DO CORROSION PITS ELIMINATE THE BENEFIT OF SHOT-PEENING?

Alan Turnbull, National Physical Laboratory
alan.turnbull@npl.co.uk
Shengqi Zhou, National Physical Laboratory
Louise Crocker, National Physical Laboratory

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Shot peening is used in many industrial applications, e.g. steam turbine blades, to induce near-surface compressive residual stresses and reduce the likelihood of failure by fatigue, corrosion fatigue and stress corrosion cracking. On the whole, shot peening has proven to be very successful in increasing the life of structures and components. However, the depth of the compressive stress layer is typically only about 250 µm and this poses the question as to the retained benefit when corrosion pits develop to varying depth. In the first stage to addressing this issue we show that the fatigue limit of a 12 Cr martensitic stainless steel turbine blade material tested in air at varying pit depths, ranging from 50 µm to 320 µm, was still significantly enhanced by shot peening even for the maximum depth studied. Complementary measurement of the crack propagation rate from a corrosion pit showed that the propagation rate was retarded by the near-surface compressive stress for crack depths up to 0.9 mm, well beyond the depth of the compressive layer. Serial sectioning to identify the loci of crack initiation sites yielded the unexpected result that crack development occurred preferentially away from the pit base, especially for the smaller pit depths. Finite element analysis to predict the stress and strain around a corrosion pit and to estimate the stress intensity factor will be described as a basis for rationalising the experimental observations.

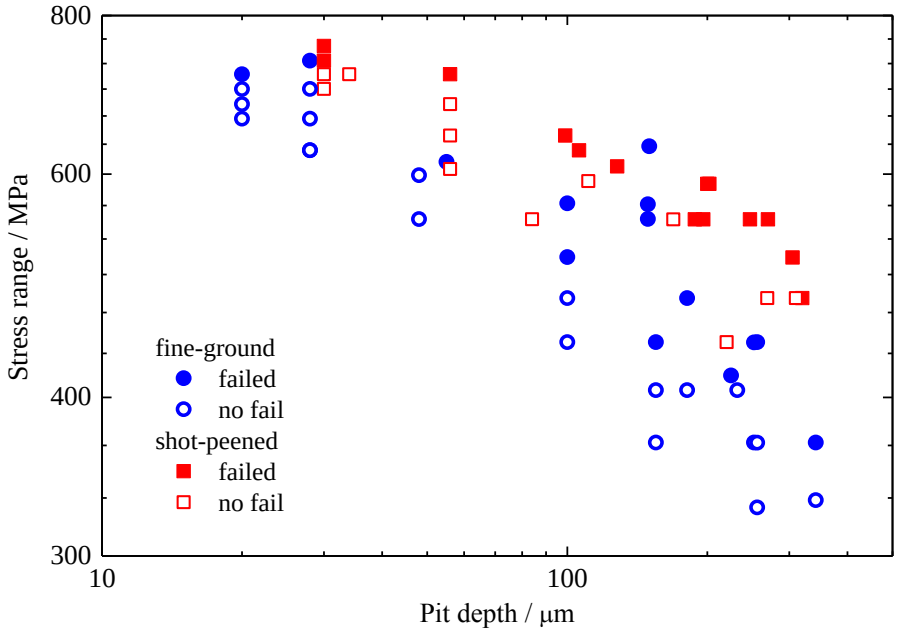

Figure 1. Effect of pit depth on the fatigue strength at 10^7 cycles for fatigue crack initiation from pits in fine-ground (stress-relieved) and shot-peened blade steel surface in air at 90 ℃; R=0.1; Frequency = 35 Hz.