STUDY OF CERAMIC VACUUM CHAMBERS IN HLS NEW INJECTION SYSTEM*

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Abstract

Ceramic chambers and ferrite kicker magnets were developed in HLS new injection system. The inner surfaces of the ceramic chambers were coated with 0.1ohm/square metallic Mo layers to meet the requirements of both the penetration of pulse magnetic field and small beam coupling impedance. This paper presents the issues in fabricating these chambers and measurement of their loss factors and wake functions. Broadband impedance parameters of these ceramic chambers were obtained by fitting the measured data

1 DEVELOPMENT OF CERAMIC VACUUM CHAMBERS

1.1 Review

There are several technical schemes of constructing a injection kicker magnet and its vacuum chambers. A traditional one is air-coil magnet, in this case, a one-return parallel current plates are housed in a stainless steel vacuum chamber. Although simple, it is difficult to obtain a very homogeneous field and beam loss more energy due to coupling impedance compared with other parts of the vacuum chambers. An improved air-coil magnet which is called slotted-pipe kicker was originally developed in DELTA ring [1] and planned to be adopted in the damping rings of NLC (Next Linear Collide) combined with solid-state modulators [2]. In this design, small loss impedance can be achieved. Ceramic chambers with ferrite magnet outside are widely used in the third generation synchrotron radiation machine [3] [4]. Because of high excitation efficiency of magnetic field and small beam coupling impedance, this disign was employed in the new injection system of HLS ring.

1.2 Ceramic chambers development

The chambers were made of 97.5% Al_2O_3 ceramic and pressed isostatically during fabrication. They were metalized and welded to stainless steel flanges. The chambers have racetrack apertures with dimensions of 80mm*24mm and 96mm*24mm respectively. The whole length is 350mm. Original coating material was selected as Ti. But we encountered some technical problems when sputtering Ti to the inner surfaces of these pipes. Thus the material was changed to Mo and the coating was realized by the method of sintering. Coating and metallization were accomplished simultaneously in H_2 oven at the temperature of 1500 ^{o}C. Coating layers sintered in such temperature adhere to ceramic firmly. Surface resistance of the Mo layer was determined by inductive coil method. and the parameter is about 0.1ohm/square. Some isolating strips were applied to the coating surface in order to decrease the eddy current induced by pulsed magnet field. A shielded bellow with the same aperture was used to connect two 350mm chambers.

Experiments to test the vacuum performance of the coating layers were carried out. The outgassing rate was estimated to be less than 1×10^{-10} Torr·l·s^{-1} cm^{-2}.

Fig.1 ceramic chamber and shielded bellows

2. IMPEDANCE MEASUREMENT

2.1 measurement system introduction

An automatic measurement system using wire method was established to measure the energy loss factor K, longitudinal wake function and coupling impedance of ceramic chambers. The hardware of this system is based on HP instruments and a personal computer. The data acquisition software was developed in HP VEE. This system has the ability of measuring energy loss factor and wake functions for various bunch lengths σ . The σ can be from 80ps to 125ps and the $\Delta\sigma$ can be less than 1ps.

2.2 Comparison between coated and non-coated chambers

The K-σ curves and loss power of 1 ohm/square coated pipes and non-coated pipes are illustrated in Figure2. In the calculation of loss power, the number of

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bunches is chosen to be 45 while the beam current to be 300mA , It is seen that *K* and *P* of coated pipes at σ=100ps reduced by a factor of five , that is 0.14V/pC and 61W respectively.

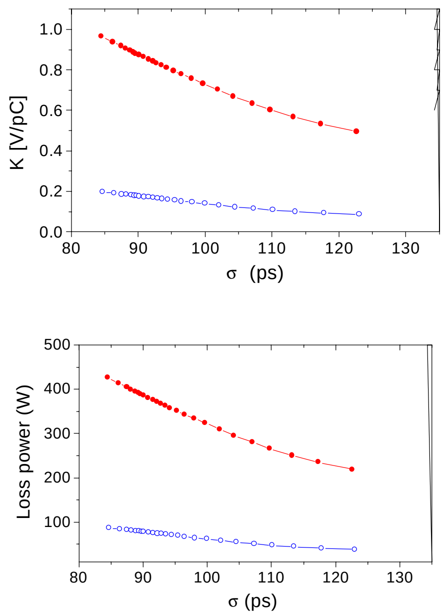

Fig2. K-σ curves and loss power of ceramic chamber with and without coating
●--coated pipe O---non-coated pipe

2.3 other pipes

Besides the ceramic chambers, several other types of vacuum pipes were measured too. Together they were as following:

(a) coated ceramic pipes with ferrite kicker outside
(b) coated ceramic pipe
(c) coated pipes with a thick metal layer outside.
(d) stainless steel pipe with a diameter of 35mm ,
(e) non-coated ceramic pipes with a thick metal layer outside (aluminium 0.5mm)

A ceramic pipe without coating but with a thick metal layer outside is like a metal pipe in the view of impedance measurement. The thick metal layer and flanges at two ends were connected tightly for good conductivity. It has a similar cross section and irregularity structure. A stainless steel pipe with round cross section and with a diameter of 35mm was measured too. It also can be a reference. All the measured data are plotted in Figure 3. The *K* values at σ=100ps are 0.134V/pC、0.091V/pC and 0.063V/pC for case (b), case (d) and case (e) respectively. Obviously the *K* of (b) is relatively bigger compared with case (d) and case (e), therefore it can be estimated that 1 ohm/square film is thin and should be made thicker

In real situation, the ferrite kicker was placed outside ceramic pipe. This case was measured too in order to find the influence of ferrite kicker and current plates.outside. The current plates were connected to flanges when measuring and the results show no difference. The small difference in *K* values is within the system error. Already coated pipe with a thick metal layer outside shows no difference too, and it seems that the inner layer screens the wake field.

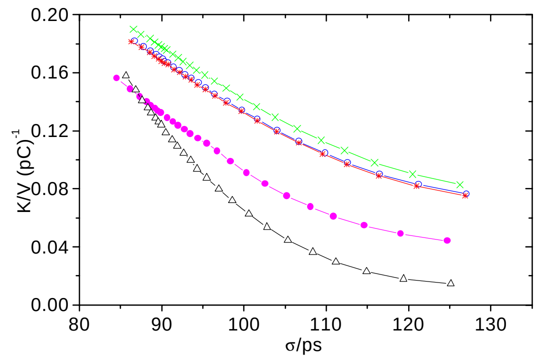

Fig3. K-σ curves of different vacuum chambers

×Coated pipes with ferrite kicker outside,
OCoated pipes
*Coated pipes with a thick metal layer outside
● stainless steel pipe with a diameter of 35mm
Δ Non-coated pipe with a thick metal layer outside

2.4 Broadband impedance calculation

We can obtain the parameter $|Z/n|$ by some numerical calculation based on the measured data of K-σ. The result $|Z/n|$ is 0.377 Ω for 1 ohm/square coating pipe and 1.898 Ω for non-coated pipe. The whole $|Z/n|$ of the ring is about 12.8 Ω, and $|Z/n|$ from four coating pipes is about 1.5 Ω which seems to make much contribution.

2.5 Conclusion

The thickness of coating should be increased. The present coating has already changed to be 0.1 ohm/square. According to the result of magnetic field study, a coating of $0.1\Omega/square$ will still meet the requiement of homogenity and magnitude of penetrating field.

3 REFERENCES

[1]G. Blokesch, M. Negrazus, K. Wille. A Slotted-pipe Kicker for High-current Storage Rings[J]. Nuc. Ins. & Meth. A 338(1994) 151~155.
[2]C. Pappas, R. Cassel, Damping ring kickers for the next Linear Collider. Proceedings of PAC99
[3]D,Tommasini. Injection into the Eletra Storage Ring[C], IEEE Proceedings of PAC, 1993, 1375-1377.
[4]S. Milton, D.Warner. APS Ceramic Chambers[C], Proceedings of EPAC, 1994, 2494-2496.