Digital twinning to predict the residual life of composite pressure vessels - COMPLAS 2021

Nesrine Klebi[1*], Pierre Kerfriden[1,2], Basile Marchand[1], Alain Thionnet[1]

[1]Mines ParisTech, PSL University, MAT - Centre des Matriaux, CNRS UMR 7633, BP 87, 91003 Evry, France
*nesrine.klebi@mines-paristech.fr, pierre.kerfriden@mines-paristech.fr

[2]Cardiff University, School of Engineering, Queen's Buildings, The Parade, Cardiff, CF24 3AA, United Kingdom

ABSTRACT

Predicting the residual life of an in-service composite structure remains a major challenge in today's industry. This is mainly due to the non-homogeneous nature of these materials. In particular, the damage evolution mechanisms, as they appear on a relatively small scale compared to the structure's scale, plus the brittle aspect of the failure. Current solutions to diagnose damage patterns in a composite structure are mainly carried out experimentally with **N**on **D**estructive **T**esting [1], using either active or passive **NDT**. However, employing these techniques, we are not able to describe neither the overall state of the structure and its degradation, nor its remaining lifetime. To overcome these difficulties, we propose a damage prediction approach via the use of digital twinning, where a numerical model will progressively assimilate data and provide damage states as time advances.

Finite Element models, such as FE^2, could be utilized to outline the evolution of damage within composite materials and to describe their behavior on multiple scales. However, due to its extreme computational cost, many alternative-FE^2-based techniques are put forward to re-model the structures. One known approach is the process of meta-modeling, where we construct an homogeneous constitutive model at the mesoscale, which implicitly embeds the FE^2 constitutive generality and improves it.

In this work, we will present the homogenized mesoscopic constitutive model based on an improved FE^2 model [2,3] and its validation. Thus, we intend to predict the residual lifetime of a **C**omposite **P**ressure **V**essel using data assimilation. The state estimation method will be the **E**nsemble **K**alman **f**ilter [4] where the determined model will be merged with external information, namely acoustic hit measurements to model the pressurized tank during its service, and will manage to assimilate data coming from sensors placed on the structure to construct sequential damage states with an optimal computational cost.

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