Predictive modeling of surface degradation and materials damage of metal alloys

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PEO coated extruded magnesium tested in slow strain rate configuration (eugen.gazenbiller@hereon.de)

Mechanical damage induced failure within protective coatings is one of the main reasons for loss of coating integrity. Thus, for applicability of any coating and sealing technology it is mandatory to know the stress/strain levels at which mechanical component failure will occur and it is important to understand which physical entities drive damage initiation and propagation. Within this work a model has been developed which allows to correlate and study the effect of brittle porous coatings on the stress-strain curve evolution of plasma electrolytic oxidation (PEO) coated extruded Mg substrates. This is a great benefit as deriving material laws might be challenging since measured stress-strain relationships are a convolution of substrate and coating material contribution. The approach is based on a damage model which allows to distinguish between the substrate contribution model as a bulk body described by dedicated material laws, and the brittle coating contribution mathematically modelled as a boundary condition. The effect of coating thickness, the resulting steady state crack spacing and the contribution of coating porosity on the stress-strain curve is shown. The approach allows direct estimation of PEO coating barrier properties from slow-strain rate tensile testing.

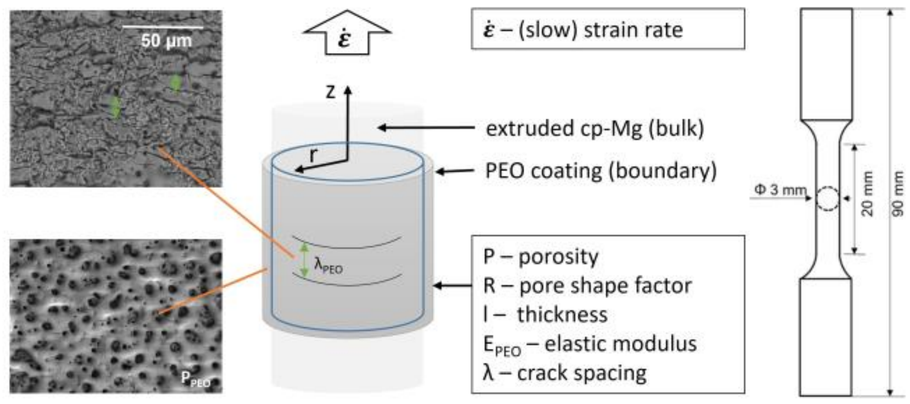
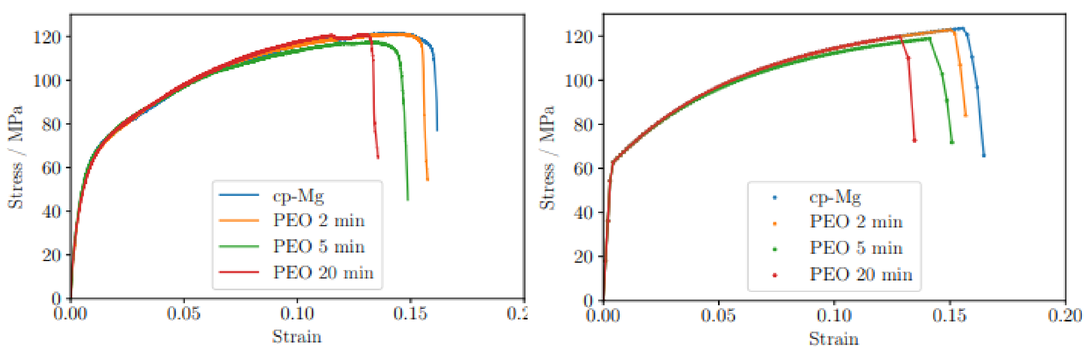


Fig.1 Problem description with relevant parameters of PEO coated cp-Mg.



a) Experimental values b) Simulated values

Fig.2 Experimental and simulated stress-strain curves of bare cp-Mg and PEO coated specimen.[1]

[1] E.Gazenbiller, S.Mansoora, N.Konchakova, M.Serdechnova, M. Zheludkevich, C. Blawert, D.Höche Computational damage modelling of PEO coated extruded magnesium tested in slow strain rate configuration.Surface and Coatings Technology . Volume 446, V.25 2022, pp. Article 128758

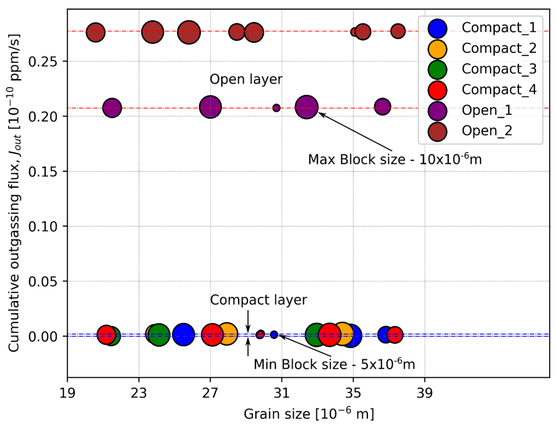


Fig. 3 The cumulative outgassing flux over grain size for outgassing simulations at 230°C performed on the metal-coating structures. The size of the markers denote the block size in the steel substrate.

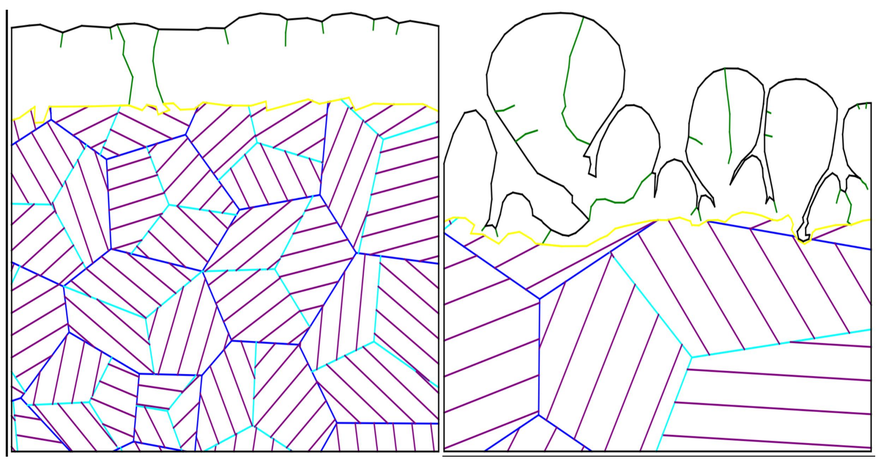


Fig. 4 The geometry of the outgassing simulation domains, which includes the metal substrate, coating, interface and microcracks. Two selected geometries with the compact layer (left) and open layer (right) are shown here

Numerical Estimation of the Residual Life-Time of the Elements of the Centrifugal Pump of the Energy Station Due to Corrosion Wear (kseniia.potopalska@hereon.de)

Using modern technologies of computational and mathematical modeling the calculations of pump body for defining its stress-strain state taking into account the change thinness of body details was carried out. The three-dimensional CE models were created, which take into account the actual geometry of the pump parts and the predict of its possible change for the period of extended time work. Estimation of static strength was performed for the main operating mode of the pump (under normal operating conditions). The statistical deformed state of the structure was investigated with taking into account the predicted values of the percentile pump wall thinning. On the basis of statistical data, the damage parameter and the probability of failure-free structure operation was determined.

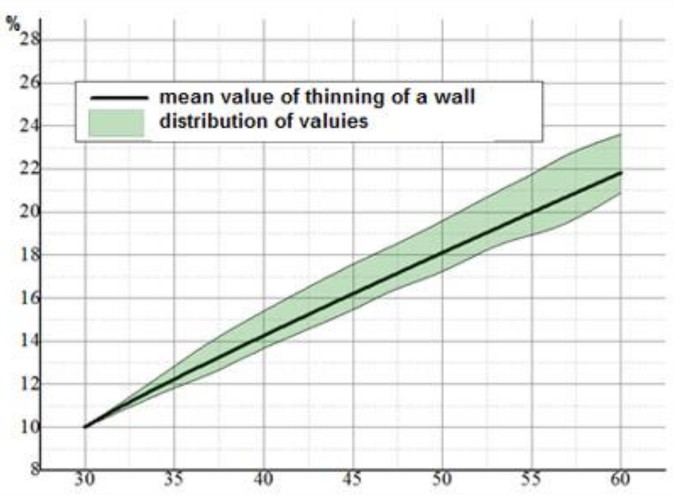


Fig. 5.Operation time-dependent percentile pump case wall thinning values distribution.

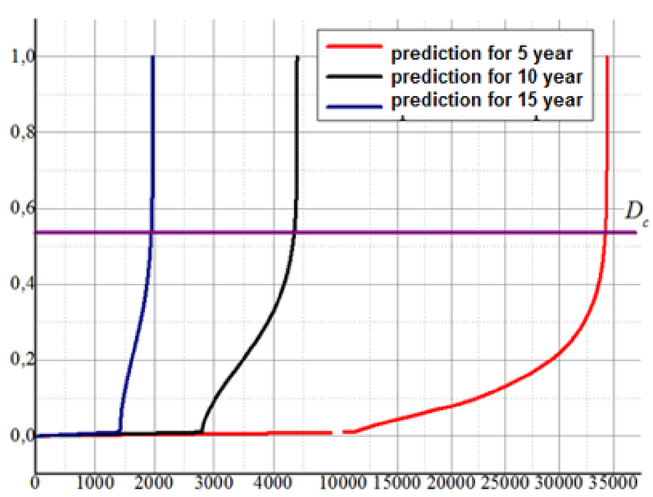


Fig. 6. Damage parameter mean value when predicting 5, 10 and 15 works over the design period

Hydrogen outgassing in martensitic steels with ZnNi coating. (aravinth.ravikumar@hereon.de)

The prevalent disadvantage of using ultra-high strength martensitic steels is their susceptibility to HE. Herein, a finite element model is developed to capture the transport of hydrogen in plated UHSS during hydrogen embrittlement relief treatment (degassing). Naturally, the morphology of the plating plays an important role in the degassing efficiency and the grain structures, grain boundaries, trapping sites and residual stresses dictate the diffusion of hydrogen in the steel. Thus, microstructural images are analyzed to understand the microstructure, distribution of the phases and grain structure of the UHSS and the plating, and are subsequently utilized to create the geometry of the model. The underlying equations account for the surface reactions leading to the release, reflection back into the steel lattice and inflow due to the difference in partial pressure of hydrogen across the surface. The computational model is calibrated using experimental data for 300M steel with different plating morphologies, and finally a workflow is established to determine the concentration of hydrogen in a part after hydrogen embrittlement relief treatment.

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