ORA101

Development of a model to predict the s-phase thickness of plasma nitrided austentitic steels

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Austenitic steels are known for their high corrosion resistance but at the same time possess low hardness which results in low wear resistance. A common way to improve the tribological properties of austenitic steels is plasma nitriding. The formation of the so-called s-phase leads to a strong lattice distortion in the surface area which leads to an increase in the hardness. At the same time, in order to retain the corrosion resistance, process parameters such as temperature and duration must not exceed a certain threshold, otherwise chromium nitrides may be formed.
The aim of this study is to develop a model which predicts the thickness of the s-phase in plasma nitriding processes. For this purpose, a number of processes were executed and analyzed under specific variation of temperature ranging from 360 °C to 450 °C and duration of 10 to 24 h. Other process parameters such as voltage, pressure, pulse-pause ratio and gas mixture remained constant. A temperature dependent growth rate could be determined after the analysis of the results. On one hand this allows to predict the thickness of the s-phase for any given treatment temperature and process duration in the given temperature window, while on the other hand one of the two process parameters regarding treatment temperature and process duration can be explicitly selected via iso-thickness progressions line and combined with the other to obtain the required thickness of the s-phase.
In this way a possible formation of chromium nitride by the plasma treatment can be avoided. The developed model was verified by control experiments and shows a maximum relative error of 5.5 %.
The model is currently being extended by an additional parameter, namely the chemical composition of the material, in order to enable transferability. A factor for the transfer of the nitriding depth to other microstructures or steel classes is also conceivable. Subsequently, additional factors for other process parameters, e.g. voltage, gas mixture or pressure, will be included.

Keywords
plasma nitriding
s-phase
model