Thermographic Measurements of Selected Materials During Uniaxial Tensile Testing

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Modern materials require reliable characterization of failure parameters for numerical modelling, particularly in ballistic applications. This includes proper description of failure initiation and propagation mechanisms, as well as the associated thermo-mechanical effects. The aim of this study was to investigate temperature evolution on the surface of selected materials during uniaxial tensile testing using infrared thermography. The investigated materials included structural steel as well as high-performance ballistic fibres such as aramid fibres and ultra-high molecular weight polyethylene (UHMWPE). Two measurement approaches were analysed: (i) specimens with natural surface condition and (ii) specimens coated with black paint to increase and standardize surface emissivity. Temperature fields were evaluated in terms of average temperature within the selected region of gage length as well as maximum local temperature. The UHMWPE fibre specimen mounted in the testing machine together with the thermographic images obtained during tensile testing are presented in Figure 1.

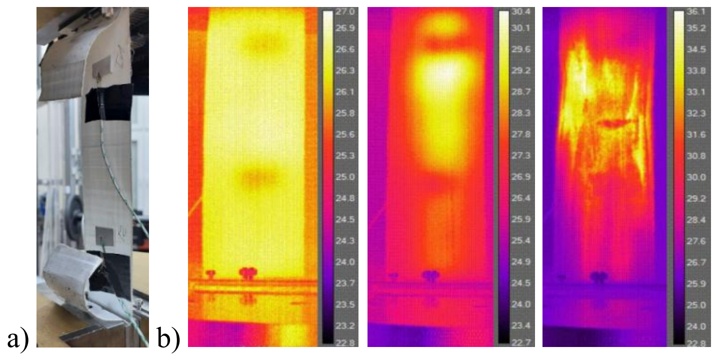

Figure 1. Example UHMWPE specimen mounted in a universal testing machine during uniaxial tensile testing (a), and representative failure progression recorded by infrared (IR) thermography during tensile loading (b).

The thermographic signal is fundamentally related to thermal radiation governed by the Stefan–Boltzmann law, where the emitted radiation E is proportional to the fourth power of the absolute temperature T [1]:

$$E = \varepsilon \sigma T^4. \tag{1}$$

In practical infrared thermography, the recorded signal includes emitted and reflected radiation contributions, while atmospheric effects are typically negligible under laboratory conditions [2]. Therefore, emissivity coefficients ε were experimentally determined for all investigated materials. The observed temperature distributions reflected the local damage development and failure progression occurring during tensile loading.

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