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Replacing natural gas with Hydrogen in heat treatment furnaces: impact on scale formation, surface quality and pickling kinetics of stainless steel

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This study investigates the effects of replacing natural gas with Hydrogen in heat treatment furnaces for stainless steel strip (both austenitic and ferritic grades). Using Hydrogen as a fuel, the vapor content in the furnace atmosphere increases, which could affect the characteristics of the oxide scale, including its composition, thickness and adherence to the base metal. Eventually changes in scale characteristics may subsequently impact on scale removal processes, such as descaling (mechanical or electrolytic) and pickling, thereby influencing the kinetic and quality of the steel surface.
The experimental scenario was defined to verify the effects of the combustion atmosphere simulating the annealing process and the subsequent scale removal process of three types of stainless-steel products AISI 304, AISI 316L and Type 441, either cold or hot rolled.
The stainless-steel samples underwent oxidation and annealing tests in both 100% natural gas and 100% Hydrogen combustion atmospheres at three different thermal cycles, specific for each steel grade. After the thermal treatment the oxidation state of the scale formed in both combustion atmospheres was analyzed using advanced techniques such as scanning electron microscopy (SEM), energy-dispersive spectroscopy (EDS) and Glow Discharge Optical Emission Spectroscopy (GDOES) to characterize the morphology and chemical composition of the formed oxides. A comparative analysis was performed to find the differences among the scale characteristics formed in the two combustion atmospheres.
Once the scale was characterized, the effect of the combustion atmosphere on scale removal was studied. An experimental comparison was made by determining the minimum pickling time (through visual inspection and weight loss comparison) and the impact on productivity. For a more in-depth evaluation, the surfaces of the samples were analyzed using SEM and optical microscopy.
This research underscores the potential of Hydrogen combustion as a sustainable alternative to natural gas, with no carbon emissions in annealing furnaces.

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