1.5.7. HEAT TRANSFER MODELLING OF LOCAL THERMAL EXCITATION FOR SURFACE CRACK DETECTION AND CHARACTERIZATION

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Using of non-destructive testing (NDT) techniques in industrial and production applications is greatly increased over the last decades. Active thermography has also become a powerful tool in the field of NDT. Nowadays the infrared thermal imaging technique is widely used for the non-contact inspection of materials by visualizing thermal surface contrasts after a thermal excitation.

In the presented work local thermal excitation (active thermography) for surface crack detection and characterization is simulated using the finite element method (FEM). These surface cracks (the vertical cracks starting at the surface) are the common failures in materials. The heat transfer process is simulated for the 2D and 3D geometry cases, where the surface cracks with known properties (width and depth in 2D cases, and length in 3D cases) are presented. The lateral heat transfer, affected by crack position and size, gives us possibilities to detect the temperature differences between two reference points (different sides of crack) on the specimen's surface. In the case of absence of any crack the temperature difference is zero. Simulations for 2D cases have been done for fixed width and depth of cracks, where the optimal positions for reference points and heat flux (local excitation) have been investigated. Then these simulations with optimized heating/detection parameters have been repeated for 3D cases, where the influence of crack length on the lateral flow has been studied. The influences of heat conduction, convection and radiation (surface to surface and surface to ambient) on the lateral heat flow through the crack have also been studied. For these purposes simulations have been done for two cases: in vacuum and in air. For the given conditions influence of radiation and convection in air and influence of radiation in vacuum seems to be negligible.

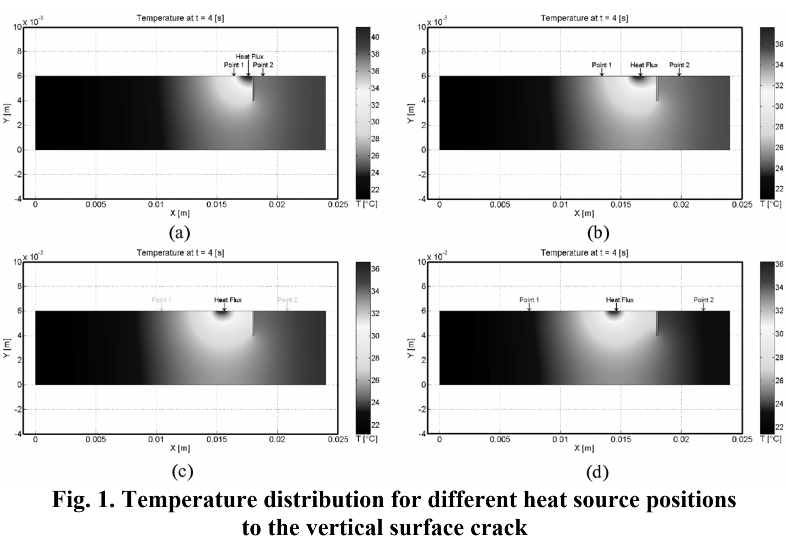

Fig. 1. Temperature distribution for different heat source positions to the vertical surface crack

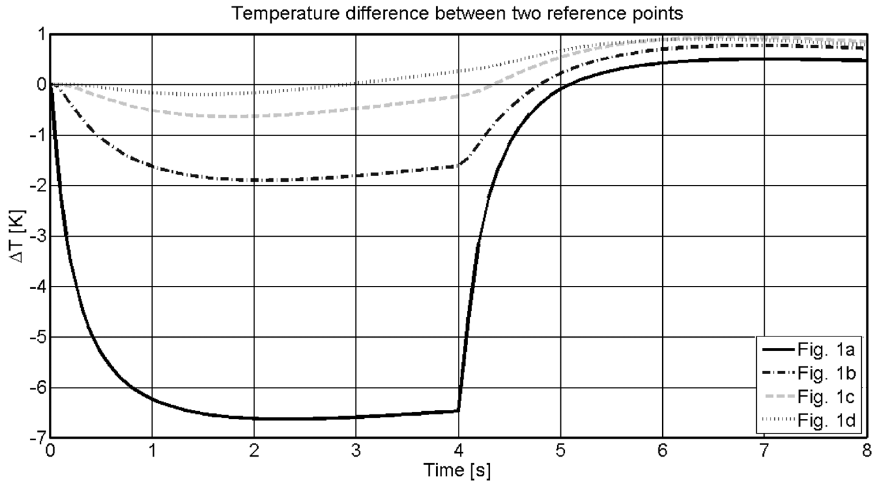

Fig. 2. Temperature difference between two reference points (according to fig. 1)

As an example, the temperature distribution for the different positions of heat source, which corresponds to the local thermal excitation, are plotted in fig. 1. On this figure results are shown for the time point at which the heat flux is switched off. The temperature differences between two reference points (point 2 minus point 1), which are symmetric to the heat source position, are plotted in fig. 2. As one can see from given figures for better identification and characterization of surface defects the closest possible position of heat source from the vertical surface crack is desirable. Simulations and post-processing have been done by using the commercial software COMSOL Multiphysics 3.5a and MATLAB R2007b.