Active and passive optical diagnostics in a model HV circuit breaker

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We present results on the probing of an air arc in a HV circuit breaker model geometry using two distinct experimental techniques. First we apply Speckle imaging, an active refractive index based technique that yields quantitative information on the radial temperature distribution *T(r)* via a generalization of the Gladstone-Dale law [1]. Second, in a passive technique we use high speed video imaging of selected atomic (O-I) and ionic species (N-II) using appropriate narrow band filters. Post-processing the videos also allows to obtain *T(r)* based on the Fowler-Milner method [3] for the atomic emission. The results of the two techniques are found to be in good agreement.

1. Introduction and Experimental Set-Up

Optical diagnostics are a non-invasive means of probing the spatio-temporal evolution of key quantities (e.g. temperature) in the understanding of the phenomena in HV switching arcs: such experimental data are important for the benchmarking of CFD simulations that are used in the development of HV gas circuit breakers. The goal of the present work is to provide such validated data by employing two distinct optical diagnostic techniques and comparing their findings.

On the one hand we apply the Speckle interferometric technique [1] which probes the spatial derivative of the refractive index by illuminating the arc with a pulsed (20ns, 60kHz) Nd:YAG laser at 532nm. On the other hand we record the emissions of selected atomic and ionic lines with the use of a high speed video camera (1μs integration time, 20kfps) [2]. In both cases we record side-on images that are used for deriving 2D information by Abel inversion based on a rotational symmetry assumption. Furthermore, the temperature is estimated under an LTE assumption, that should be valid in the conditions here investigated.

The aforementioned methods are employed for the probing of a switching arc in a simplified circuit breaker model suitable for such optical diagnostic measurements [1]. The test object was operated in air at an exhaust pressure of 1 bar, while the arc was blown with quasi-constant pressure in the range of 3.5 to 8 bar. Sonic flow conditions in the arcing zone are thus ensured, while the interaction of the gaseous arc with the surrounding PTFE nozzle walls and CuW electrodes is negligible.

2. Results and Discussion

Fig. 1 shows the evolution of arc mantle and arc core diameters as a function of arc current (*I*) under a a constant blowing pressure of 8 bar. These are estimated both from Speckle measurements [1] as well as from measuring the luminous lateral extent of the corresponding video frames

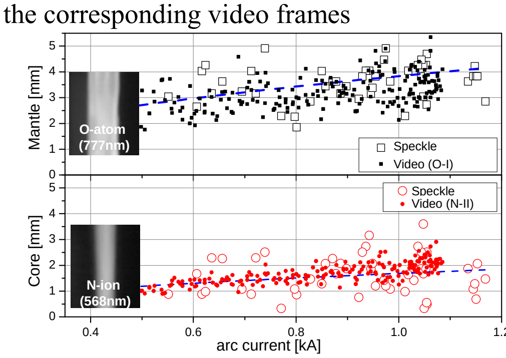

Figure 1: Current (*I*) dependence of arc mantle and core diameters. The dashed eye-guides correspond to a √*I* law.

Fig. 2 shows the radial distribution of temperature as estimated by the Speckle technique and the O-I emission intensity using the method [3].

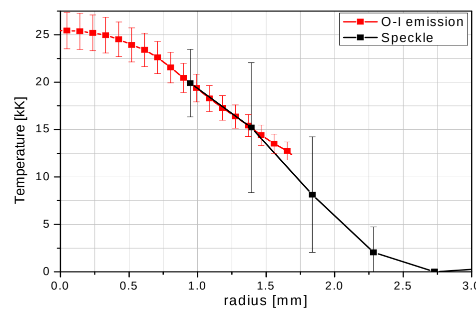

Figure 2: Radial distribution of temperature *T(r)* for a 1kA air arc at 3.5 bar blowing pressure.

We observe in both figures a good agreement between the two measurement techniques: validated measurements of a switching arc are thus obtained.

3. References

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