THE RESEARCH ON SPOKE 0.40 CAVITY*

P. Sha#, H. Huang, W. M. Pan, X. Y. Zhang, IHEP, Beijing, China

Abstract

Spoke superconducting cavity can be used in the low-energy section of the proton accelerator. It has many significant advantages: compact structure, high value of R/Q, etc. The Chinese ADS (Accelerator Driven System) project will adopt many spoke cavities with 3 different β values (0.12, 0.21, 0.40). Spoke040 cavities (Geometric β = 0.40) are used to increase the proton energy from 34 MeV to 178 MeV. Now the physical design of spoke040 cavity has been finished, and the machining of prototype is undergoing right now. The vertical test is supposed to be held at the beginning of next year.

INTRODUCTION

ADS project is proposed to transmute the nuclear waste in China [1]. The ADS accelerator consists of two injectors and one main LINAC, which will be built by IHEP and IMP. Spoke040 cavity is adopted in Injector I, as Figure 1 shows. Its RF and mechanical design will be presented in this paper.

RF DESIGN

Spoke040 cavity is the biggest of the three spoke cavities. According to the requirement of beam dynamics, 50 mm is chosen to be the diameter of beam tube. When the accelerating gradient (E_{acc}) reach 7.7 MV/m (maximum value), the peak electric field (E_{peak}) should be below 32.5 MV/m and peak magnetic field (B_{peak}) should be less than 65 mT. The distance of gap-center to gap-center is defined to be $\beta\lambda/2$.

Initially a flat end-wall structure of Spoke040 cavity has been presented. Later, a convex end-wall [2] is adopted for better mechanical performance, which is shown in Figure 2.

The goal of RF design is to maximize R/Q and G, while minimize the peak electric filed (E_{peak}/E_{acc}) and peak magnetic field (B_{peak}/E_{acc}). The width (W), thickness (T) and diameter (D) of spoke are optimized to achieve this goal.

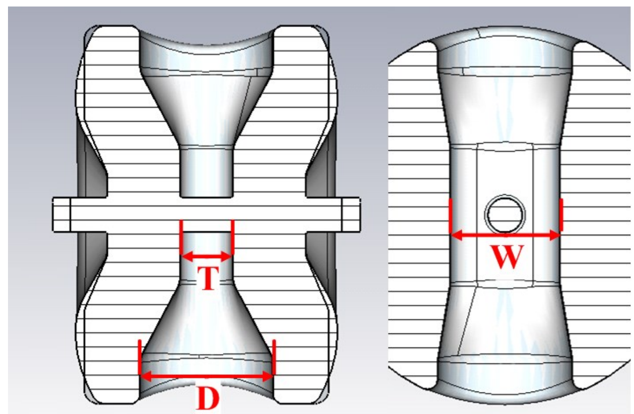

Figure 2: Flat and convex end-wall of Spoke040.

The electric filed mainly concentrates at the centre of spoke, so T and W are optimized to achieve low peak electric field. Figure 3 shows the simulation results.

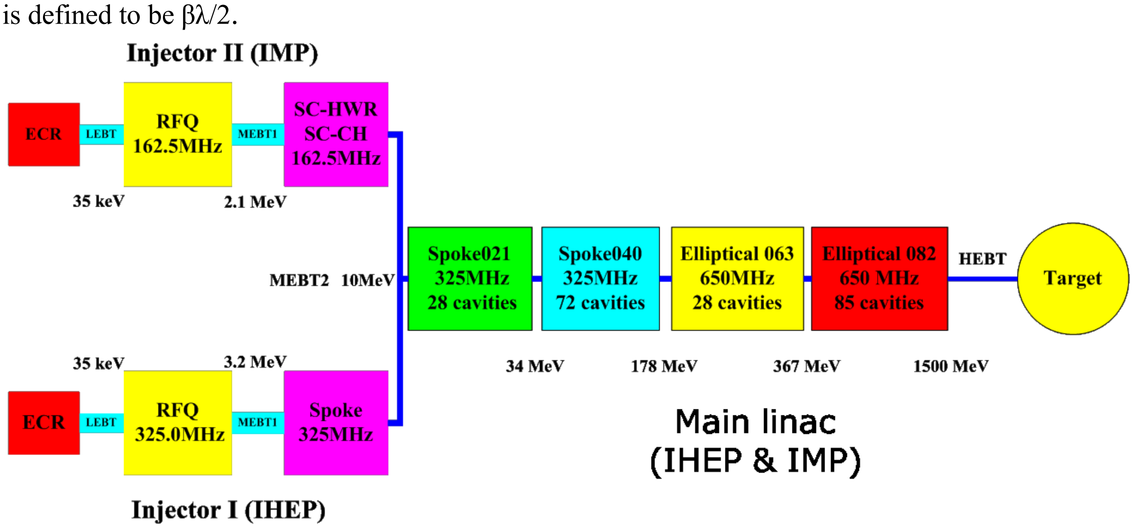

Figure 1: Layout of ADS accelerator.

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#shapeng@ihep.ac.cn

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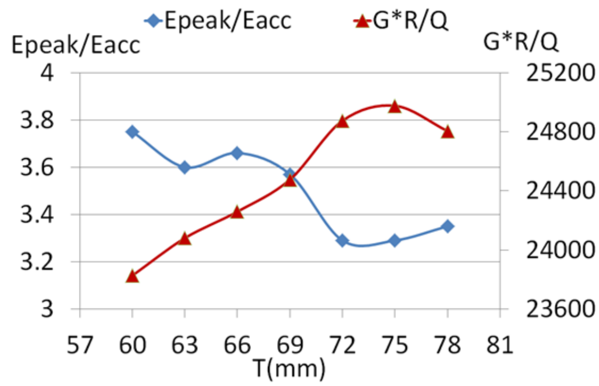
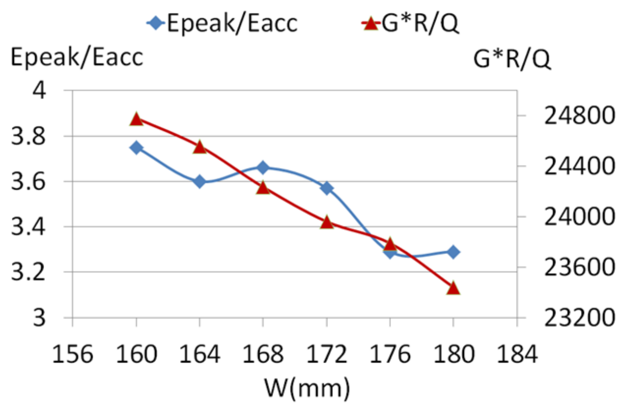


(a)



(b)

Figure 3: Optimization of peak electric field.

The magnetic field mainly concentrates at the end of spoke, so D is optimized to achieve low peak magnetic field. Optimization of B_{peak} is more important, because it is very close to the value 65 mT. Figure 4 shows the simulation results.

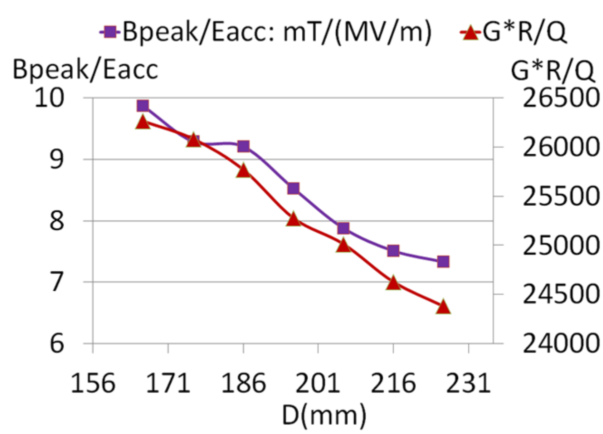


Figure 4: Optimization of peak magnetic field.

The final RF parameters are listed in Table 1.

Table 1: Main Parameters of Spoke040 Cavity

Parameters	**Value**	**Units**
Diameter	556	mm
length	386.5	mm
Beam aperture	50	mm
R/Q	250	Ω
G	104	Ω
E_{peak}/E_{acc}	3.6	
B_{peak}/E_{acc}	8.2	mT/(MV/m)

MECHANICAL DESIGN

The goal of mechanical design is to make df/dp as low as possible and obtain enough tuning range. Because ADS is a CW LINAC, Lorentz force detuning isn't serious [3]. Stiff ribs have been added to minimize frequency shifts and stress due to the pressure vibration. But the cavity shouldn't be too solid, which would reduce the tuning range. So there's a compromise between df/dp and tuning capacity in the mechanical design. Many stiff schemes have been analyzed, and the final edition is showed in Figure 5.

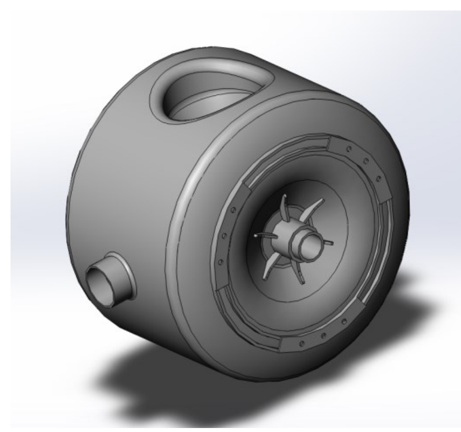


Figure 5: Schematic of Spoke040 cavity and stiff ribs.

Main mechanical simulation results are listed in Table 2 when the cavity withstands the pressure of 1.5 bar at room temperature.

Table 2: Margin Specifications

Parameters	**Ports free**	**Ports locked**
Peak stress (MPa)	85	38
Peak deformation (mm)	1.32	0.136
Df/dp (kHz/torr)	-0.67	-0.044

The distribution of deformation and stress under 1.5 bar is showed as Figure 6 when ports are locked. Maximum deformation locates at the centre ring of the cavity, while maximum stress locates at the stiff ribs around beam tube.

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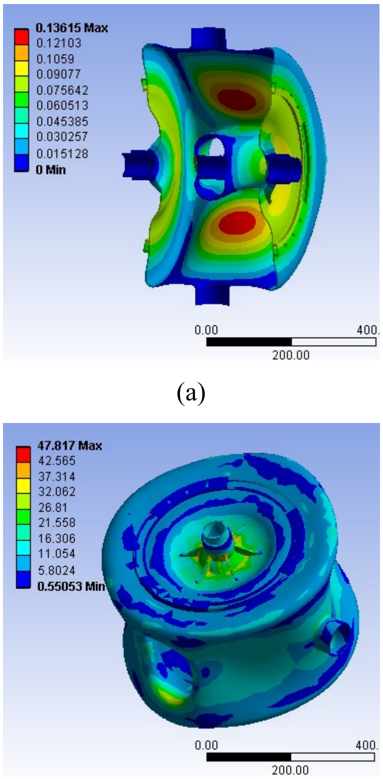

(a)

(b)

Figure 6: Distribution of deformation (a) and stress (b).

Tuning is very important because tuning sensitivity of Spoke040 cavity is too low (250 kHz/mm). Two tuners (one per side) will be adopted in order to increase the tuning range, which also keep tuning loads symmetrical. The tuning range is required to be over 200 kHz, and the maximum force produced by each tuner should be more than 5 kN. Then, maximum deformation would reach 0.42 mm and maximum stress 37 MPa.

MACHINING

Machining of the prototype has begun at this summer. Several components have been obtained through deep-drawing, as Figure 7 shows. It's planned to complete the machining at the end of this year.

Figure 7: Components after deep-drawing.

CONCLUSION

Design of Spoke040 cavity has been completed, which meets the requirement of beam dynamics. And the fabrication has begun, too. Vertical test will be held to verify the performance of the prototype in future.

ACKNOWLEDGMENT

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