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Effect of hydrogen oxyfuel combustion on oxide scale descability by thermal shock for low-carbon steels

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Steel industry is in transition concerning heating methods due to requirement to reduce CO2 emissions. Use of hydrogen as a fuel in combustion for heating makes the reheating furnace a possible method to reduce use of fossil fuels. Furthermore, oxyfuel combustion increases efficiency of the heating process compared to air-fuel method. The complete combustion of the fuel is ensured by excess oxidant, providing free oxygen in the furnace atmosphere. Free oxygen content is kept low in industrial reheating furnace to prevent excess oxidation caused material losses. After reheating process, oxide scale formed on the steel surface is removed by water jet descaling to provide clean surface for hot rolling process.

Oxide scale formation of two low carbon steels is investigated in isothermal tests at 1200 ℃ for 2 hours with methane-air and hydrogen-oxygen combustion atmospheres using free oxygen contents of 1% and 6%. Both steels contained silicon, but steel A had higher amount of manganese and steel B had higher amount of chromium and nickel. Descaling efficiency of oxidized samples is studied by thermal shock, dipping the hot sample in water vessel straight from the furnace. Characterization for oxidized and descaled cross-sections of samples was performed by digital microscopy and field-emission scanning electron microscopy (FESEM).

Steel B produces less oxide scale in all studied atmospheres. Hydrogen combustion simulations produce more oxide scale compared to methane due to higher water vapor content, increasing oxidation. Higher free oxygen content has increasing effect on amount of oxide scale and outer layer of oxide scale changes from sharp shaped wüstite to levelled magnetite on the top of the wüstite layer.

Hydrogen combustion simulations decrease the amount of oxide scale detached from the sample for both steels. Surface layer of oxide scale from methane-air with 1% O2 simulations was weak and its fall off by small pieces, while hydrogen-oxygen with 1% O2 had stronger surface layer. Although Steel B was less oxidized, its descalability was weaker compared to Steel A. After hydrogen-oxygen heating with both O2 contents, descaling caused only cracking inside the oxide scale without any part of oxide totally detached out for Steel B, while part of the oxide scale detached out from the sample for Steel A. Thus, increase of water vapor based on hydrogen fuel and oxyfuel method, and oxygen content of furnace atmosphere influence formed oxide scale and its strength against thermal shock.

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