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## Modelling the influence of clustered defects on HCF properties of Ni-based superalloys

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### ABSTRACT:

Casting defects like shrinkages and pores are very detrimental for material's High Cycle Fatigue (HCF) performance. It is known that defect's size and their location from free surface are the most important parameters to take into account regarding HCF properties. However, this conclusion is questionable in the case of clustered defects: specimen lifetime seems to also depend on other characteristics of the defect cluster. The distribution of defect size in an individual cluster is found to be dependent on clustered defects volume and thus influencing the ASTM grades of the material. The gradient associated to the same isolated defect is modified in the presence of cluster further modifying the fatigue predictions via non-local approaches like volumetric homogenization.

However, this type of analysis requires a very large number of three-dimensional observations of casting defects dataset which is impractical and very expensive. Therefore, in this work, a Generative Adversarial Network (GAN) is integrated with Convolutional Neural Network (CNN) to generate synthetic defects (see figure 1.a) and are distributed in material space with the aid of spatial point pattern analysis of defects to generate synthetic microstructures that mirrors real specimens as shown in figure 1.b. Four Inconel 100 and nine Rene 125 specimens tomographed via X-Ray Computed Tomography have been used to study the spatial point pattern of defects and to train Deep Neural Networks (DNN). Spatial point pattern analysis helps to understand how the defects are distributed in material space whilst GANs generate synthetic defects which can be placed randomly respecting the statistics of real specimens.

These N synthetic samples are submitted to numerical simulations to exploit the fatigue behavior via non-local approaches, see figure 2. Furthermore, some of the important features of defect clusters such as, defect volumes, cluster thickness, density of defects in a cluster etc., are controlled to analyze the influence on stress gradients in the synthetic microstructures.

### KEYWORDS:

Ni-based Superalloys; HCF; Deep learning; X-ray Tomography; Casting defect

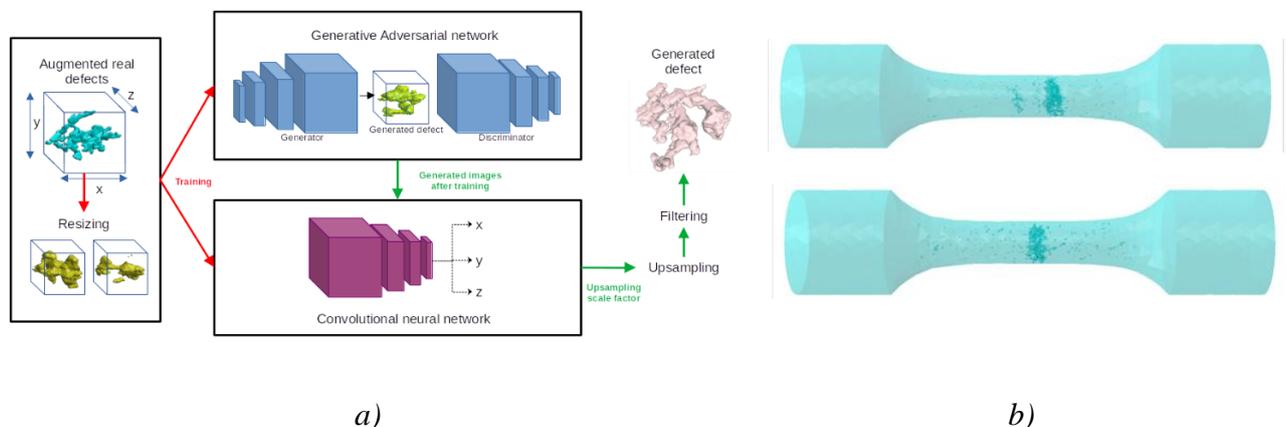


Fig. 1 a) Representation of DNN to generate synthetic defects b) Examples of few generated

synthetic microstructures

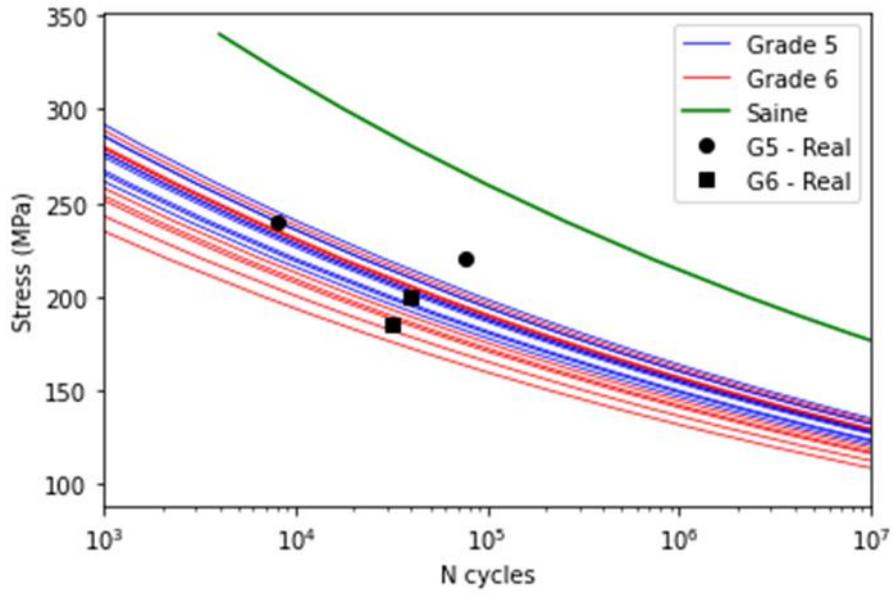


Figure 2. *Wohler curves of synthetic microstructures*