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NUMERICAL MODELLING OF PIPELINE CONSTRUCTION

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ABSTRACT

During the construction of pipelines, the girth welds, which join pipe sections, are placed under various stresses. The stresses are due to mechanical handling loads such as those that occur when lifting the front end of the pipeline to place it on supports as well as thermal stresses due to the welding thermal cycle. These stresses, combined with the presence of hydrogen from cellulosic electrodes, can produce hydrogen assisted cold cracking (HACC) in the root pass of pipeline girth welds. HACC can cause catastrophic failure of a pipeline girth weld. By reducing the residual stress and hydrogen concentration experienced in a pipeline girth weld, the risk of HACC is also reduced. The method used in this study to reduce the residual stress and hydrogen concentration is modification of the construction procedure.

A numerical model of the pipeline construction process has been created. After surveying the literature this appears to be the first model capable of modelling the process in a transient sense. This is extremely useful as the residual stress and hydrogen diffusion is not only dependant on the application of process parameters but also their timing.

In order to validate the modelling scheme developed, an experiment was conducted using the 'Blind Hole Drilling' strain gauge method of residual stress measurement. There was sufficient agreement between numerical and experimental results to indicate that the numerical modelling procedure was capable of conducting a study of pipeline construction.

The use of cellulosic electrodes for the welding of pipelines in Australia is preferred. Such electrodes possess certain favourable running characteristics suited to pipeline construction but unfortunately produce a very large amount of diffusible hydrogen, leading to saturation of the weld metal. The diffusion of hydrogen has been modelled using a scheme based on Fick's Second Law of Diffusion. The parameters reported to dominate the rate of diffusion are the timing of the weldment passes, the joint geometry, pre-heating and post-heating, all of which have been investigated in this thesis.

This study has highlighted the influence of process parameters on the resulting residual stress and hydrogen diffusion. By analysing the pipeline construction process in a transient sense, an understanding of the transient risk of HACC has been developed. This has enabled recommendations regarding procedural changes to be made to the pipeline industry.

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