A. Hydrogen Reduction In FCAW Steel Weld Metal: Spectroscopic Monitoring Of Arc During Deposition

By J. Chandler, C. Clasper, S. Liu, and G. Edwards; Colorado School of Mines

Introduction

The presence of diffusible hydrogen in steel weldments can be reduced through the addition of fluorides and yttrium in the flux. In this research, the two methods have been combined and the activity of fluoride additions in the arc is studied through use of a spectrometer. Correlations between arc activity during FCAW deposition and diffusible hydrogen in the steel weldment were used to determine the optimal flux composition for a FCAW consumable to be used in high strength steel welding.

Technical Approach

Spectroscopic analysis of an arc generated by FCAW process in this research requires a transition from spectroscopic studies performed on GTAW arcs in previous research periods. Complicating factors such as the presences of molten metal droplets, metal vapor, and molten flux in the arc were studied individually to determine the effect of each on arc emission characteristics. Spectroscopic analyses of GMAW processes were performed with and without fluorides under various shielding gases to study the effect of each factor. Once these tests were performed, the transition to spectroscopy of FCAW processes was made. The results of the FCAW spectroscopy are presented in the following paper.

Results and Discussion

The goal of this program, funded by the Office of Naval Research, was to reduce the amount of diffusible hydrogen in high strength steel weldments. Previous research in this program studied yttrium and fluoride additions separately. Yttrium additions form oxides in the steel weld metal which serve as hydrogen trapping sites and are most effective when a [%Y]/[%O] ratio of less than 3.7 is maintained. Fluoride additions combine with hydrogen in the arc to form a product insoluble in liquid steel. In the current program, the two methods were combined to produce an optimal flux composition for a FCAW consumable. Spectroscopy was used in previous funding periods to study the effect of fluorides on a GTAW arc. In this research, the arc of a FCAW process was monitored during deposition of the weld metal. This involved the transition of spectroscopic techniques from the original GTAW research to GMAW processes then ultimately to FCAW processes. In its final stage, spectroscopy was used to monitor the fraction of hydrogen in the arc to determine the most effective flux composition for reducing diffusible hydrogen. The intensity of the light collected by the ionization processes in the arc was used to determine the fraction of elements present in the arc. Filtering was utilized to accentuate the hydrogen ionization signals because of its overlapping with argon ionization wavelengths (up to 600 nm). Temperature measurements deduced from the spectroscopic data collected from the FCAW processes were used to determine which fluoride formation reactions were most likely to occur in various regions of the arc. Steel weldments deposited under monitored arcs were tested for diffusible hydrogen levels. Correlations between the activity of hydrogen in the arc and diffusible hydrogen in the steel weldment were used to produce a FCAW consumable with optimized diffusible hydrogen characteristics.

Conclusions

Spectroscopic analysis of FCAW processes during deposition was utilized to correlate hydrogen activity in the arc to diffusible hydrogen levels in steel weldments. Diffusible hydrogen levels around 2 mL/ 100g weld metal have been recorded with experimental consumables fabricated for this research program. Spectroscopic data was collected for various FCAW consumables with flux additions of yttrium (2-5 wt%) and fluoride (2-10 wt%) to determine the optimal flux composition. The optimal flux composition regarding fluoride and yttrium content was then incorporated into a FCAW consumable for use in high strength steel welding.