Reliability Analysis of Low Alloy Ferritic Piping Materials

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Abstract The aim of this study is to improving microstructure and mechanical properties of the weldable gas pipeline steel using laboratory mill. To achieve the required microstructure and mechanical properties of thermo mechanically processed HSLA steels, it is necessary to have an idea about the role of composition and process parameters. The large numbers of parameters obtained during the production process in the plant were systematically changed to optimize the strength and toughness properties. The optimized parameters were used for the production of the API X60/X70 steel. However, the controlled cooling after rolling should result in transformed products that provide excellent combination of strength and toughness. The coiling at an appropriate temperature have the advantage of the precipitation strengthening, giving further rise to the high yield strength and also improvement in toughness of the steel. The coiling temperature is a decisive parameter because it determines the beginning of the formation of fine precipitations. Therefore, four different laboratory cooling systems were used, in this study to simulate the rolling conditions of a real industrial Thermomechanically controlled process, as close as possible and to check the possibilities of improving the mechanical properties of the welded pipeline steel.

Keywords: Micro Alloying, TMCP, Controlled Rolling, Controlled Cooling, Processing Parameters, Mechanical Properties.

1. Introduction

Piping systems experience fatigue damage as a result of anticipated plant transients (e.g. rapid cooling of the piping during auxiliary feed water initiation following a scram) and because of unanticipated transients (e.g. check valve leakage) [1]. This paper describes the probabilistic fracture mechanics computer code and structural mechanics modelling approach used to simulate the effects of these cyclic fatigue stresses on the reliability of reactor piping.

Probabilistic fracture mechanics (PFM) calculations often assume that the stress state in the pipe wall is uniform through the wall thickness. This approach is appropriate for stresses as a result of internal pressure and for bending stresses as a

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result of the thermal expansion of pipe systems, but does not address through-wall stress gradient as a result of radial thermal gradients or geometric discontinuities [2]. This paper describes modifications to pc-PRAISE to provide capabilities for probabilistic analysis of fatigue-crack initiation and growth. This expanded version of the software is referred to as Version 4.2. The PRAISE code was originally developed to provide a probabilistic treatment of the growth of crack-like weld defects in piping due to cyclic loading [3]. This treatment of fatigue-crack growth was later expanded to include the initiation and growth of stress corrosion cracks [4]. The software was then made to run on a personal computer for ease and economy of use [5]. The purpose of the efforts reported herein is to expand the capabilities of PRAISE to include a probabilistic treatment of fatigue-crack initiation. The current capabilities for analyzing fatigue-crack growth are then used to continue the calculations to crack penetration of the pipe wall. The schematic diagram of the steps in the piping reliability calculations by pc-PRAISE are presented in Fig. 1.

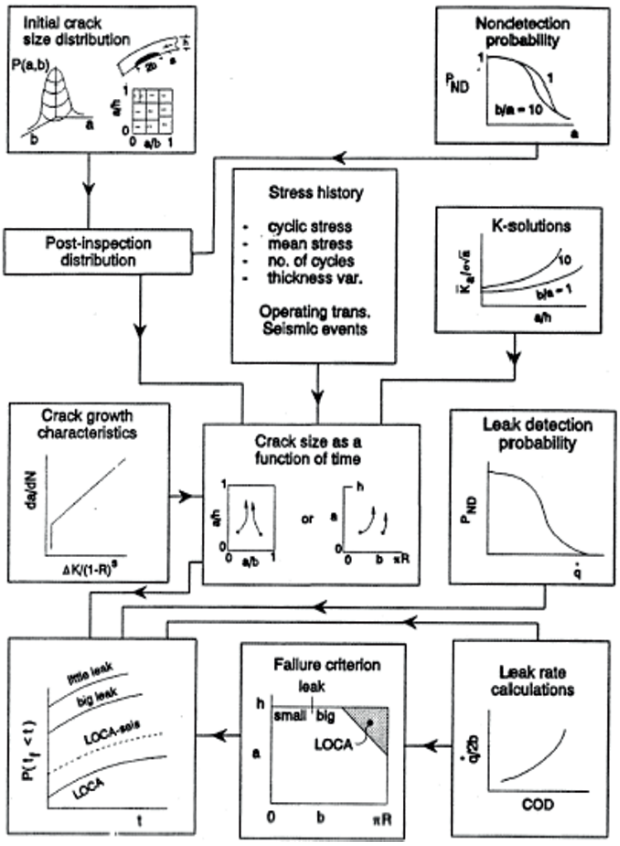

Fig. 1. Schematic diagram of piping failure probability calculation as performed by pc-PRAISE (baseline case)