Electromagnetic and Mechanical Design of Gridded windows for closed-Cell RF Cavities

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I. OUTLINE

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I. Introduction

II. Sample problem : Thermal analysis of a symmetric pillbox cavity

III. 805MHz cavity

- Normalized Electric field map for different grid configurations
- Electromagnetic and thermal analysis

IV. Conclusions and remarks

V. Present and future work

I. INTRODUCTION

- The 805 MHz test cavity model contains a Be-window from one side and a grid from the other side

- The objective is to perform electromagnetic, thermal and structural analysis of different RF windows (including the grids)

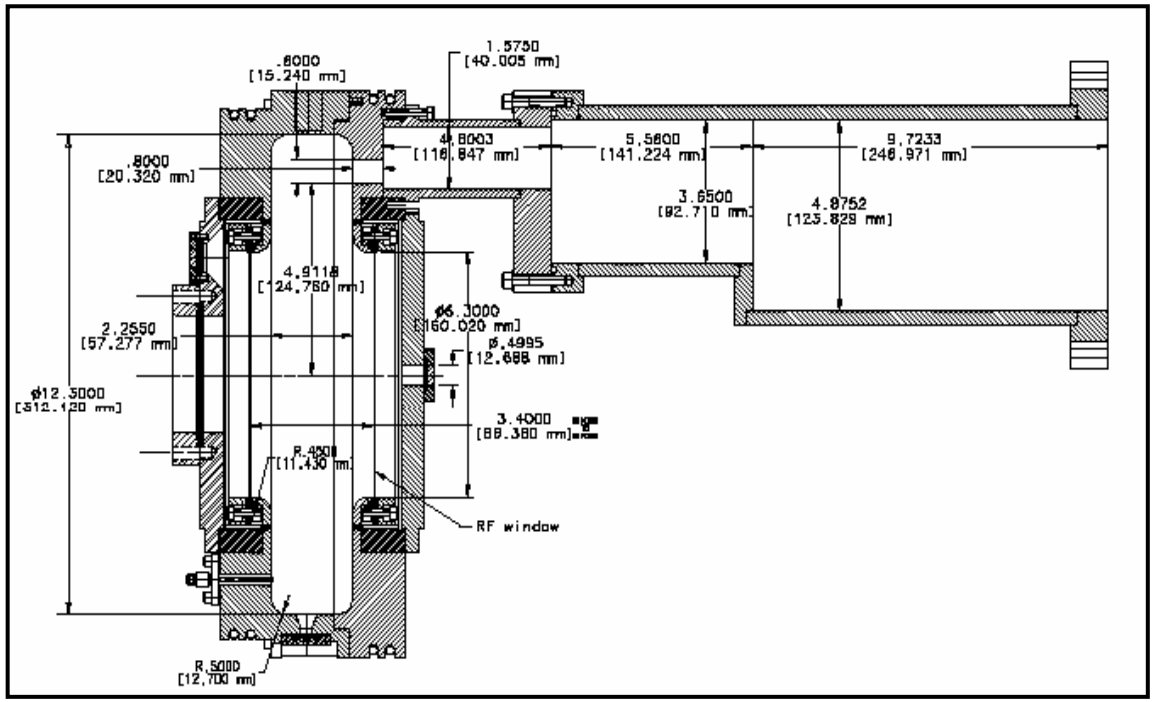

Fig. 1: Cross-sectional view of the 805 MHz cavity

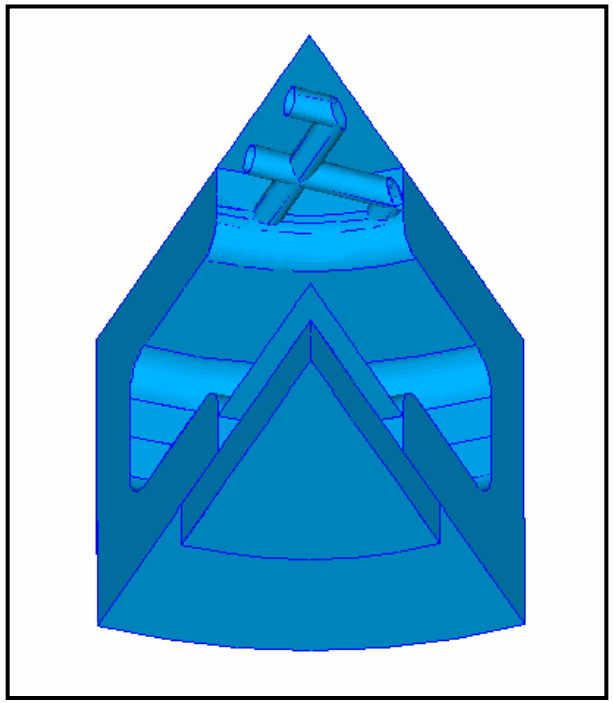

Fig. 2: FEA model

II. Sample Problem

A right circular cylinder similar to the 805MHz test cavity is modeled as a sample problem. The cavity copper body is closed by two circular beryllium foils from both ends. The foil dimensions are chosen to be the same as the dimensions of the beryllium foils for the 805 MHz test cavity.

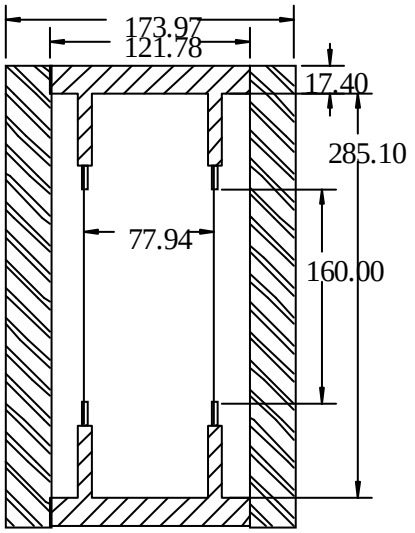

Fig. 3: Sample problem (mm)

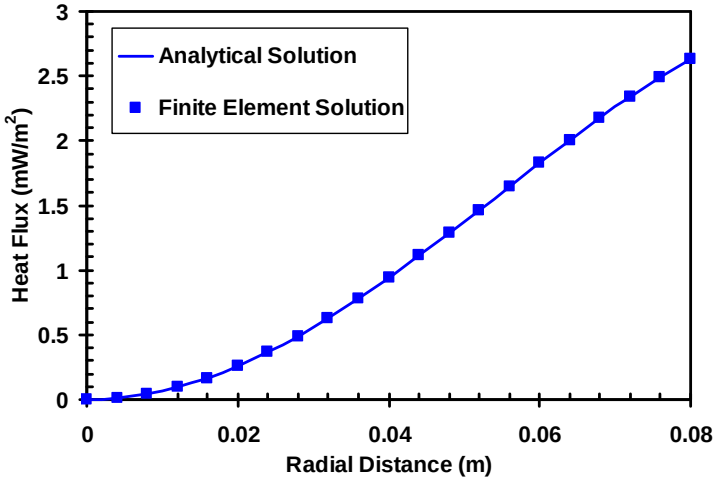

Fig. 4: Heat flux in the Be-window

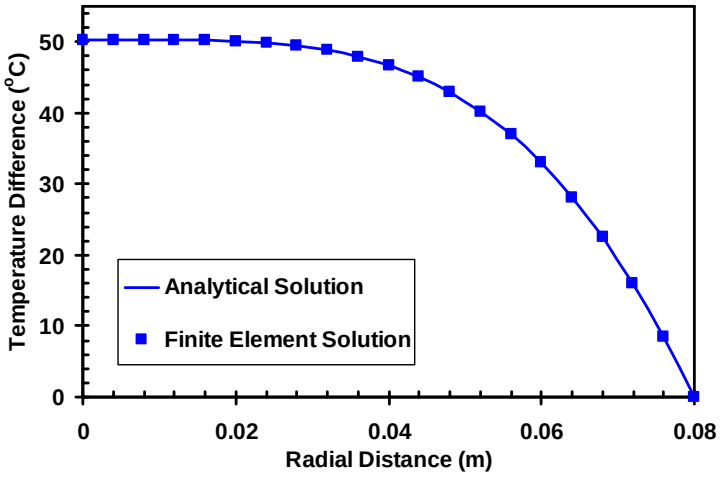

Fig. 5: Temperature difference in the Be-window

III. 805 MHz Test Cavity
- Normalized Electric field maps

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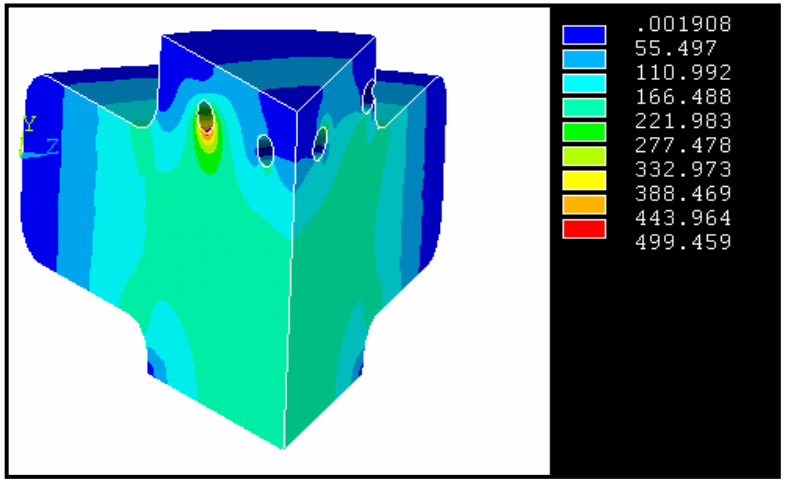


Fig. 12: One array of parallel tubes (1/8 model)

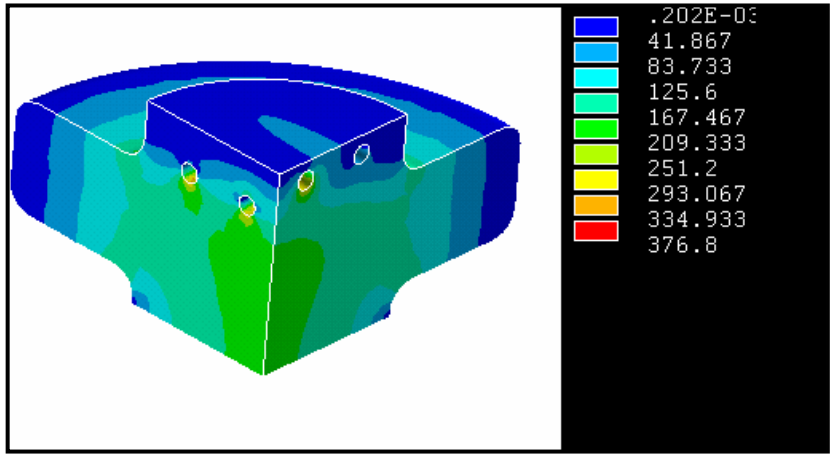


Fig. 13: Two non-touching arrays of tubes (1/4model)

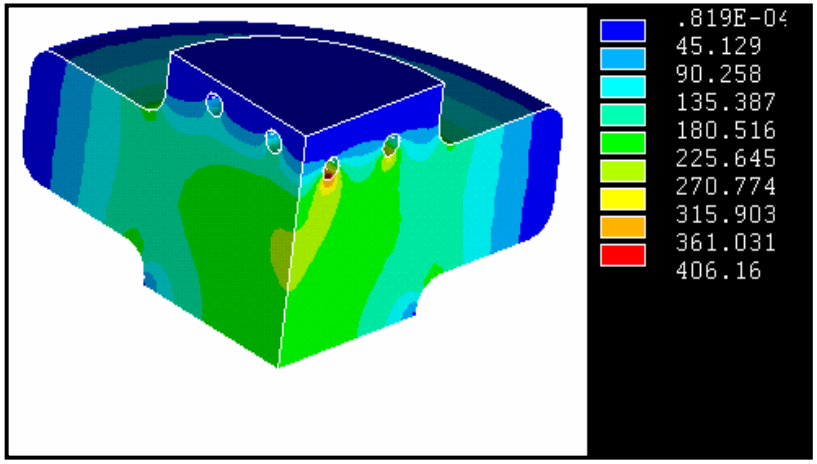


Fig. 14: Two touching arrays of tubes (1/4 model)

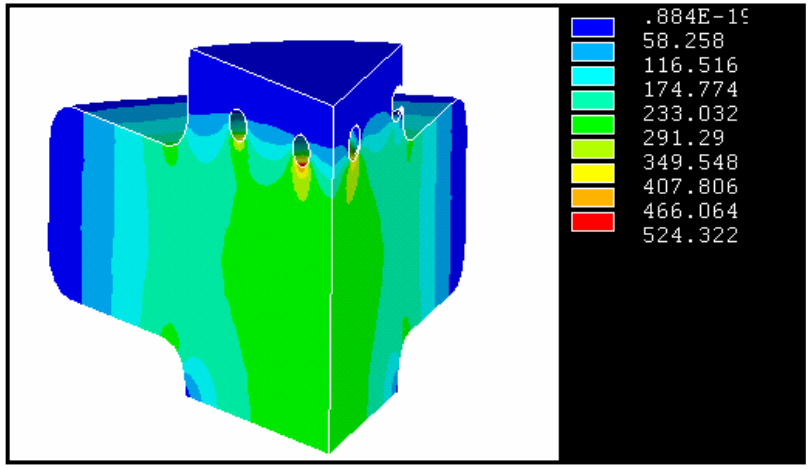


Fig. 15 fully overlapped arrays of tubes “waffle”(1/8 model)

Average power loss in the cavity =500 W. Be window thickness=127μm, tube DIA=0.9525 cm, Tube wall thickness= 254 μm

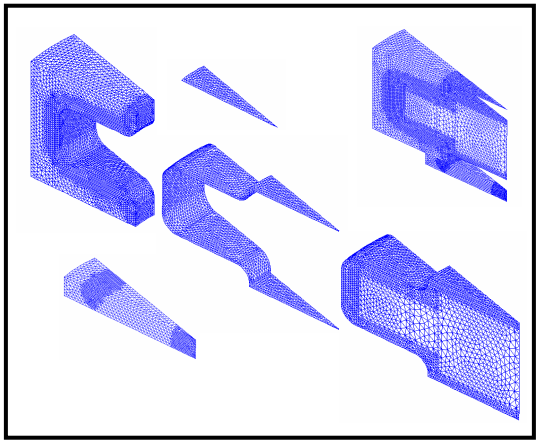


Fig. 6: FEA mesh

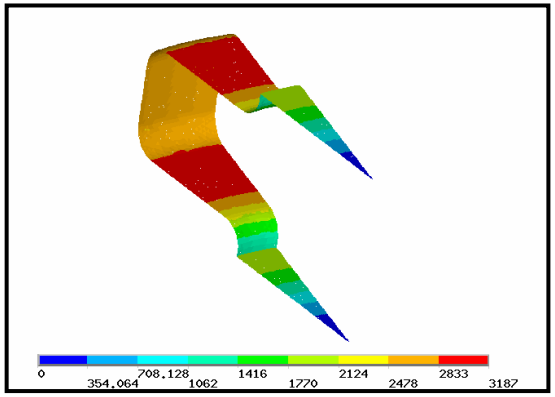


Fig. 7: Heat flux distribution (W/m^2)

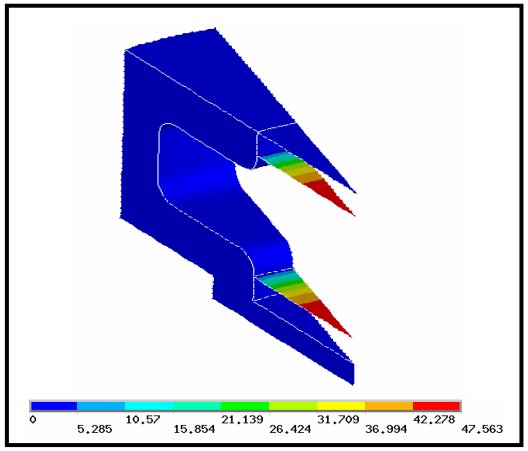


Fig. 8: Temperature difference (^0C)

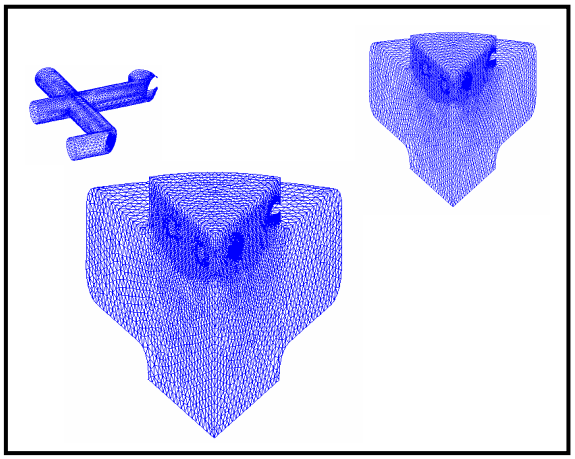


Fig. 9: FEA mesh

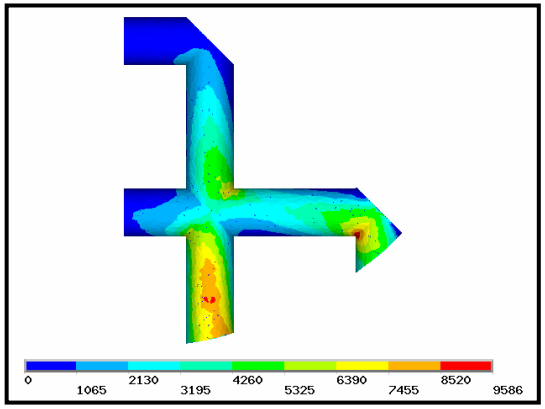


Fig. 10: Heat flux distribution (W/m^2)

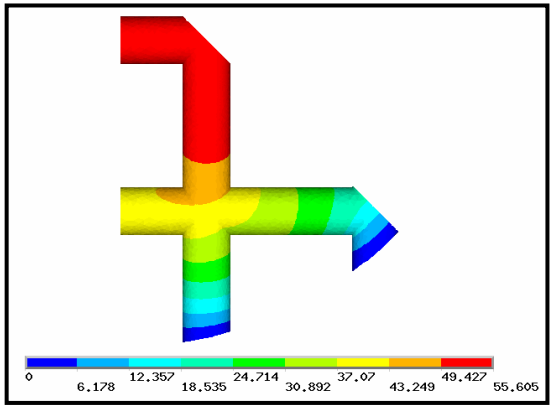
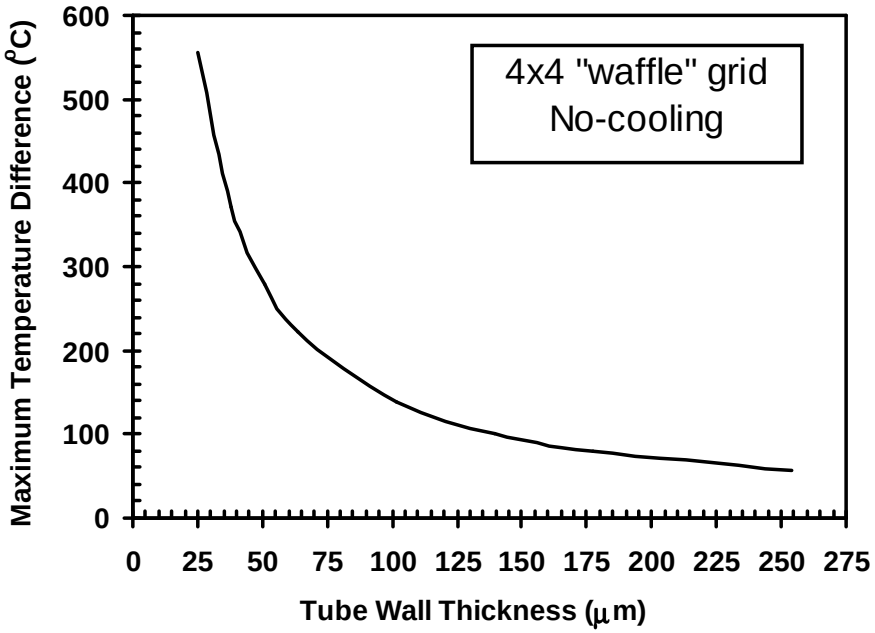


Fig. 11: Temperature difference (^0C)

Assuming turbulent and fully developed flow (Hydrodynamically and thermally), with a mass flow rate of 7.9e-4 kg/sec, the film coefficient h is calculated to be 250 W/m^2.k (*)



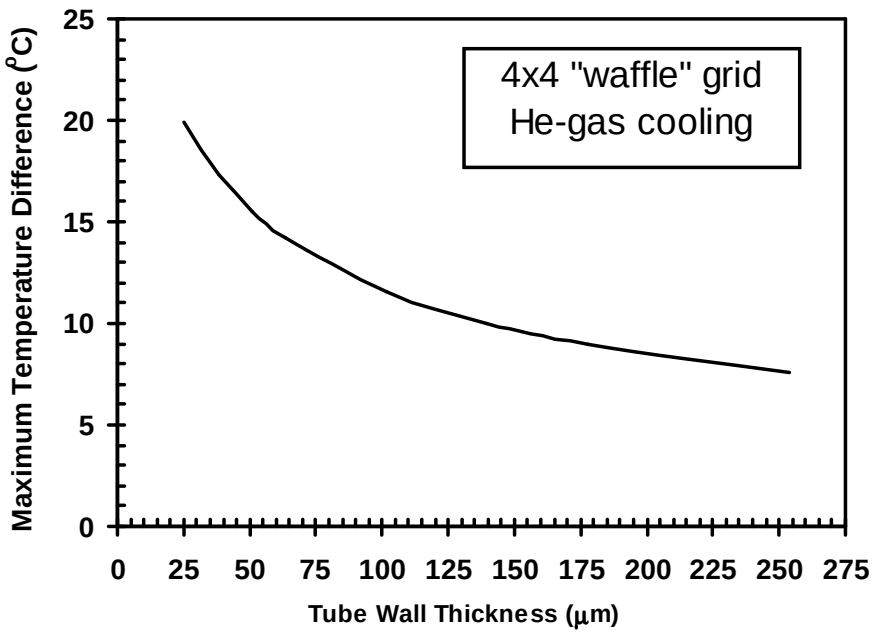


Fig. 16: Temperature.vs. thickness (No-cooling) Fig. 17 Temperature.vs. thickness (He-gas-cooling)

(*) *F. P. Incropera, D. P. Dewitt, Fundamentals of heat and mass transfer, 3rd Edition, John Wiley &Sons, New York, 1990.*

IV. Conclusions and Remarks

- Complete design procedure of RF cavity windows is constructed based on iterative finite element analysis.
- Electromagnetic and thermal solutions are obtained analytically for beryllium foils of an 805 MHz right circular cylinder.
- Electromagnetic field maps, thermal solutions and deflection results are obtained for different windows of the 805MHz test cavity including the gridded windows.
- Engineering outcomes from working within the muon collider collaboration:
  - Educating engineers about accelerator physics.
  - Improving research in joint accelerator-engineering applications.

V. Present and Future Work

- Electromagnetic and mechanical analysis of different RF gridded windows; 6x6 and 8x8 (In progress).
- Electromagnetic and mechanical analysis of curved beryllium windows.