Accelerated RCF testing boosted by crystal plasticity modelling

V. Heino[1*], M. Lindroos[1], R. Parikka[1], H. Ronkainen[1]

[1] VTT Technical Research Centre of Finland Ltd
P.O. Box 1000, FI-02044 VTT, Finland

High quality, high strength steels are commonly used in applications where the rolling contact fatigue is one of the key failure modes, such as in gear contacts in wind-turbine gear box. The size of the wind turbines designed, and build is increasing and the demand to ever increasing power to weight ratios is putting more pressure towards improved fatigue life of materials. The larger the component size, the higher the probability for the fatigue failure to occur while statistically the occurrence of material impurities are higher than in smaller size of the component. This led to increased down-time for the power plant or in worst case scenario (if sudden failure, without clear indications via machine diagnostics) total failure of whole gear box. The key player related to the rolling contact fatigue is the purity of the material and also sufficient hardness of the surface region with moderate hardness gradient towards the inner section of the component. Therefore, many of components that are in high risk to suffer the rolling contact fatigue failure, have high hardness surface and ductile inner section provided for example by case hardening.

The high quality and purity of these steels evidentially also affect the rolling contact testing. For instance, with twin disc type of testing devices, the testing will take many weeks to show any signs of fatigue failures even with the highest load. There is need to define the tests concept and pay more attention on the characterization of the subsurface region of the tested components.

This study relates to the defining the rolling contact features with accelerated rolling contact fatigue testing for case-hardened high strength steels. It was observed that by accelerating the rolling contact failures with artificial flaws which concentrates high contact pressures in the surface regions, results can be obtained in reasonable time. However, it should be noted that with accelerated testing more precise analysis of the rolling contact failure mechanisms and the characterization of the material properties should be made. Crystal plasticity model is utilized to increase understanding of the phenomena related to the fatigue behavior of the investigated microstructures. Damage tolerance is assessed with a damage model embedded in the crystal plasticity framework and strain/damage localization of the microstructures are analyzed with respect microstructural characteristics.

Keywords: rolling-contact fatigue, twin-disc, high-strength steels, crystal plasticity modelling.

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*Corresponding author: vuokko.heino@vtt.fi