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DESIGN AND SIMULATION OF 500 MHz SINGLE CELL SUPERCONDUCTING CAVITY*

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ABSTRACT

The Shenzhen Industrial Synchrotron Radiation Light Source is a fourth-generation medium-energy light source with a 3GeV storage ring electron energy beam and an emissivity less than 100 pm·rad. In order to ensure the long-term stable and efficient operation of the light source, a new type of 500 MHz single-cell superconducting cavity was designed in this study to be used as a backup superconducting cavity for Light Source. The 500 MHz superconducting cavity has a larger beam aperture and lower higher order modes (HOMs) impedance, which can be used in accelerators with larger currents. In this design, we simply adopted the same design scheme as the KEKB-type and CESR-type superconducting cavity. Using CST electromagnetic field simulation software to calculate and simulate the characteristics of the cavity, the results show that the designed 500 MHz single-cell cavity can meet the requirements of a higher acceleration gradient, a higher r/Q value, and a lower peak surface field.

INTRODUCTION

With the development of superconducting radio frequency technology, the superconducting cavity has been proven to be the best solution for compact, high-power and high-current accelerators. The application of single-cell superconducting radio frequency cavities in synchrotron radiation sources has also been widely recognized. The 500 MHz single-cell superconducting cavity has been successfully applied to major synchrotron radiation sources in the world. The most representative one should be the CESR and KEKB 500 MHz single-cell superconducting cavities developed by Cornell University and KEK in the 1990s. The KEKB type superconducting cavity has a cylindrical large beam tube (LBP), which is designed to 1) propagate the high-order modes (HOMs) along the beam axis; 2) Damping the HOMs through the ferrite absorber pasted on the inner surface of the beam tube on both sides of the cavity. The ferrite absorber damps the HOMs. The CESR cavity uses a fluted beam tube (FBT) to propagate HOMs. It has four special grooves that can reduce the cut-off frequency of the dipole mode and the round beam tube (RBT), and its cut-off frequency is high enough to exceed the resonance of the fundamental mode Frequency, but less than the resonant frequency of the HOMs of the second magnetic monopole.

In this thesis, a new type of 500 MHz single cell superconducting cavity is proposed based on the development of the international 500 MHz single cell superconducting cavities in recent years. Through a large amount of simulation design and calculation, the spare superconducting cavity of Shenzhen Industrial Synchrotron Radiation Light Source was designed. This research provides the preliminary structure design and simulation calculation of various performance parameters. The optimization goals of this design include, for example, lower surface electromagnetic fields (E_p/E_{acc}, H_p/E_{acc}), lower low temperature loss, stronger HOMs damping, or lower loss factor. Some of these goals are mutually exclusive, so in the actual design, we have carried out comprehensive considerations to achieve the best results. The innovation of this design lies in the combination of the advantages of the two cavities, the LBT of KEKB and the FBT of CESR.

CAVITY DESIGN

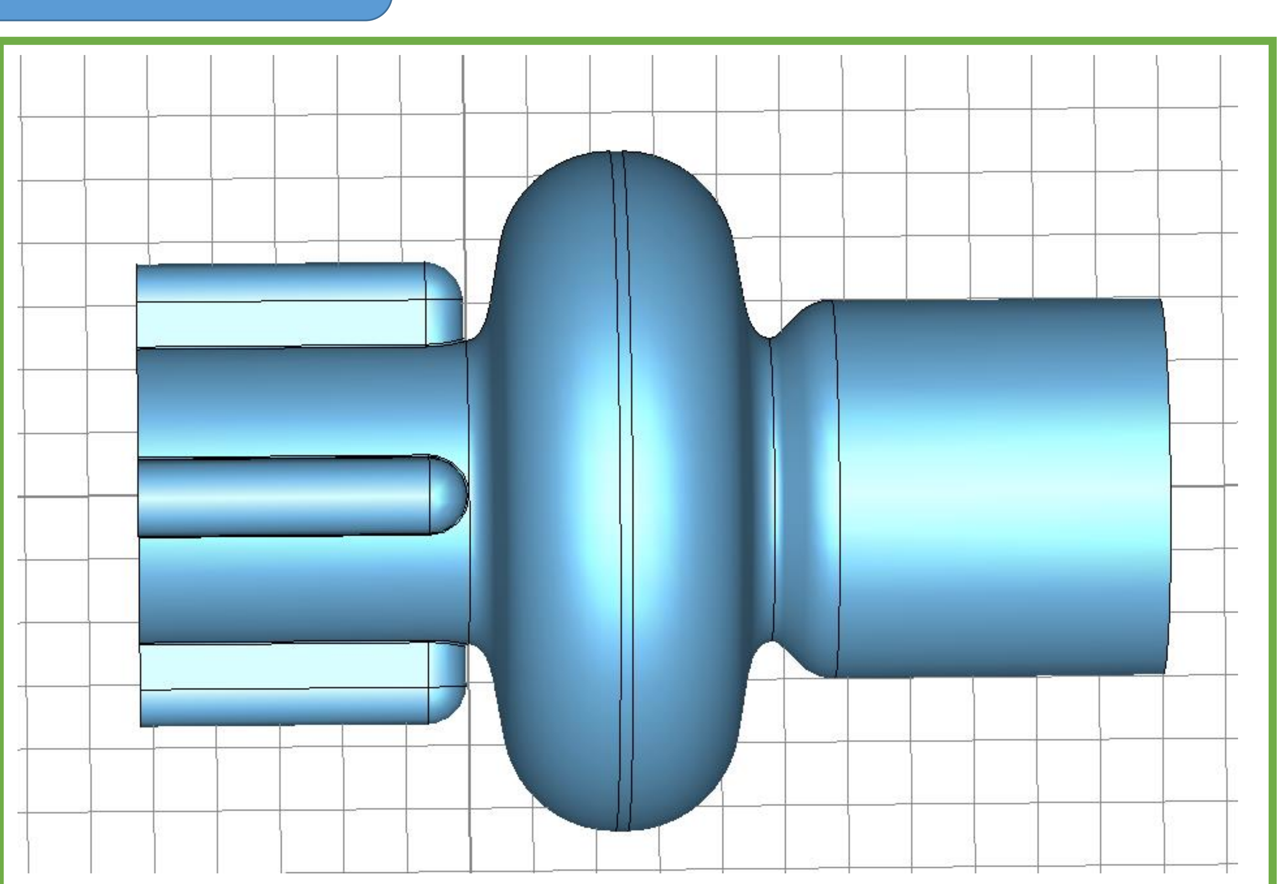

Figure 1: 3D structure model of the new superconducting cavity.

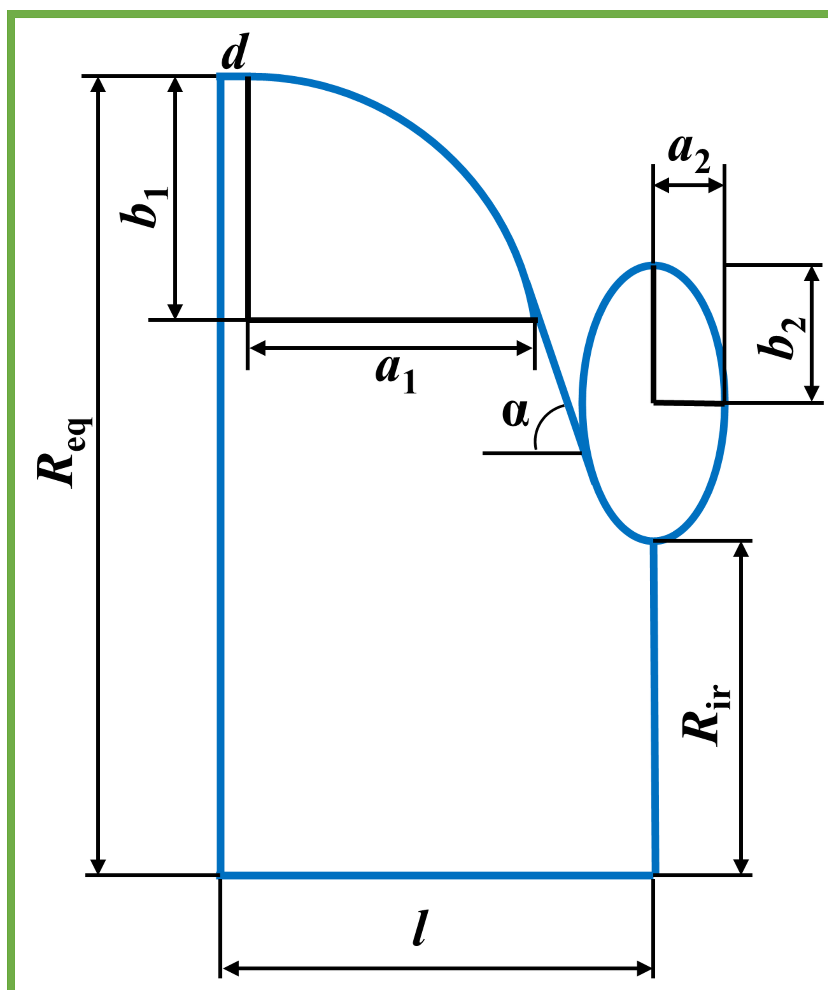

Figure 2: Geometric parameters of a typical cavity.

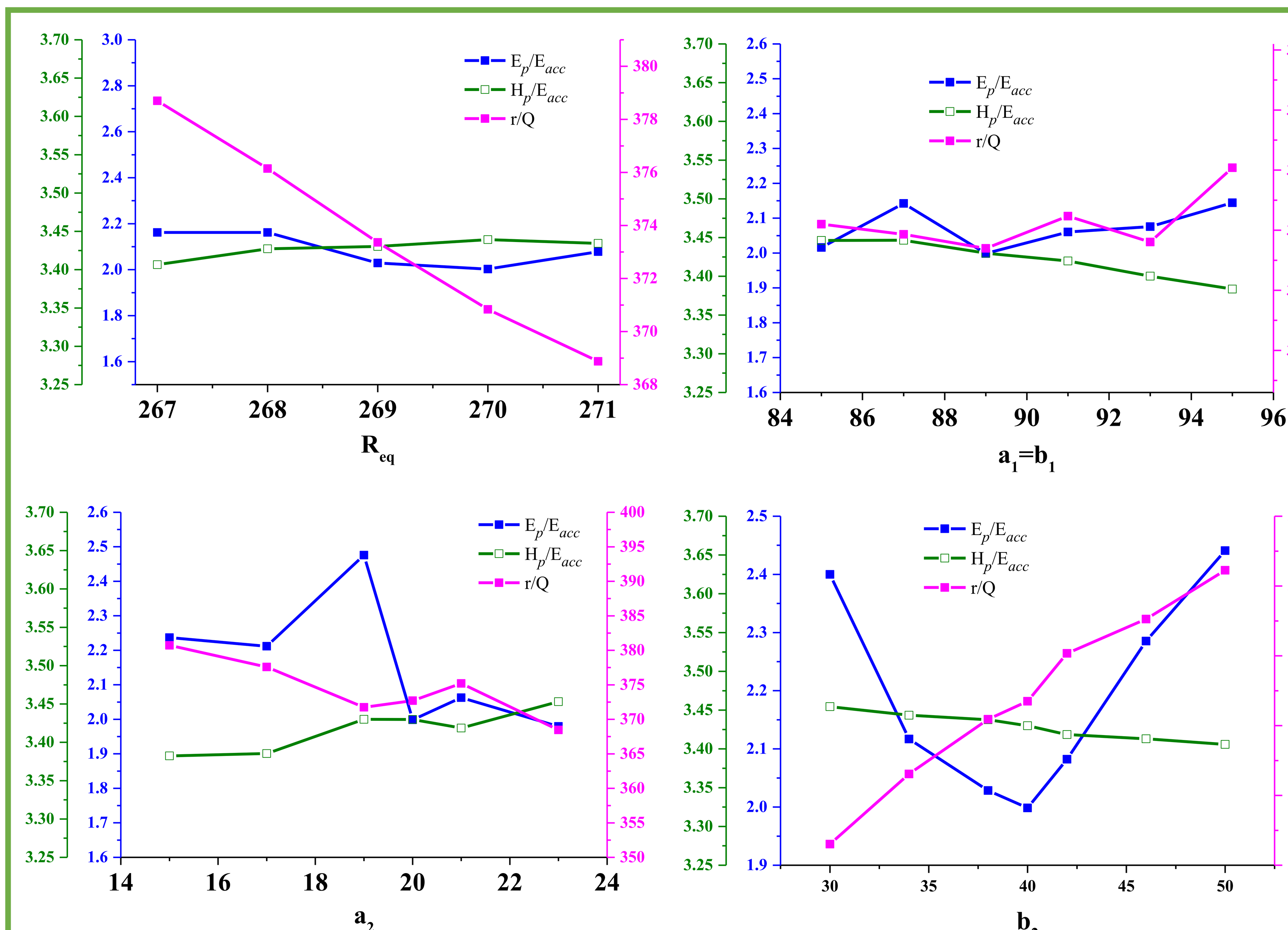

Figure 3: The relationship between the performance of the basement membrane and the adjustment of the cavity parameters.

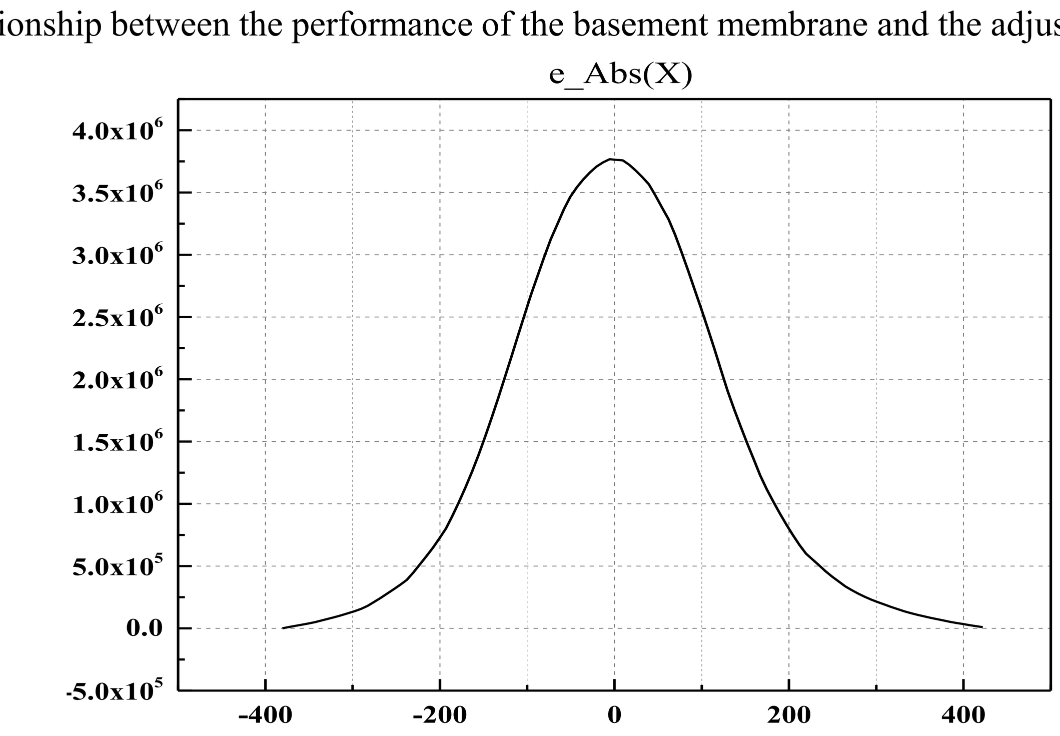

Figure 4: The distribution curve of the electric field of the fundamental mode along the axial direction.

CONCLUSION

This design refers to two types of superconducting cavities, KEKB and CESR, which are the mature superconducting cavity types widely used in the world, and optimizes the cavity structure. The results show that the performance parameters of the new 500 MHz single cell superconducting cavity are significantly better than those of KEKB and CESR. This new cavity combines the advantages of CESR's FBT and KEKB's LBT. The new cavity type meets the fundamental mode frequency of 500 MHz, and other performance parameters, such as r/Q value, ratio of surface electromagnetic field to accelerating electric field (E_p/E_{acc}, H_p/E_{acc}), meet the design requirements. At this stage, this research is still in the cavity design stage. The next work is to design the high-power input coupler, and then carry out the electron Multipacting research. Finally, the superconducting cavity manufacturing, surface treatment, vertical testing and horizontal testing will be carried out.

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