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Abstract

Pipe grade is a dominant parameter in a pipeline's service life. Critical decisions on the design, construction, and maintenance of pipelines are made on the basis of pipe grade. The implied assumptions or expectations are that pipes of the same grade would behave similarly and the experiences with a particular grade can be applied to all pipelines of the same grade. This simplification does not adequately take into account the other characteristics that are not represented by pipe grade, but can play a critical role in the safe and economical operation of pipelines. For instance, the evolution of steel-making processes and advancements in field welding practice can lead to significant differences in weld behavior among pipes of the same nominal grade.

Most of the design, construction, and maintenance practices in the pipeline industry were established before the extensive use of modern control-rolled and microalloyed steels. With the exception of a few isolated research projects, the impacts of the fundamental changes in the steel metallurgy in modern microalloyed steels have not been systematically examined and understood. For instance, these steels may have very low strain-hardening capacity as a result of the TMCP process and may be subject to high levels of heat-affected zone (HAZ) softening due to their ultra-low carbon low-hardenability steel chemistry. HAZ softening reduces the longitudinal pipe strain capacity of girth welds, and low strainhardening can potentially have a negative impact on tolerance to anomalies such as corrosion or mechanical damage.

This paper starts with a brief review of linepipe manufacturing history with a focus on the chemical composition and rolling practices that directly affect the mechanical properties and the response to welding thermal cycles. The characteristics of linepipes made from modern microalloyed steels are contrasted with those made from vintage hot-rolled and normalized steels. The resulting mechanical properties of these two types of materials in the presence of welding thermal cycles are presented, and compared in terms of their behavior.

The consequence of the weld characteristics is shown using examples of girth welds subjected to longitudinal strains. The implications of the pipe and weld characteristics on the design, field girth welding, and maintenance of pipelines are highlighted. Future directions and best practices in linepipe alloying and manufacturing strategies, linepipe specifications, field girth welding, and building strainresistance girth welds are briefly described. It is emphasized that assessing the performance of pipelines based on their grades has fundamental shortfalls, and that gaps in codes and standards can lead to unexpected outcomes in pipeline integrity. In the long-run, revising relevant codes and standards is necessary to ensure consistent and reliable applications of new materials in the entire industry.

Keywords

Linepipe, Modern microalloyed steels, Vintage pipelines, Girth weld, HAZ softening, Strain capacity