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THE WAKEFIELD STUDY OF THE RF-SHIELDED BELLOWS AT THE ILSF STORAGE RING*

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Abstract

The corrugated geometry of the bellows made it critical to be shielded with an RF-Shield. Different types of RF-shields can be applied to the ILSF vacuum chamber to cover this component's destructive impedance peaks. Then, Impedance study and optimization of the RF-shields can improve the impedance budget. In this article, two common types of RF-shields are simulated in CST software.

INTRODUCTION

The Collective effect and impedance considerations [1] are among the most critical issues for the ILSF storage ring as a third-generation, low emittance machine [2, 3].

The simulated geometry of the bellows is illustrated in Fig. 1. Two common types of RF-Shields were simulated and compared inside these bellows. The Flat-Type RF-Shields have been frequently used in light sources. The Finger-Band type has been designed and studies for the wakefield considerations. The geometry of these two types is presented in Fig. 2.

The thickness, length, and width of the grooves in the finger-band model have been optimized for the ILSF vacuum chamber. The fingers on the side and on the anti-chambers were omitted to minimize the wake impedances. A series of springs should be added to this geometry to fix the place of the fingers. Although the beam does not see the springs, they are not covered in this simulation. We are going to compare these two types of the RF-Shields for the ILSF vacuum chamber.

In the first section, Both of the geometries were simulated in CST Particle Studio. Then the wakefield study was done. The heat load was calculated in the last part:

- Wakefield & Impedance
- Power Loss

Geometry & CST Design

Both geometries were modeled in the CST suite studio. It is suggested firmly to solve with the Wakefield solver.

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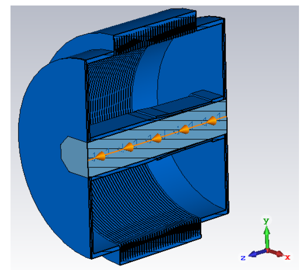

Figure 1: The Outer geometry of the bellows.

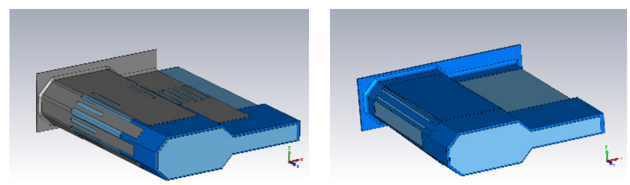

Figure 2: The Finger-Band (right) and the Flat-Type (left) geometry inside the Bellows.

Simulation Details

All normal background and electric boundary conditions in transverse directions were set on the geometries. An open boundary was defined in the longitudinal direction. All the materials were considered stainless steel 316. A 3 mm bunch length and 20 lines per sigma were added to the geometries. The mesh setting determined the line mesh properties. A local mesh setting was added to the simulation with (0.2, 0.2, and 0.1) in x, y, and z-direction. The total number of mesh cells reached 100 million cells.

WAKEFIELD & IMPEDANCES

Wake potentials are calculating in the time domain. A Fast Fourier Transform (FFT) can switch the results to the frequency domain. The longitudinal and transverse results should be studied separately.

Longitudinal Direction

The simulated results in the longitudinal direction are presented in Figs. 3 and 4.

The Flat-Type and Finger-Band RF-Shields in the graphs' legend represent the geometries shown in Fig. 2. The width of the fingers is around 2 mm.

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Based on Fig. 3, both of the models contain a serious resonance peak at 8 GHz. The height of this peak in the finger-band type is higher than the flat-type. Although considering the fluctuation of the wake potentials, the loss factor of the flat-type is more than finger-bands. Wake potentials are compared in Fig. 4. The evaluated loss factors are presented in the power-loss section.

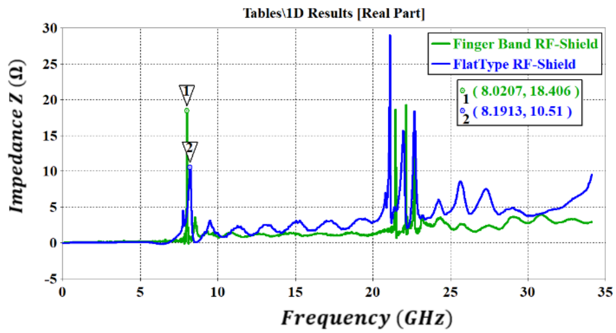

Figure 3: The comparison of longitudinal impedance in the Z-direction.

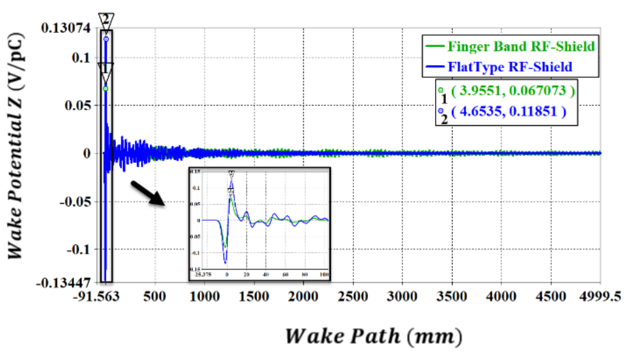

Figure 4: The comparison of longitudinal wake potential in the Z-direction

Transverse Direction

The transverse wake potentials in the y-direction are compared in Fig. 5.

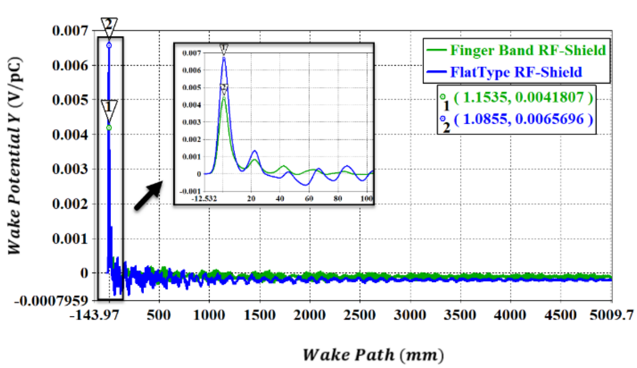

Figure 5: The comparison of transverse wake potential in the Y-direction.

In the frequency domain, the impedance graphs are derived. The structures in this direction are almost the same (Fig. 6). Therefore, the kick factors should be the same too.

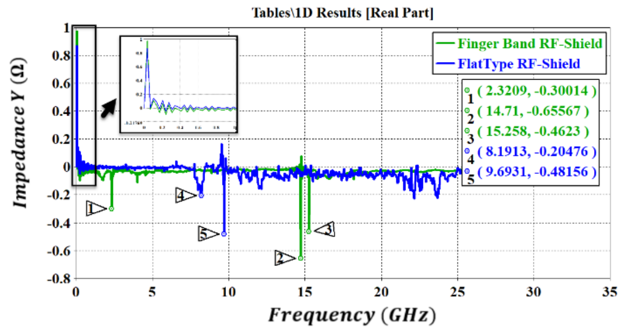

Figure 6: The comparison of transverse impedance in the Y-direction.

Based on Fig. 7, the difference of the wake potentials at the x-direction is more tangible. Therefore, the kick factors of the finger-band will be lower.

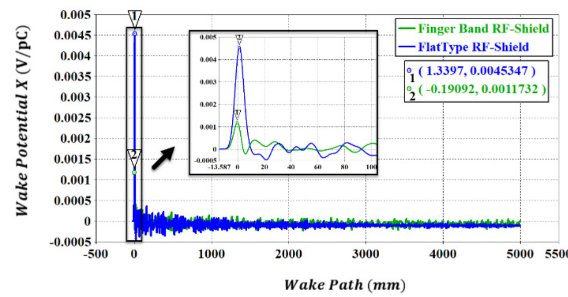

Figure 7: The comparison of transverse wake potential in the X-direction.

The subsequent studies show that the fingers in the side part of the vacuum chamber are responsible for increasing the wakefield in the x-direction. Therefore, the wake impedances could be minimized by omitting them (Fig. 8).

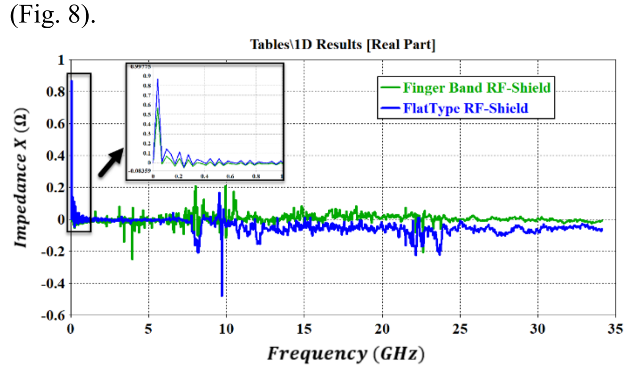

Figure 8: The comparison of transverse impedance in the X-direction.

The kick factors are calculated based on the integral of the wake potential and bunch length. The evaluated amounts are presented in Table 1.

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Table 1: Kick Factors in Two Types of RF-shields

Type	Kick Factor X (K_x) [V/pC/mm]	Kick Factor Y (K_y) [V/pC/mm]
Finger-Band	5.18e-4	2.4e-3
Flat-Type	2.30e-3	3.6e-3

Consequently, the performance of the finger-band model is more optimized in the transverse direction.

POWER LOSS

There is a famous formula to calculate the heat load [4]

$$P_{Loss} = -N_{bunch} \frac{q^2}{T_0} K_{Longitudinal} . \quad (1)$$

In this formula, N is the number of bunches equal to 140 at the ILSF storage ring. Also, q in each bunch is 5.028 nC, and the revolution frequency is $T_0 = 1.76$ µs. The calculated power loss in each type of rf-shields is presented in Table 2.

The longitudinal wake potentials were expected to have a lower heat-load for the finger-band (Table 2).

Table 2: Heat Load and Power Loss for Each Bellows (7.9 mm Bunch Length & 140 Bunch)

Type	Loss Factor Z (K_z) [V/pC]	Power Loss (P_L) [W]
Finger-Band	4.6e-3	9.25
Flat-Type	5.6e-3	11.26

CONCLUSION

Two types of rf-shields were simulated and run for the cross-section of the ILSF vacuum chamber. Both these types were compared and presented in the heat-load and instability parts. The finger bands are better in heat-load calculations and analytical transverse instability. It is suggested to study the RF-shields' thermal behavior by H-monitors in the MPHYSICS module of the CST software.

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