THERMAL CALCULATION AND DESIGN OF THE RFQ CAVITY

Peng Zhao-hua
China Institute of Atomic Energy, P.O.Box 275-10, Beijing 102413, China

Abstract:

Using a finite element analysis software---ANSYS, RFQ cavity's deformation, which is caused by power dissipation in the walls, can be calculated. Basing on the result, water cooling system's design can be optimized.

1 INTRODUCTION

When waves travel in rfq cavities, the walls will absorb some of their energy. This part of energy will be converted into heats. For high intensity RFQ accelerator, the heats will deform rfq cavities, then there will be two problems :

a. The cavity's synchronous frequency will be changed.
b. The tips of poles will be deformed, other harmonics will be introduced.

So it's very important to calculate the deformation and evaluate its influence to the electromagnetic field in theory. If we can do it, we can optimize our design to reduce the influence.

We use ANSYS and SUPERFISH to do this job. SUPERFISH calculates the power dissipation in the walls. ANSYS does thermal-structure coupled calculation.

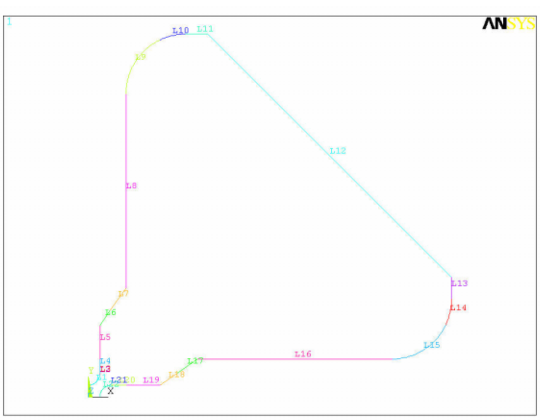

Figure 1 the meshed model of 1/4 rfq cavity

2 CALCULATIONG AND DESIGN

2.1 Power dissipation in the walls

Because the cavity is symmetrical, we only need calculate 1/4 cavity. Figure.1 is the meshed model. Table 1 is the calculating result, where dF/dX is the change of frequency per unit deformation along x coordinate, dF/dY is along y coordinate, P/A is the power dissipation per unit area.

Table 1. the calculate result

Seg	P/A (W/cm^2)	dF/dX (MHz/mm)	Df/dY (MHz/mm)
2	0.3614	2.066E+01	2.284E+01
3	1.0561	4.506E-01	3.942E-02
4	1.1034	5.594E-01	0.000E+00
5	1.5331	3.572E+00	0.000E+00
6	2.3368	1.255E+00	0.000E+00
7	2.8160	1.315E-01	9.2070E-02
8	3.2817	3.497E-01	2.4480E-01
9	4.7040	-1.068E+00	0.000E+00
10	5.2583	-5.333E-01	-3.365E-01
11	5.2833	-5.889E-02	-2.585E-01
12	5.2854	0.000E+00	-2.188E-01
13	5.2306	-2.407E+00	-2.407E+00
14	5.2854	-2.188E-01	0.000E+00
15	5.2830	-2.585E-01	-5.890E-02
16	5.2570	-3.365E-01	-5.333E-01
17	4.6889	0.000E+00	-1.067E+00
18	3.2828	2.259E-01	3.2260E-01
19	2.8304	1.076E-01	1.5370E-01
20	2.3116	0.000E+00	1.2400E+00
21	1.4728	0.000E+00	4.1340E+00
22	1.0358	3.617E-02	4.1340E-01
23	0.3473	2.286E+01	2.0690E+01

2.2 Deformation of the rfq cavity

Basing on the power dissipation above, we use ANSYS to calculate the deformation of the rfq cavity. The factors we need think of are: the temperature of water that cool cavities, the number of water cooling holes and positions of cooling holes. Figure 2 is the calculating result at 24^0C and 20 holes, where DMX is the maximum of deformations (the unit is cm). ANSYS can tell us every segment's deformation.

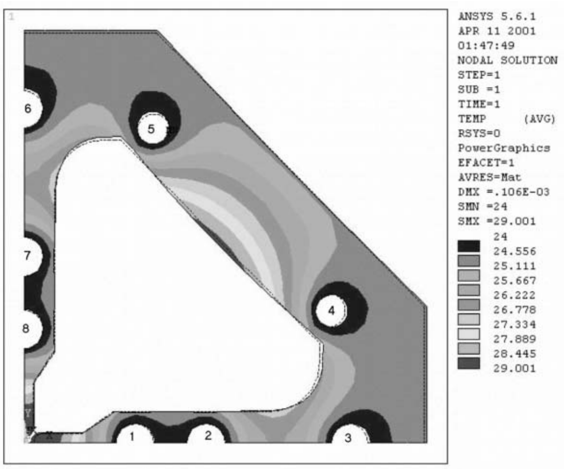

Figure 2 The result at 24^0C and 20 holes

Because we know dF/dX and dF/dY, so the change of frequency can be known. Adjusting the temperature of water and the number of cooling holes and positions of cooling holes, we can get the best condition in which the deformation is the minimum.

In our original design, there are 20 water cooling holes. After calculating, we find that 16 holes are enough, this reduces the difficulty of machining obviously. Figure 3 is the calculating result.

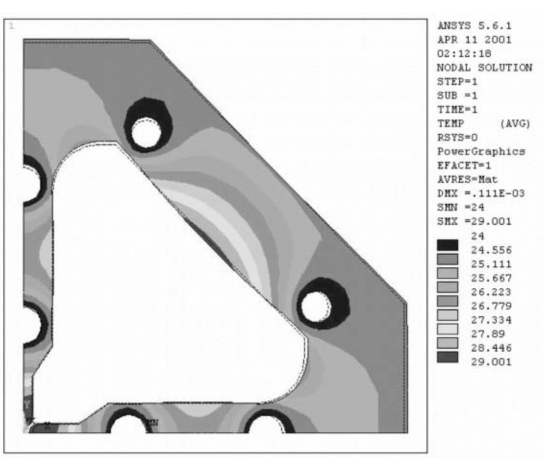

Figure 3 The result at 24^0C and 16 holes

2.3 Machining allowable tolerance

On second thoughts, we can use the calculating result to get machining allowable tolerance of water cooling holes. Adjusting positions of water cooling holes, we can get deformation of cavity, and then we calculate the change of frequency. If the change is less than the frequency tolerance, positions of hole are allowable. After doing this calculation again and again, we can get the machining allowable tolerance .

3 CONCLUSION

Thermal calculation of rfq cavity provides thermal design of rfq cavity a fundament., and optimizes thermal design of cavity.