

# **FEASIBILITY OF EB WELDED HASTELLOY X AND COMBINATION OF REFRACTORY METALS**

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## **PROJECT DESCRIPTION AND ASSIGNMENT**

As NASA continues to expand its horizon, exploration and discovery creates the need of advancement in technology. The Jupiter Icy Moon Orbiter's (JIMO) mission to explore and document the outer surfaces, rate the possibility of holding potential life forms, etc. within the three moons (Callisto, Ganymede, and Europa) proves to be challenging.

The orbiter itself consists of many sections including: the nuclear reactor and the power conversion system, the radiator panels, and the thrusters and antenna. The nuclear reactor serves as a power source, and if successfully developed, can operate for extended periods.

During the duration of my tenure at NASA Glenn Research Center's (NASA GRC) Advanced Metallics Branch, I was assigned to assist Frank J. Ritzert on analyzing the feasibility of the Electron Beam Welded Hastelloy X (HX), a nickel-based superalloy, to Niobium- 1%Zirconium (Nb-1Zr) and other refractory metals/alloys including Tantalum, Molybdenum, Tungsten, and Rhenium alloys. This welding technique is going to be used for the nuclear reactor within JIMO.

As my assignment, I was responsible for researching and optimizing the EB weld joint for this and other combinations of refractory metals to the HX alloy. In order to achieve this, interfacing with other engineers from GRC was a critical step in accomplishing personal goals and others set forth by my mentor Frank.

Beginning my summer here at GRC, the initial step was to educate myself on the JIMO project and what its goals were. A further understanding of the overall goals helped to direct me in the right direction for my individual goals. After discussing a strategy for my portion, initial analyses began.

Given a NASA GRC draft work plan for the project, seen below, I was able to begin to formulate my test matrix with the help of my mentor.

**NASA GRC DRAFT WORK PLAN (F.J. Ritzert)**

Refractory metal	Alloy*	Superalloy	Welding process
Nb alloys	Nb-1Zr	Hastelloy X	electron beam
	C103	Hastelloy X	electron beam
Ta alloys	T-111	Hastelloy X	electron beam
	ASTAR 811C	Hastelloy X	electron beam
Mo alloys	Mo-47.5Re	Hastelloy X	electron beam
	TZM**	Hastelloy X	electron beam
W alloys	W-25Re**	Hastelloy X	electron beam
Re alloys	Re***	Hastelloy X	electron beam

\*All alloys listed are currently on-hand at NASA GRC

\*\*TZM and W-25Re are not considered as promising candidates due to post-weld behavior. They may be included for reference because the material is on-hand.

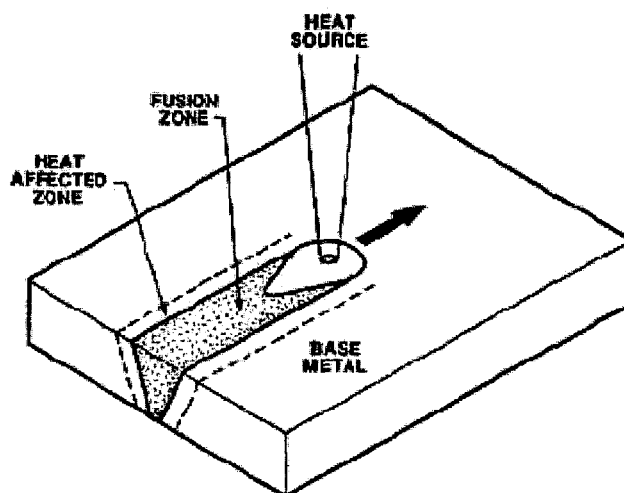
\*\*\*Re is not considered as a top tier candidate due to the lack of historical information. It may have considerable potential plus the material is on-hand.

To begin, an evaluation of the cleanliness of the EB welding process was to be conducted. To do so, a beam was run over the surface of a material, in this case Nb-1Zr, sectioned off and analyzed for the oxygen pickup within the weld. If within the suitable range, the project was permitted to press forward.

In determining the feasibility of the EB welded HX to any of the combination of refractory metals, test coupons were developed and sent to Walt Wozniak. Test coupons (1 sq. in) were EB welded together, sectioned off around the welded region, mounted, and prepped for optical analysis. The as-received weld joint was characterized based on a number of set parameters. Interest in intermetallic formation within the welded region and oxygen pickup, along with basic structure characterization, and chemical analysis of diffusion of elements into refractory alloy was conducted.

Again, Walt Wozniak helped in the optimization of the weld beam. This was done for each individual material due to the fact that each metal reacts differently to the welding process. Discussed in our meeting July 7 of 2004, Walt explained the significance to the beam width; the tighter the beam, the faster the process can be conducted as well as the lower the heat produced. The material will experience a small area of heat affected zone. Therefore, the optimization of the electron beam will be different for HX to Nb-1Zr and HX to C103. Seen below is a schematic of what and where the heat affected zone is seen:

**Figure 1: Schematic of EB welding process**



It was to be determined if having a wider electron beam would be more suitable for our overall goal, thus the optimization of the beam was key to this project.

In the case of the materials welded together, a cleaning process was done to remove any contaminants which might have caused such things as embrittlement within the welded region (oxygen pickup, etc). This was done with the help of those located in the ChemLab in Building 105.

Due to the timely process, there are no photographs to display the current analyses that have been performed to date. This is still an on-going project.

Further work to be completed in this portion of the project consists of encapsulation and aging of welded coupons at varying times. Metallographic examination and SEM analysis will be performed. Alternative joining techniques will be investigated including the bi-metal tubing concept.