

Study of the hydrogen introduction in bare and Al-Si coated steels during the hot stamping process

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Abstract

The development of new ultra high strength steels is driven by the economical and ecological challenges of the automotive industry coupled to safety considerations. The hot stamping process of Al-Si coated steels ensures these strength levels and, moreover, allows an easy forming of the material without the need of a protective atmosphere. However, to support further developments, the hydrogen embrittlement issue must be addressed. Indeed, at high temperature, the coating is hydrogen-permeable, while this is no more the case at lower temperature (below 120°C). In this context, the aim of this work is to understand how hydrogen enters in the material during the austenitization treatment with respect to different atmospheric sources. It is worth noting that a difficult aspect of this study is the continuous evolution of the material during the hot stamping process. At room temperature, the coating is indeed a solid Al-Si alloy, which has weakly reacted with iron during deposition. As temperature increases, this coating first melts and then forms ternary Al-Fe-Si intermetallic compounds which will remain after the quench.

The influence of different hydrogen sources has been studied: water vapour, which is probably the active source in the industrial process and dihydrogen, a more fundamental study case. Heavy water vapour (D₂O) is also used to ensure a controlled atmosphere in the furnace, while it allows avoiding misinterpretation that could arise with the dissociation of water into hydrogen.

The diffusive hydrogen present in the bare and coated samples as a function of the annealing conditions (time and atmosphere humidity) has been quantified owing to thermal desorption analyses (TDA). Metallographic observations of the surfaces of the samples and glow discharge optical emission spectroscopy (GDOES) analyses have also been correlated with the atmosphere parameters to understand how the equilibrium between atmospheric and diffusive hydrogen can be established. Finally, an original methodology has been developed with the TDA to understand the coating influence on the water dissociation.