Renato Nunes Teixeira

Development of High Temperature Comparison Artefacts for Radiation Thermometry

Tese de Doutorado

Thesis presented to the Programa de Pós-Graduação em Engenharia Mecânica, PUC-Rio as partial fulfillment of the requirements for the degree of Doutor em Engenharia Mecânica.

Advisor: Prof. Alcir de Faro Orlando
Co-Advisor: Prof. Graham Machin

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To my daughter Nina

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Abstract

Teixeira, Renato Nunes; Orlando, Alcir de Faro; Machin, Graham. **Development of High Temperature Comparison Artefacts for Radiation Thermometry.** Rio de Janeiro, 2013. 120p. Doctoral Thesis – Departamento de Engenharia Mecânica, Pontifícia Universidade Católica do Rio de Janeiro.

High stability tungsten strip lamps are no longer suitable comparison artefacts for high temperature radiation thermometry, because they are fragile, have a small target size, are restricted in temperature range and are not blackbodies. This study developed proof-of-concept high performance comparison artefacts, which overcome the problems encountered when using such lamps in comparisons of the International Temperature Scale of 1990 (ITS90) among National Metrology Institutes (NMIs). This work demonstrated the concept of using high temperature fixed points (HTFPs) that have unknown temperatures and hence suitable as "blind" comparison artefacts. Four of these novel HTFPs were designed, constructed, filled and measured in the work described here. Initially Co-C was chosen but due to robustness issues, Ni-C was the selected the base eutectic alloy. The Ni-C cells were doped in two different concentrations with selected elements in a successful attempt to change the pure eutectic transition temperature by some tenths of degrees Celsius. The realization temperatures of eutectic cells determined at Inmetro were compared to the ones predicted by thermochemical simulation, using Thermo-Calc software and thermochemical property databases. In addition they were used to perform a "blind" comparison with the National Physical Laboratory (UK), which did not know beforehand what their temperatures were. Very good results were achieved (scale agreement and cell stability), demonstrating that doped cells are very suitable high temperature comparison artefacts for radiation thermometry.

Keywords

High Temperature Fixed-points; Radiation Thermometry; Comparison Artefacts; High Temperatures.

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Resumo

Teixeira, Renato Nunes; Orlando, Alcir de Faro; Machin, Graham. **Desenvolvimento de Artefatos de Comparação de Alta Temperatura para Termometria de Radiação.** Rio de Janeiro, 2013. 120p. Tese de Doutorado – Departamento de Engenharia Mecânica, Pontifícia Universidade Católica do Rio de Janeiro.

Lâmpadas de fita de tungstênio de alta estabilidade não são mais adequadas como artefatos de comparação para termometria de radiação de alta temperatura, por conta de serem frágeis, terem um tamanho de alvo pequeno, serem limitadas com relação a faixa de temperatura e não serem corpos negros. Este estudo desenvolveu protótipos de artefatos de comparação de alto desempenho, os quais podem superar os problemas existentes ao usar tais lâmpadas em comparações da Escala Internacional de Temperatura de 1990 (EIT-90) entre Institutos Nacionais de Metrologia (INMs). Este trabalho demonstrou o conceito de utilização de pontos fixos de alta temperatura (PFATs) que tenham temperaturas desconhecidas e assim sejam adequados como artefatos de comparações "às cegas". Quatro destes novos PFATs foram projetados, construídos, preenchidos e medidos no trabalho aqui descrito. Inicialmente Co-C foi escolhido, mas devido a problemas de robustez, a liga eutética base selecionada foi Ni-C. As células Ni-C foram dopadas em duas concentrações diferentes com elementos selecionados em uma tentativa bem sucedida de modificar temperatura de transição do eutético puro em alguns décimos de graus Celsius. As temperaturas de realização das células eutéticas determinadas no Inmetro foram comparadas com aquelas previstas por simulação termoquímica, usando o programa Thermo-Calc e bancos de dados de propriedades termoquímicas adequados. Além disso, elas foram utilizadas para realizar uma comparação "às cegas" com o National Physical Laboratory (NPL - UK), o qual não sabia "a priori" quais eram essas temperaturas. Resultados muito bons foram alcançados (concordância das escalas e estabilidade das células), demonstrando que as células dopadas são artefatos de comparação de alta temperatura bem adequados para termometria de radiação.

Palavras-chave

Pontos-fixos de Alta Temperatura; Termometria de Radiação; Artefatos de Comparação; Altas Temperaturas.

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