Extending component lifetime by making right design choices:

mix-material Audi A6-door model evaluated by Elsyca CorrosionMaster technology

The longevity of the structure is often affected by the initial design, where the critical material choices are made. To prove that, mixed multi-materials Audi A6-door model has been evaluated toward galvanic corrosion risks (corrosion initiation sites and corrosion intensity) by means of Computer Aided Analysis (CAA) approach. The Elsyca CorrosionMaster simulation technology has been used for this purpose. The obtained simulation results clearly indicate that undertaking predictive modeling practices in an early phase of the component design is instrumental in proper material selection for mixed multi-material assemblies.

In the age of new metallic materials development, which is strongly demanded by the automotive industry, the effectiveness of the proper materials selection is a major challenge, as a corrosion engineer is not usually involved in the early stages of the component design. The design validation activities are mainly focused on Finite Element Analysis (FEA) regarding the structural performance of the materials and flow simulations for the casting process. The corrosion resistance analysis is often overlooked or is not given the required priority, which can result in a design modification or a complete redesign if the component will not pass the final corrosion testing. This implies a significant time, cost and schedule impact on the entire product delivery.

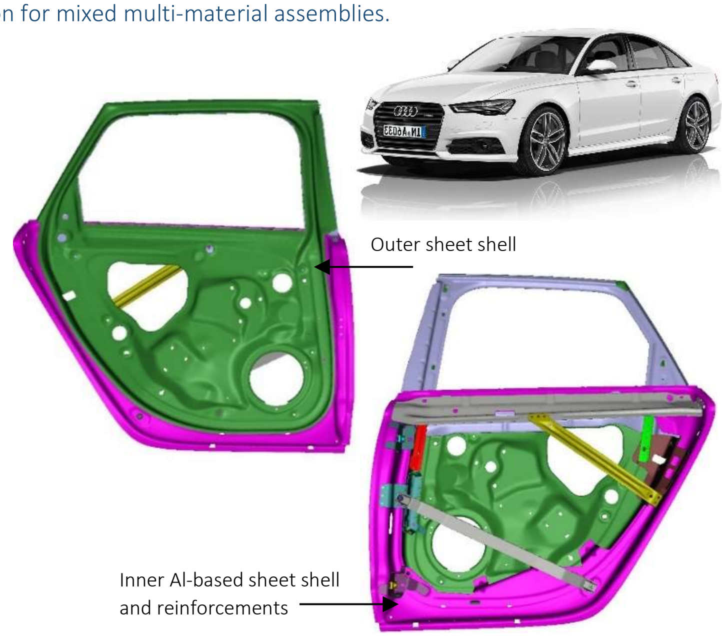

Fig. 1. 3D model of Audi A6 door used by Elsyca CorrosionMaster technology for corrosion risk assessment of a mixed-material vehicle body.

Predictive simulation of the corrosion hot spots

In lieu of the above, a systematic investigation of the materials compatibility needs to be undertaken already at the design stage. In this context, Computer Aided Analysis (CAA) delivers a fast and robust qualitative analysis of the potential corrosion risks on mixed multi-material 3D computer models. The predictive modeling approach employs a FEA method to solve the fundamental electrochemical equations that govern the corrosion phenomena: Laplace equation, Ohm's law, Faraday's law and polarization behavior (change of the metal potential under the flow of an external current).

Elsyca has an extensive and successful track record in CAA projects, utilizing computer simulation methods in order to evaluate galvanic and galvanic + atmospheric corrosion risks on geometrically challenging and mixed multi-material assemblies. The in-house developed Elsyca CorrosionMaster simulation technology has been used to validate several complex designs with regards to corrosion initiation sites (hot spots) and corrosion intensity (corrosion rates). The simulation approach is based on materials database created at the stage of laboratory experiments (DoE), executed by corrosion engineers. The DoE aims to gather electrochemical information on the corrosion kinetics of the specific substrate material exposed to a corrosive environment for which the material will be required to operate in. The generated polarization data is used as a direct input for the predictive modeling.

Elsyca has performed such CAA study on Audi A6 3D-door model (Fig. 1) as provided by Audi AG, a global automotive OEM. Traditionally, the outer and inner panels of the car door are built from steel. Nevertheless, vehicle doors are one of the most interesting car parts for evolving to light weight vehicles since the potential for total weight reduction of one door panel is quite significant - about 17% when compared to the conventional all-steel door panel. Furthermore, weight reduction of the outer side of the vehicle body shifts the center of gravity toward the center of the vehicle, contributing to improved stability in vehicle maneuvering. Thus, the application of lightweight materials for door panels, such as Al, improves the requirements towards lightweight mobility concepts. Moreover, the life service of such lightweight vehicle body is improved as the materials used have high corrosion resistance properties.

A solid baseline for better material choices

Audi A6-door body is a great example in this case: the Al-based (mixed with Steel and other alloy materials) concept has been used in the production for many years now and no corrosion problems have been identified so far. Thus, some great engineering practices have been implemented by Audi's team in order to prevent corrosion risk issues built by design. One of such is the use of corrosion predictive modeling.

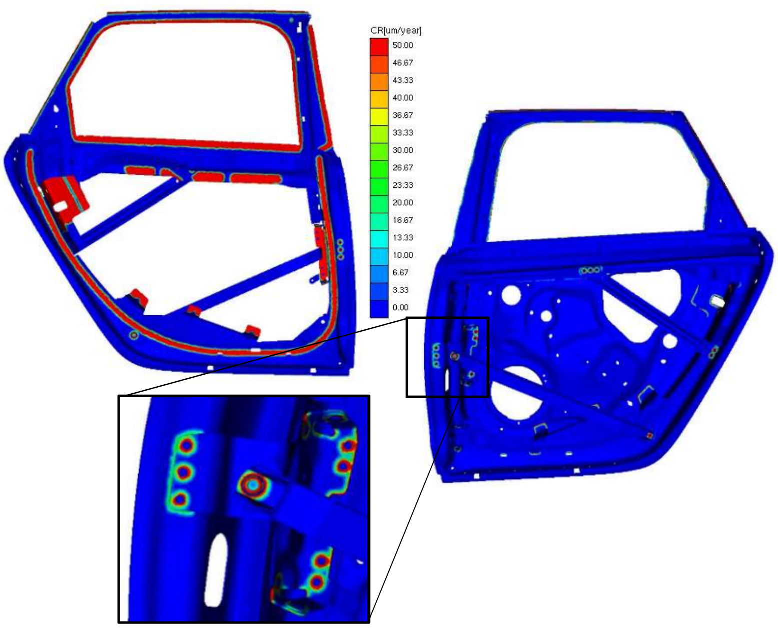

Fig. 2. Identified galvanic corrosion hot spots for Steel-based outer sheet shell and Al-based inner sheet shell and reinforcements.

In order to demonstrate the use of such predictive approach, the Elsyca CorrosionMaster galvanic simulation considered two model scenarios which differed in the outer sheet shell material selection, using either Al- or Steel-based materials. The characteristics of the thin film electrolyte were based upon the industrial environment referred to as a low salinity rain water.

In the first simulation, the model was composed of a Steel-based outer sheet shell, an Al-based inner sheet shell and Zn-galvanized steel rivets and screws. Figure 2 indicates galvanic corrosion hot spots (red/green surface areas) that are located on the interconnections between the outer Steel-based panel and inner Al-based panel. The Zn-galvanized steel rivets and bolts are completely corroded (red spots).

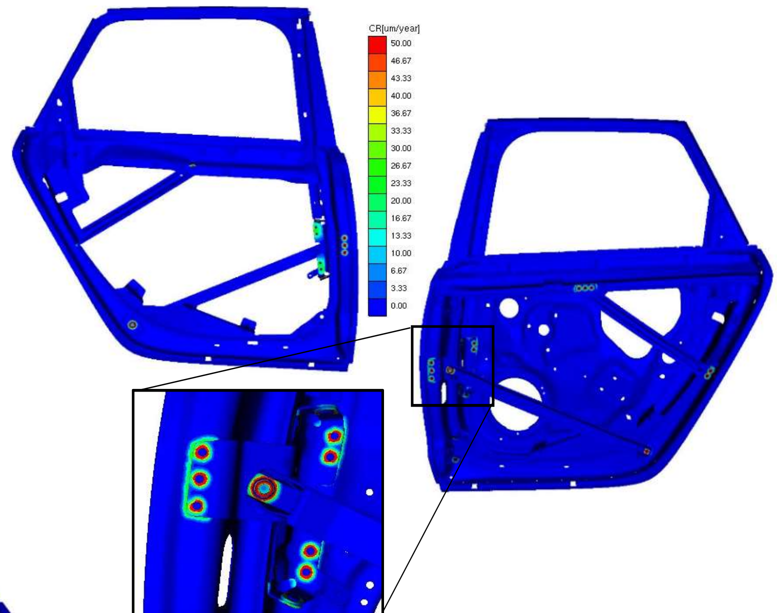

Fig. 3. Identified galvanic corrosion hot spots for Al-based outer sheet shell and Al-based inner sheet shell and reinforcements.

The second simulation case considered a scenario where both outer and inner sheet shells were made of Al-based material while all the rivets and bolts were Zn-galvanized steel based (Fig.3.). In contrast to the previous case, the galvanic corrosion CAA indicated corrosion hot spots appearing only on and around the Zn-galvanized rivets and at the bolts (red/green surface areas).

From find-it/fix-it towards predict & manage

The CAA study also provides information on the corrosion rates, which in case of the predictive modelling would typically indicate the worst-case corrosion attack. In this sense, the corrosion intensity results should be predominately considered in terms of qualitative information rather than quantitative one.

Nevertheless, computer modeling provides a great opportunity to associate corrosion risks already at the design stage, permitting to implement proper mitigation strategies long before the actual component is manufactured and begins its service life.