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# Gaussian heat flux parameters estimation during a GTAW operation

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**Key words:** gas tungsten arc welding, parameter estimation, conjugate gradient method, adjoint problem.

## Abstract

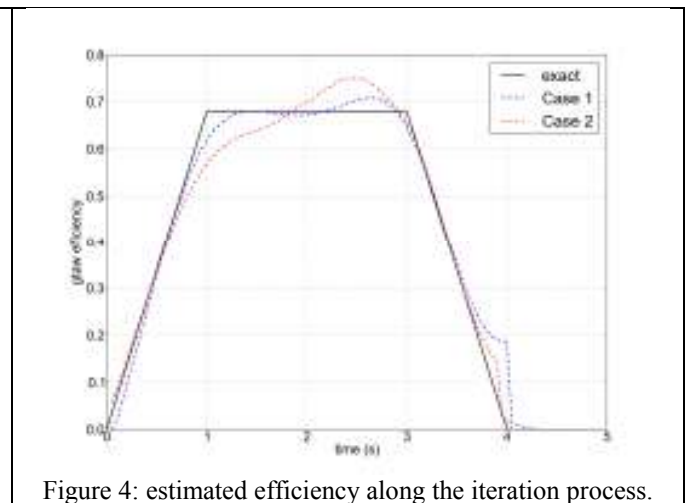
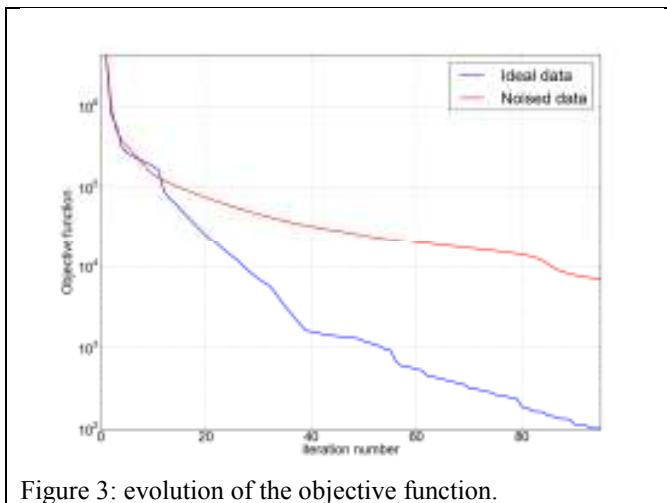
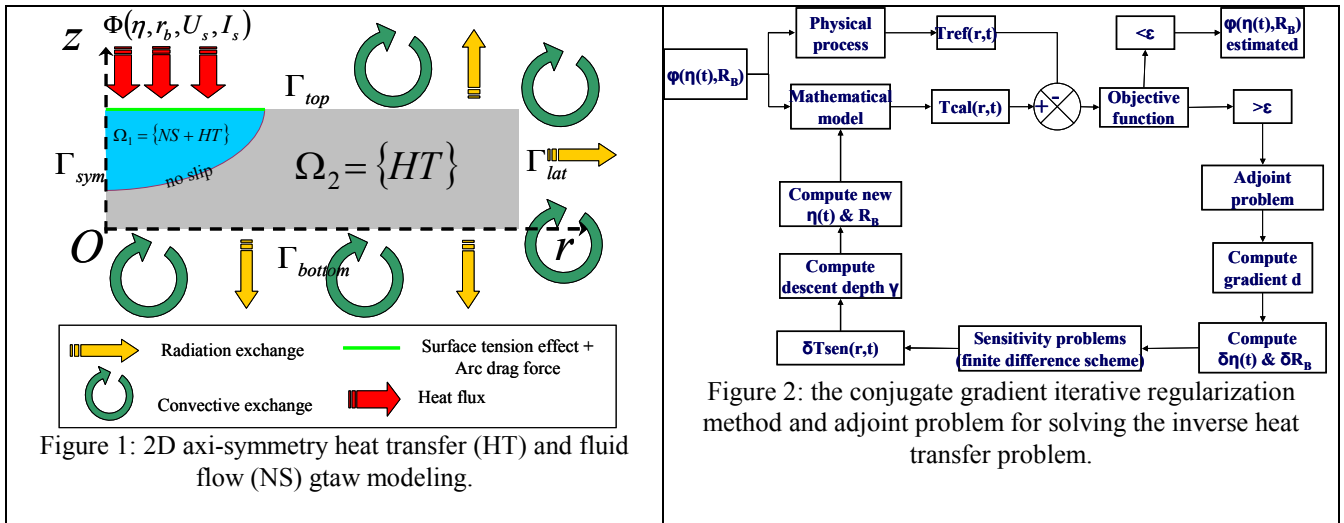
Welding processes are widely employed in manufacturing industries such as automobiles, airplanes, petrochemical plants, nuclear power stations, etc. These structures require high joint quality such as mechanical properties. Few manufacturing welding processes reach such level of performance. Gas tungsten arc welding (gtaw) is one of the most widely employed welding processes for welding stainless steels and non-ferrous materials.

In this process, a tungsten electrode is shielded with a flow of either pure inert gas. The assembly of work pieces is obtained through a local fusion due to the heat generated from an electrical arc. The analysis of the physical phenomenon (electromagnetism, fluid flow, heat transfer ...) that takes place in the process is crucial to understand, for example, weld pool formation [1], final microstructure [2] and final residual stresses [3]. In order to perform a reliable multi-physics simulation of the work piece, it is extremely important to know correctly the heat input absorbed into the work piece [4].

In this communication, an inverse heat transfer problem (ihtp) is used for estimating the parameters describing the heat flux incoming from the arc plasma into the work piece. First a heat transfer and fluid flow modeling is stated for the case of stationary gtaw operation on a SS304L disc, fig. 1. The heat flux is modeled with a Gaussian function [4]. Two parameters of this Gaussian function: time dependent gtaw efficiency and a constant Gaussian radius require to be estimated. Then an objective function is defined (quadratic difference between the measured and calculated temperatures). The conjugate gradient iterative regularization method (cgirm) is used for solving the ihtp. An adjoint problem is solved in order to get the gradient of the objective function with regards of each parameter to estimate [5]. The overall principle of the cgirm for solving the ihtp is presented in fig. 2. The main goal of this work is to validate numerically the robustness of the inverse technique for the estimation of the unknown parameters.

Two cases have been studied: the first ihtp case is solved with ideal data (no measurement or sensor location errors on the input temperatures) and the second case investigated the robustness of the method to measurement errors in the input data ( $T_{NOI}(t) = T_{REF}(t) + |\sigma(t)|$  with  $|\sigma(t)| \leq 5\% \times T_{REF}(t)$ ). Some ihtp results are presented in figs. 3 and 4 which are respectively the objective function and the estimated time dependent gtaw efficiency. In case 1, the objective decreased to zero as expected. The estimated gtaw efficiency is quite good. Input data with measurement noises led to small errors in the estimation of the gtaw efficiency especially between 2s and 4s. The Gaussian radius was easily estimated after 40 iterations of the ihtp (to the value of 0.0032 m). In the first case, the final objective function led to an average error on the

input data inferior to  $\pm 2^\circ\text{C}$ . The inverse approach is able to estimate the gtaw efficiency and Gaussian radius. The next step is to use measured temperatures during a real gtaw experiment.



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