Interaction between High- and Low-cycle Thermo-mechanical Fatigue Loadings in Small Crack Growth around Cooling Hole in A Ni-based Superalloy.

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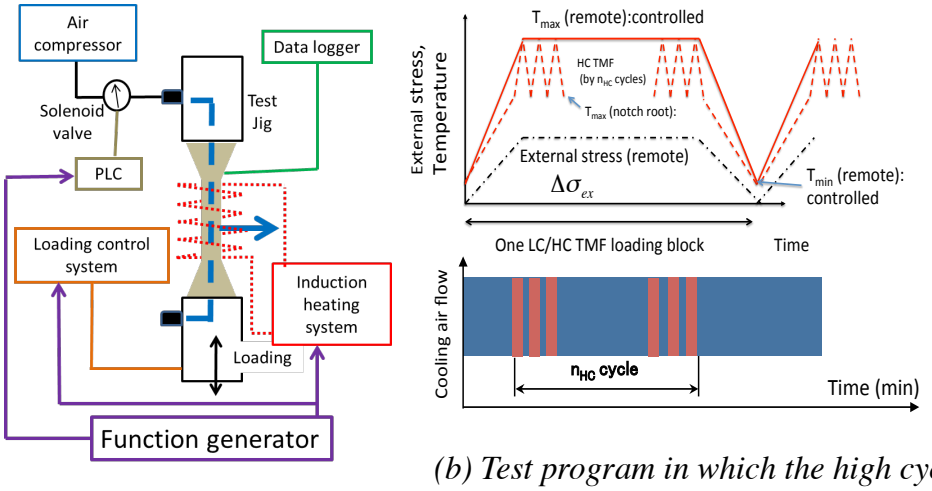
ABSTRACT: Cooling hole area introduced in gas turbine blades may be one of susceptible areas to fatigue failures, when gas turbine systems are subjected to frequent load change. Here an interaction between high- and low-cycle thermo-mechanical fatigue failure is an key issue to be concerned. In order to get basic understandings on the structural reliability under such a condition, a new testing system has been developed in this work(Fig. 1(a)). By means of the test system the propagation behavior of the small crack nucleated from a simulated cooling hole in a directionally solidified Ni-base superalloy was studied under the artificial condition in which the high-cycle thermo-mechanical fatigue (TMF) loading was superimposed on the stationary low-cycle TMF loading(Fig. 1(b)). The experimental works demonstrated that the role of the high-cycle thermal stress cycle resulting from non-stationary response of the structure significantly interacted with the stationary low cycle TMF loading (Fig. 2).



(a) A New test system

(b) Test program in which the high cycle TMF cycles are superimposed on the low cycle TMF cycles.

Fig. 1 A new test system developed and the test program performed.

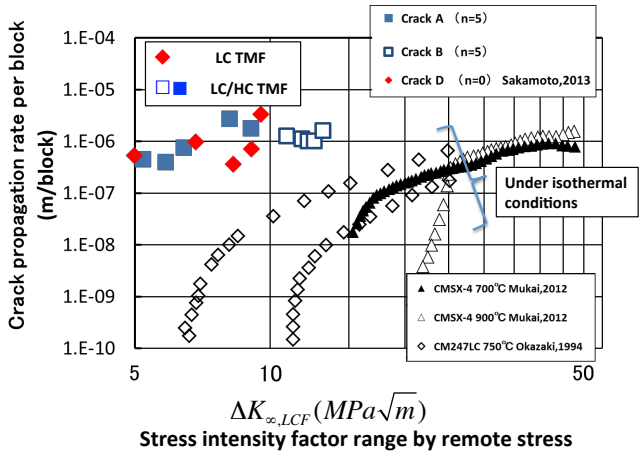


Fig. 2 Low cycle TMF crack propagation rates significantly affected by the superimposed high-cycle thermal fatigue loadings.

Keywords: Gas turbine blades, Cooling hole, Fatigue failures, High cycle thermo-mechanical fatigue (TMF), Small crack