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Introduction

Cast iron is a ferrous alloy with a complex microstructure composed of anisotropic graphite inclusions embedded in a metal matrix. One application of cast iron can be found in truck engine cylinder heads (Fig. 1).

A problem present in cylinder heads is thermo-mechanical fatigue (TMF). TMF is related to the thermal stresses developed due to the start up-shut down engine thermal cycle which leads to valve bridge cracking and ultimately to TMF failure (Fig. 1). Among the process involved, mechanical stresses and stress relaxation play a key role in TMF (Fig. 2).

Cast iron microstructural model

A 2D Representative Volume Element (RVE) has been developed (Fig. 3) to study cast iron’s mechanical and thermo-mechanical response.

Elastoplastic model: a uniaxial tensile load up to 0.5 % of strain is applied to the unit cell.

Viscoplastic model: the time dependent behaviour is introduced, via a viscoplastic model for the matrix. Creep and tensile tests were done to estimate the model parameters.

Conclusions

The model provides a deeper understanding of cast iron micro-mechanics. Also, it can be used to assess the influence of different factors (microstructural heterogeneity, thermal cycle dwell time) on the cylinder head TMF response.