Integration of Electron Beam Diagnostics in Weld Transfer and Quality Control Procedures

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Introduction

The Enhanced Modified Faraday Cup (E-MFC), developed at Lawrence Livermore National Laboratory (LLNL), has been used for many years to measure the size, shape, and power density distribution of electron beams. The introduction of this tool into weld development and production requires additional effort and the development of new procedures to standardize this technique. The use of this tool in both weld transfer between LLNL and the BWXT Y-12 Plant (Y-12) and production quality control at LLNL is demonstrated. Procedures for the integration of electron beam diagnostics in these activities are also presented.

Technical Approach

The E-MFC diagnostic tool measures the peak power density, full width at half maximum (FWHM), and full width at $1/e^2$ (FWe2) of the beams produced by the individual welders. This information provides a quantitative baseline of the performance characteristics of the welders, which is required to develop economical weld transfer and quality control procedures. Performance characteristics of two Hamilton Standard welders at LLNL and a Leybold Heraeus welder at Y-12 were determined using the E-MFC diagnostic at constant power (1 kW) over a range of working distances. Welds were then made at both LLNL and Y-12 on 304L stainless steel samples at the sharp focus setting. The resulting weld dimensions were then measured and compared.

Results and Discussion

Previous work with electron beam diagnostic tools has primarily dealt with characterizing the beams produced by individual machines. The resulting knowledge base is now being used to develop applications for use the transfer of welding parameters from one machine to another. The transfer process is complicated by differences in machine performance and the respective vacuum chamber size, which results in welds being made at different work distances. For example, welds being made at work distances of 457 mm in the Y-12 welder and 210 mm in the LLNL welder, respectively, are not the same unless they are adjusted to account for this difference. Using the EMFC, it is found that a positive machine focus setting on the LLNL welder will produce a beam equivalent to the sharply focused beam produced by the Y-12 welder at the longer work distance. Welds have been made, and the resulting weld depths differ by only 8%. Based on these results, a means for efficiently transferring electron beam welding parameters between machines is described. Electron optics concepts are also used to describe the effects of work distance on the beam diameter to develop a more fundamental understanding of these effects and better methods for transferring beams between machines.

During production, the E-MFC diagnostic tool has proven to be extremely useful in monitoring machine performance over an extended period of time. With the ability of this tool to document beam characteristics (peak power density, FWHM, and FWe2), it can be integrated into production quality control. An example of a successful integration of this diagnostic tool into a year-long low volume production run at LLNL is discussed. Prior to each weld, the E-MFC diagnostic tool was used to determine the machine sharp focus setting and the focus setting required to achieve the desired beam properties. The variability in both the sharp focus setting and the amount of defocus requred to achieve the desired beam properties was monitored. With this close monitoring of machine performance, all of the electron beam welds made over the course of the production run met all requirements.

Conclusions

The integration of the E-MFC diagnostic tool into development and production processes has been demonstrated. A means for transferring welding parameters between electron beam welders based on beam parameters rather than machine settings has been demonstrated. In addition, the diagnostic tool has been integrated into production quality control conditions. With this tool, the day-to-day variability of the machine is monitored and focus settings modified in order to produce beams with the desired properties for each weld. This work provides a basis for the continuing development of procedures and equipment for characterizing electron beams and increasing the reliability of existing tools.

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