OXIDATION POTENTIAL AND BARRIER EFFECTS OF CR-BASED COATINGS ON ALUMINIZED PRESS-HARDENED STEELS

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Key Words: Aluminized Press Hardened Steel – hydrogen prevention – barrier coating – Physical Vapor Deposition

Press-Hardened Steels (PHS) offer an interesting compromise between reaching ultra-high strength and enabling a sufficient formability. This sequence of austenitization followed by simultaneous quench and forming in the press is indeed widely used in the automotive industry. For this process, PHS are commonly protected from external atmosphere through the use of Zn- or Al-Si-based coatings. Those coatings are generally deposited by hot dipping and continuously evolve during high temperature operations through interdiffusion, oxidation phenomena and intermetallic formation. The metal surface constitutes the first entry site for hydrogen ingress. Indeed, hydrogen sources are often present in the atmosphere, generally in the form of water vapor, and allow hydrogen uptake by the material, furthermore, enhanced during high temperature operations through an oxidation process. Therefore, PHS could be subject to hydrogen embrittlement, in case of detrimental conditions or severe load.

Many different solutions to avoid hydrogen embrittlement are explored in the literature: deep trapping in the metal microstructure, formation of specific phases,… In this work, the application of barrier coatings to impede or delay hydrogen absorption for aluminized PHS is investigated. The coatings are deposited by Physical Vapor Deposition prior to austenitization heat treatment. Efficient barrier effects (down to 50% diffusible hydrogen reduction) are observed for 200nm-thick Cr and NiCr coatings.

This work is focused on hydrogen-metal interactions during heat treatments for PHS with/without the barrier coatings and in atmospheres containing humidified air or nitrogen. For this purpose, the barrier effect is evaluated by hydrogen thermal desorption quantification. Surface and microstructure evolutions are characterized through microscopy and surface techniques (such as x-ray photoelectron spectroscopy, glow-discharge optical emission spectroscopy, …). Hydrogen measurements and microstructure examinations aim at understanding the mechanisms of barrier effects in relation with the oxidation potential. The hydrogen uptake and consequently, the associated efficiency of barriers are observed to be dependent on the used atmosphere oxidation potential during austenitization. Indeed, smaller hydrogen uptake occurs in air compared to humidified nitrogen atmosphere. The barrier efficiency changes with the coatings and the oxidation potential. The application of barrier coatings offers the main benefit that the internal structure of steel is not altered, allowing it to keep its mechanical and chemical properties in both atmospheres.