Final Report

Metal Transfer in Gas Metal Arc Welding in the High Current Regime

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I. Summary of previous three years of effort

The work performed during the three previous years can be roughly divided into two main categories:

- Development of Advanced Modeling Techniques
- Modeling of Arc Welding Process

Our work in the first category comprised the development of the Order of Magnitude Scaling (OMS) technique, which is complementary to numerical modeling techniques such as finite elements, but it provides approximate formulas instead of just numerical results. Borrowing concepts from OMS, another modeling technique based on empirical data was also developed. During this stage special software was also developed.

The second category comprised the application of OMS to the three main subsystems of arc welding: The weld pool, the arc, and the electrode. For each of these subsystems we found scaling laws and regimes. With this knowledge, we analyzed the generation of weld pool defects during high current arc welding, proposed a mechanistic description of the process, and possible solutions.

Sixteen publications were generated during this period. The list below lists them according to publication type. The article "Welding Processes for Aeronautics" received the Silver Quill Award of the American Welding Society (AWS). These articles are attached to this report.

II. Software development

Order of Magnitude Scaling integrates the dominant balance technique from mathematics with dimensional analysis and scaling techniques from engineering. This methodology deals with the governing equations in all of their complexity, and allows one to systematically obtain the dominant driving forces in a problem, the corresponding scaling laws, their range of validity, and the dimensionless groups that represent the influence of the secondary forces. This methodology has been implemented in the form of a computer algorithm, and has been applied to high current arc welding problems problems involving coupled heat transfer, fluid flow and free surfaces, for which novel laws were discovered.

A user interface called "Salamandra" was developed to enable the use of OMS by students and other engineers. This way, they can take advantage of the results from OMS without the need to spend effort in tedious computer programming. Figure 1 shows a screen capture of the input fields of Salamandra, and Figure 2 shows the outputs obtained. The core mathematical operations were performed in MATLAB.

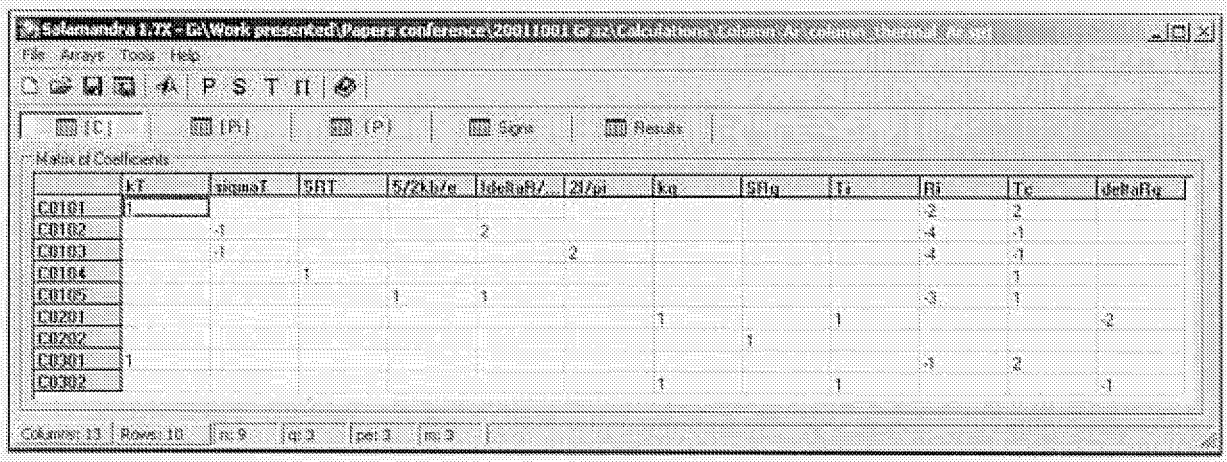

Figure 1: Input screen of Salamandra

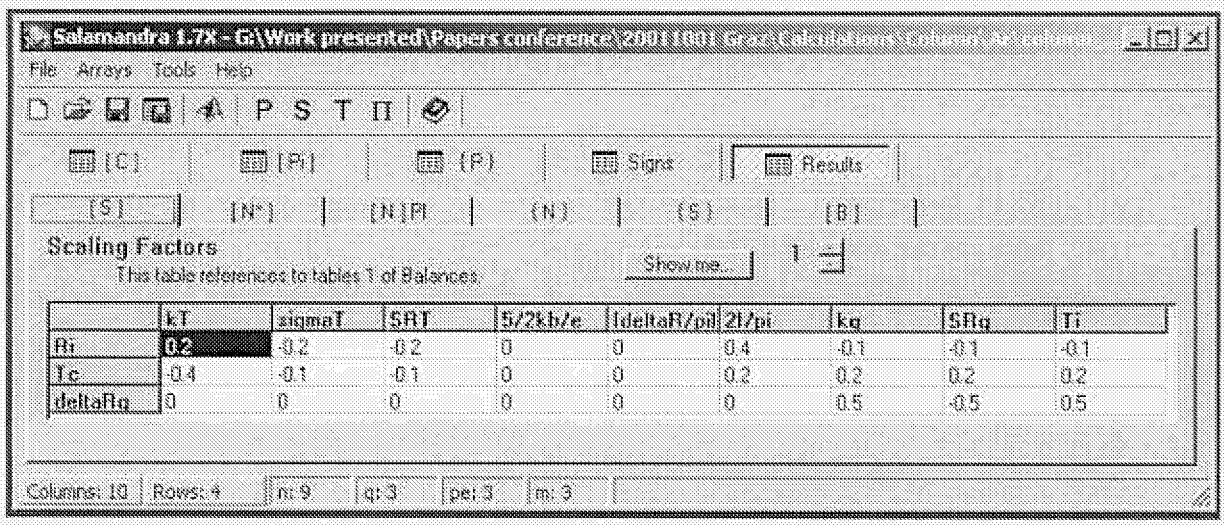

Figure 2: Output screen of Salamandra

III. Publications