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Modeling, Fabrication, and Optimization of Niobium Cavities – Phase I: Quarterly Progress Report August 20, 2001 - November 20, 2001

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Modeling, Fabrication, and Optimization of Niobium Cavities – Phase I

Quarterly Progress Report
8/20/01 - 11/20/01

UNLV-AAA University Participation
Program

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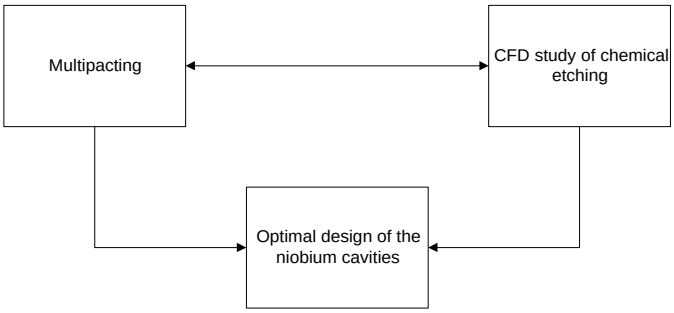
Principle Investigators

Purpose and Problem Statement

Multipacting is one of the major loss mechanisms in rf superconductivity cavities for accelerators. This loss mechanism limits the maximum amount of energy/power supported by the cavities. Optimal designs have been identified in others' studies. In practice, these designs are not easily manufactured. Chemical etching processes used to polish the cavity walls result in a nonuniform surface etch. A nonuniform surface etch will leave some unclean areas with contaminants and micron size particles. These significantly affect mutipacting. Further, a nonuniform etch will leave areas with damaged grain structure, which is not good for superconducting properties. Typically, the depth of chemical polishing etch ranges between 10 to 150 microns.

It is the purpose of this study to examine the chemical etching process in the design of niobium cavities so to maximize the surface quality of the cavity walls while minimizing the multipacting losses. Single and multiple cavity cell geometries are to be investigated. Optimization techniques will be applied in search of the chemical etching processes, which will lead to cavity walls with near ideal properties. Figure 1 depicts a block diagram of the optimization procedure, which is intended to be fully automated among a variety of existing codes.



Personnel

Principal Investigators:

- Dr. Robert A. Schill, Jr. (Electrical Engineering)
- Dr. Mohamed B. Trabia (Mechanical Engineering)

Research Investigator:

- Dr. Yi-Tung Chen (Mechanical Engineering)

Students:

1. Ms. Myong Holl, Undergraduate Student, (Mechanical Engineering)
2. Mr. Satishkumar Subrmanian, M.S. Graduate Student, (Mechanical Engineering).
3. Ms. Qin Xue, M.S. Graduate Student, (Mechanical Engineering).

National Laboratory Contact:

- Dr. Dominic Chan, Project Leader for Superconducting RF Engineering Development and Demonstration AAA Technology Project Office at Los Alamos National Laboratory

Management Progress

Budget Issues:

- Purchase of software codes (Chemical Engineering Module for FEMLAB).
- The third computer system arrived near the end of October or early November. This system is to be used for the multipacting studies.

Notes:

1. Most of the major equipment budget has been spent.
2. Salary expenditures are on target.

Management Problems

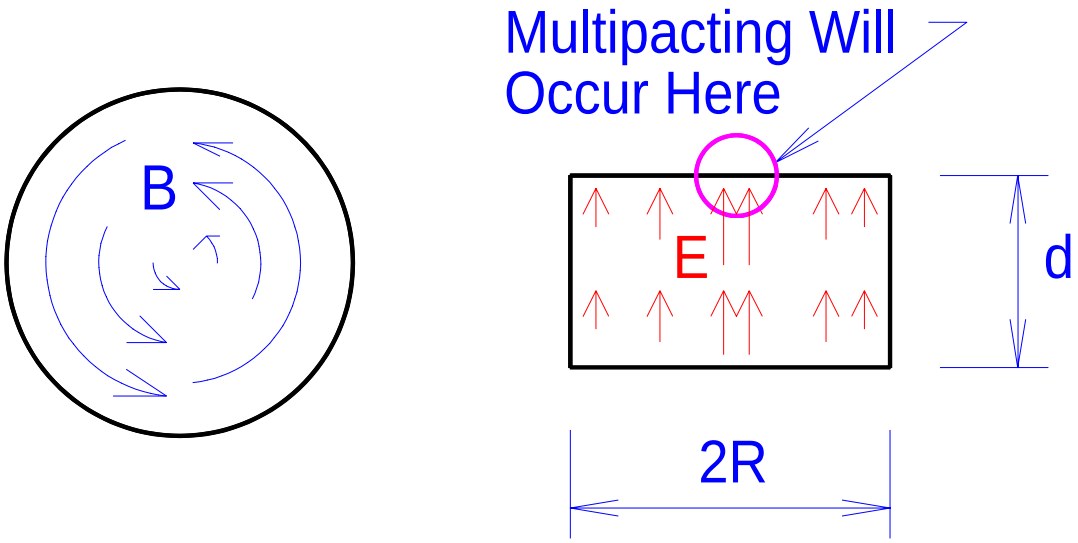
We intend to overcome some of the software difficulties. A purchase of a chemical engineering toolbox helped in the study of azimuthally symmetric geometries. Significant time was spent in creating a model of mutiple-cell cavity with the etching baffle in Femlab.

We had difficulties in identifying a student to work on the multipacting codes and simulations. By mid-October, Ms. Myong Holl modified her scope on this research to aid us in the multipacting simulation studies. We are currently examining the codes obtained from Field Precision Inc.

Technical Progress

Multipacting Study

Starting in mid-October, Ms. Myong Holl began learning the suite of codes purchased and obtained from Field Precision Inc. At present, the rf Trak code is being examined for consistency. Recently we learned from the author of the code (Dr. Stan Humphries) that the code uses a random number generator to characterize secondary electron emission. We have also identified some limitations in the code that must be considered in the interpretation of technical results of the code. For example, the secondary electrons do not appear to be tracked. Only the primary electron is tracked before and after emission.



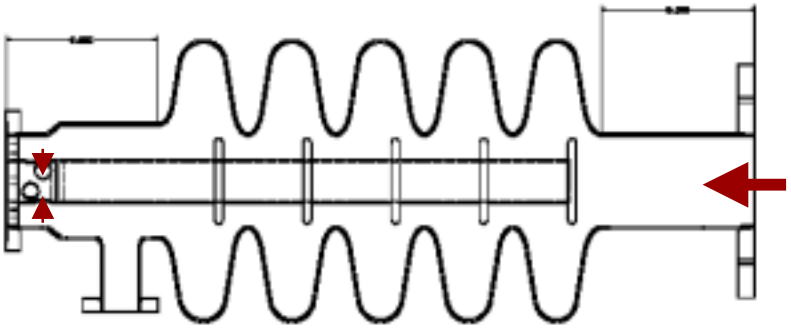
We are now investigation multipacting in the cylindrical pill box cavity supporting the dominant mode. Multipacting in this geometry is well known and will be used as a means of bench marking the code. Once confidence in the code has been gained in this bench marking study, we will be in the position to examine cavity structures of interest in this research.

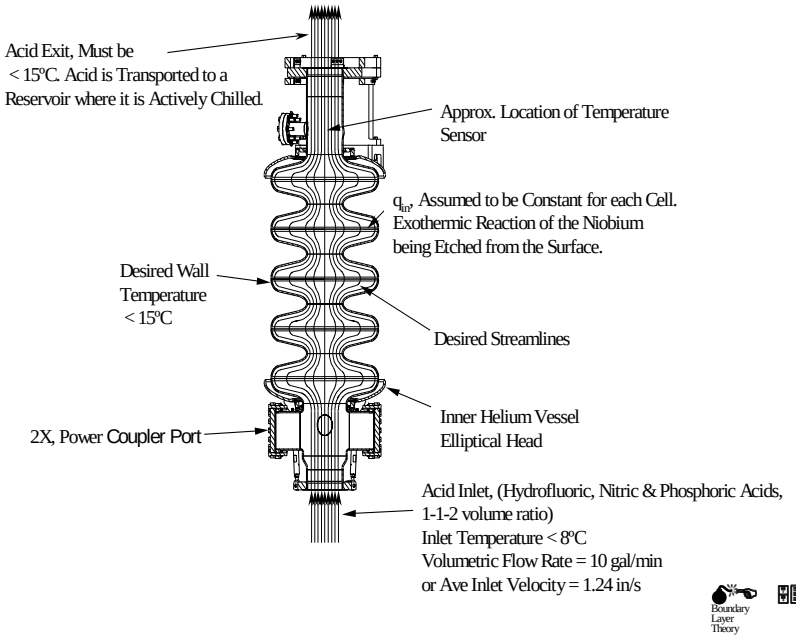
Dr. Humpries has been invited to give a seminar in March of 2002. During his visit, we will be interacting with him, in person, on his code.

CFD Study of Chemical Etching

Surface finish of the niobium cavity plays an important role of achieving the best performance. Perturbation of the geometry of the cavity inner surface can seriously affect its performance due to rf heating or electron field emission. Therefore, fabrication of the cavity is followed by a surface finish treatment using chemical etching. A baffle is inserted inside the cavity and an etching fluid is

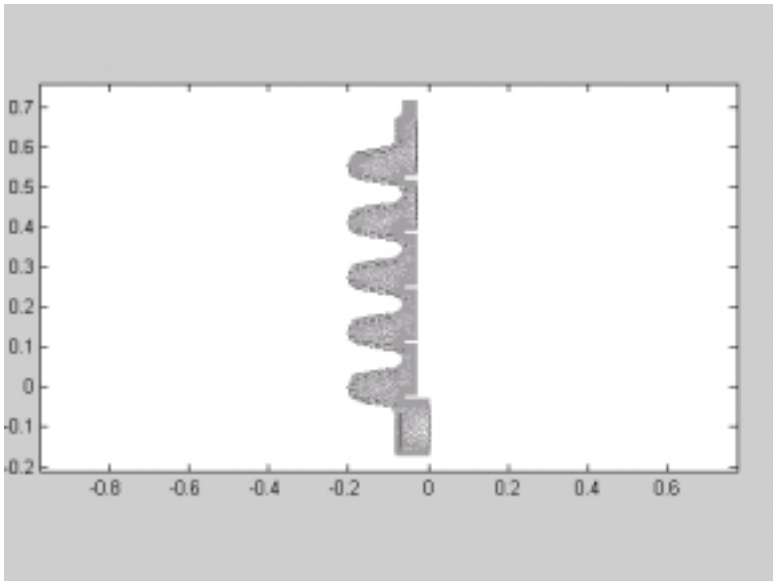
circulated to improve surface finish. The function of the baffle is to create desired pattern of streamlines.





The following steps were taken toward understanding and modeling of this problem:

1. Continuous discussions with Dr. D., Chan, LANL, and his colleagues to understand the problem.
2. Developing a finite element model for five-cell niobium cavity with a baffle using FEMLAB software (chemical engineering module).
3. Proposing a performance index to assess the etching process based on the standard deviation of the velocity vector along the cavity surface. The figures below show the cavity mesh, surface plot of the velocity field and flow plot of the same field.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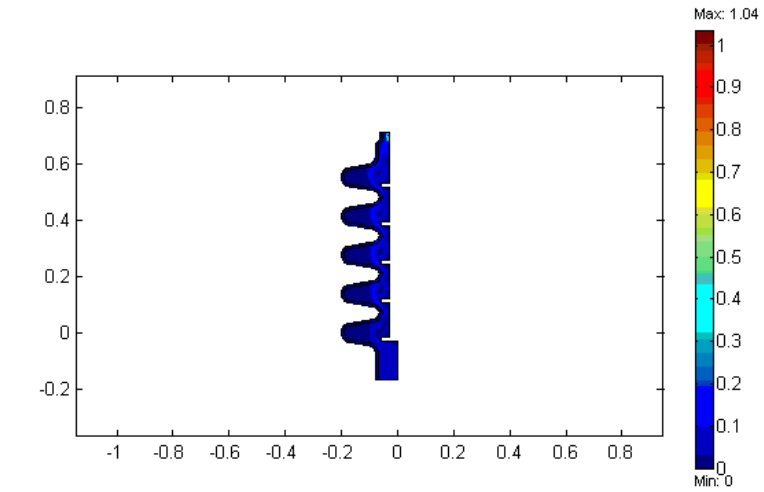
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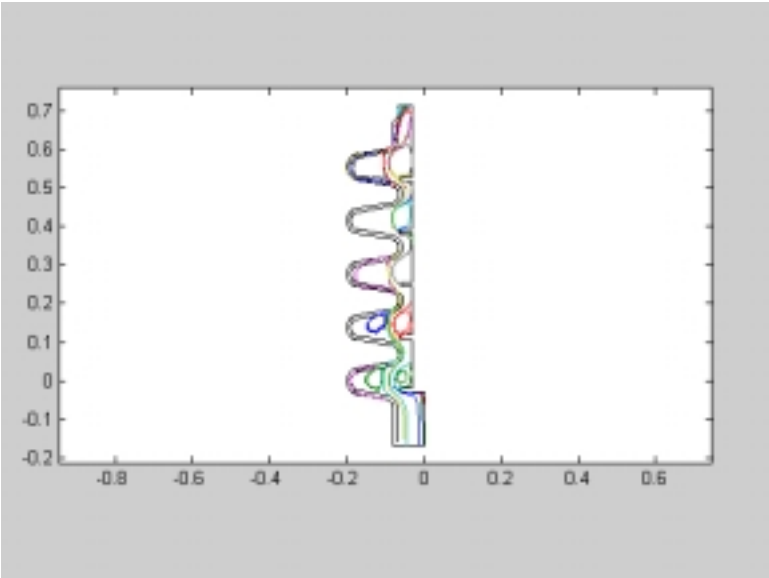

Optimization Study

We started performing a parametric study of the effect of various factors on the etching process. We will use our findings to conduct an optimization study. We are having ongoing discussions with LANL personnel regarding these issues.