Modeling, Fabrication, and Optimization of Niobium Cavities: Phase II Second Quarterly Report

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Second Quarterly Report

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AAA Research Area: Accelerators / Transmuter
Abstract

Niobium cavities are important parts of the integrated NC/SC high-power linacs. Over the years, researchers in several countries have tested various cavity shapes. They concluded that elliptically shaped cells are the most appropriate shape for superconducting cavities. The need for very clean surfaces lead to the use of a buffered chemical polishing produce for surface cleaning to get good performance of the cavities. Up to this point, the second phase has resulted in the design of an experimental setup for the fluid flow experiment. Other experimental activities include the evaluation of a vacuum system are underway. Little reportable progress has been made on the optimization code for a five cell niobium cavity.

Summary of Achievements of Phase II:

1. **Optimization of the shape of the cavity to produce the desired resonant frequency and mode of operation**: Convergence of solution has been a significant problem at this time. The optimization code based on resonant frequency and mode tends to run for days without advancing to the next iteration. Alterations on how the set of codes interact and function is under investigation.

2. **Assessment of a vacuum chamber and assembly to be used for SEE from niobium test piece**: An existing vacuum chamber is being checked for leaks. Ultrasound has been used to evaluate some of the ports with hairline deformations. At this time it is concluded with the materials currently available that the cavity may contain leaks that may cause problems when reaching vacuum pressures to $10^{-8}$ Torr. It was decided that the chamber must be checked at a more adequate facility to determine if it truly is not leak free.

3. **Assessment of current etching techniques presently used in LANL**: The current method uses a baffle to direct the etching fluid toward the surface of the cavity. Refer to Figure 1. Finite element analysis shows that the baffle partially succeeded in achieving its purpose as can be seen in Figure 2. The flow is however restricted to the right half of the cavity with very limited circulation in the left half, which results in more etching of the iris region compared to that of the equator regions. The current design also experiences flow circulation behind the baffles in the second through fifth cavity cells. There is a significant increase in velocity at the outlet.
4. **Optimization of the Baffle Design**: An alternative design is proposed and modeled. The proposed baffle design is also modified so that it can be extended inside the cells of the cavity. The exit flow is now parallel to flow inlet, Figure 3. Results show that flow circulation is eliminated. The flow is now closer to the surface of the cavity. We used optimization techniques to improve this design.
5. **Experimental Visualization of the Verification of the Etching Process:** LANL has loaned us a transparent cavity for use in flow visualization, Figure 4. A transparent plexiglass box is being designed to enclose the cavity and reduce light refraction. Pump and piping system were also modeled. A complete setup including a computer-controlled x-y traverse and digital camera is under investigation.

![Figure 3. Velocity Field for the Optimized Modified Baffle Design](image1)

![Figure 4. Photo of the LANL Transparent Cavity](image2)