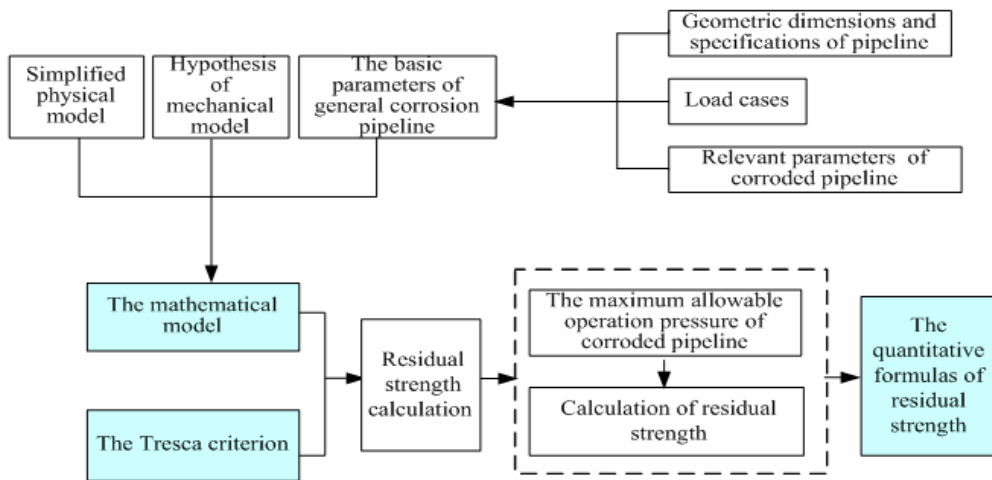

Fig. 1. Residual strength calculation process of general corrosion pipeline.

2.2. The mathematical model of general corrosion pipeline

This paper takes the following hypotheses in conditions of reasonable simplified the actual problem for the convenience of studying problem: ①.Stress hypothesis. The corroded pipeline bears the inner pressure and axial force, which evenly distribute in the respective surface [4]; ②.Condition hypothesis. Corroded pipeline always meets the simple load cases and the Tresca criterion, in the condition of ignoring elastic deformation.

Oil and gas pipeline is infinite long in practical engineering, for the convenience of analysis, a section with general corrosion is picked to conduct a micro-unit analysis, as shown in figure 2(a). The force analysis of the pipeline section is as shown in figure 2 (b)、figure2(c).