DESIGN OF IRANIAN LIGHT SOURCE RF SHIELDED BELLOWS

H. Ghasem, School of Particles and Accelerators, IPM, Tehran, Iran
J. Etemad Moghaddam, Iranian Light Source Facility, IPM, Tehran, Iran

Abstract

Total impedance is one of the most effective parameters for proper operation of an accelerator system. This quantity is evaluated with the summation of individual component impedance of the vacuum pipe and is desired to be as low as possible. The bellows have very significant effects on total impedance of the accelerator systems particularly synchrotron light source storage rings. Design of the bellow for Iranian Light Source Facility (ILSF) with a practical approach for fabrication has been down. Minimization of the total impedance budget, loss factor and the resulting wake field due to the passage of 400 mA electron beam is the main goal of our design.

INTRODUCTION

The ILSF is a new 3 GeV third generation synchrotron light source which is currently in design stage and will be built in Iran. One of the most effective and commonly used components in the accelerator system is bellow which connects the separate sections of the vacuum chamber and provides uniform vacuum chamber for the particle beam. It also makes possible movement of the required equipments and replacement of the accelerator components in each section. In a storage ring, bellow usually used at both end of the straight sections, both end of RF cavities, at the injection system and also between magnets where is needed. The latest design of the ILSF ring which will be approved by the advisory committee is based on the used five low field dipole magnets in a super period of ring and totally provides 20 straight sections [1-2]. As proposed, 4o bellows will be used at the straight sections and 3 bellows per cell between the magnets. Totally, 100 bellows are proposed to place in the 528 m designed ring.

Several types of bellows have been explored for the storage ring. As explained in the Ref. [2], the minimum effective drift space between the magnets is 18.5 cm. To provide more space for installation of the required equipments in the ring, the bellows have been considered to be self tapper and can successfully match two kinds of the vacuum chamber cross section with different dimensions to gather.

In this paper, we briefly give design specifications of the self taper bellow for the ILSF ring and discuss on the effective parameters which significantly affect the efficiency of self tapper bellow.

DESIGN SPECIFICATIONS

The RF shielded bellows are designed and built as moving connections with maximum smoothness on cross-section area of vacuum chamber. These connectors are designed so that they can verify the good performance of accelerator system a few tens millimetres axial and a few millimetres transverse stroke. For this purpose, sliding contact is usually used [3]. As shown in Fig. 1, the sliding contacts are comprised by two parts: a sleeve as sliding metallic RF shield and a set of spring finger as a connector between the sleeve and inner pipe of bellow [3,4].

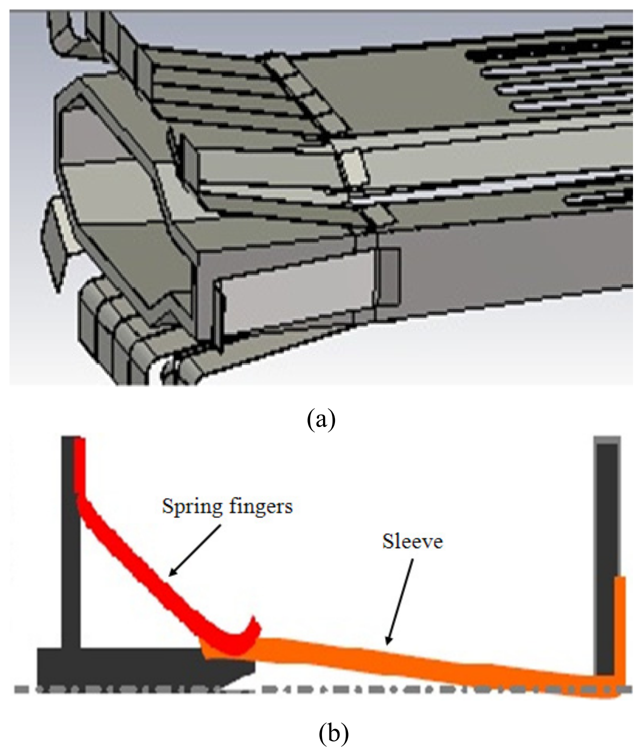
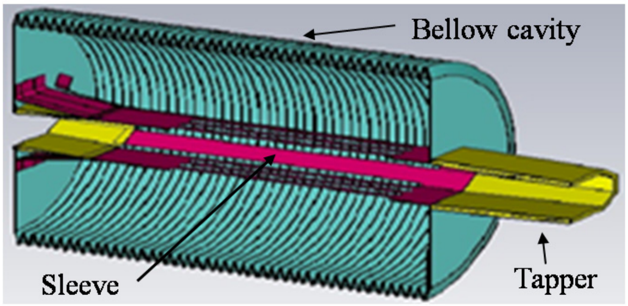
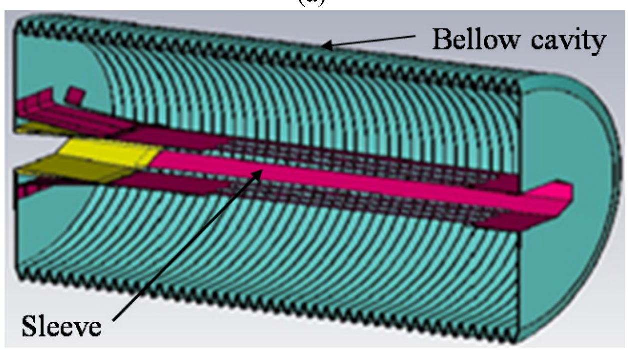


Figure 1: (a) Three and two (b) dimensional perspectives of the sleeve and spring fingers.

Due to the similarity of the ILSF storage ring vacuum chamber to ALBA ring chamber [3], the incipient idea is adopted from one of the ALBA bellows to design the RF shielded bellow for the ILSF ring. We used the simulation codes in two alternative tabulate and taper sleeve models, Fig. 2. In the case of tabulate sleeve type, the outlet cross-section is bigger than inlet just as pipe thickness. Thus to come round to the original vacuum chamber size, a taper is placed at the end of the bellow. While in taper model, the sleeve nugget is designed as a taper and the cross-section at the outlet is just as vacuum pipe. Considering output taper, the total length of tabulate model is exactly 300 mm and is 225 mm for the alternative model. The only degree of freedom is along the axis of bellow and is equal to 35 mm.



(a)



(b)

Figure 2: (a) 3D perspective of longitudinal section of bellow, (a) tabulate sleeve and (b) taper sleeve model.

There exists a 3 mm stair at the contact point of beam pipe and sleeve. Dramatic increase in impedance and loss factor is inevitable result of this sudden change in size of the cross-section [5]. To avoid this happening, thickness of the inlet beam pipe is gradually reduced to zero. Although, this change seems so modest but going the electron beam down to the bellow leads to a large amount of wake fields, which should be properly damped. For this purpose, several longitudinal slots are provided on the sleeve. It should be noted that during the propagation, the produced wave fields, which undergo a transverse expansion, are trapped and damped on the bellow cavity after passing through the longitudinal slots (see Fig. 2). To obtain the optimum situation (in terms of location, size and number of slots), each of the above mentioned models were designed in a large number of various cases. Then, the interaction between them and ILSF electron beam (400 mA current, 4.5 mm rms bunch length and 1 pC charge) was simulated. The results are given in Table 1.

Table 1: The Optimized Specifications of Tabulate and Taper Model

Parameter	Tabulate	Taper
No. of slot	16	16
Slot width (mm)	3	4
Loss factor (V/pC*10^{-2})	475367.1	336343.4
Max. Of wake field (V/pC)	857257.2	215486.1

The optimum cases are selected with respect to mechanical stability and feasibility of building as well as minimized loss factor. The final optimized case is observed for sixteen slots taper model with 4 mm slots width. Corresponding wake function and longitudinal impedance are exhibited in Fig. 3 and Fig. 4 respectively.

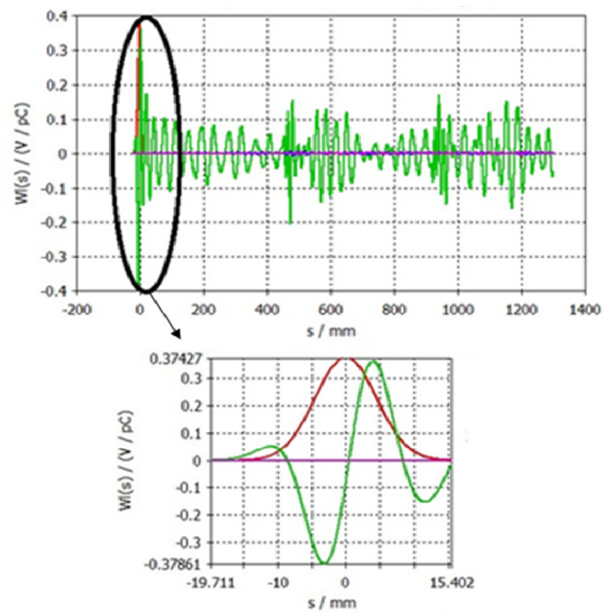


Figure 3: The wake function of final optimized case.

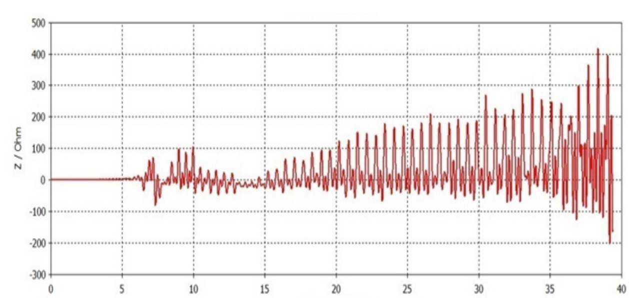


Figure 4: The longitudinal impedance of final optimized case, higher order modes are exited up to 40 GHz.

ISBN 978-3-95450-132-8

There are three types of wakes produced by a component; capacitive (cavity-like), resistive and inductive [5,6]. These types of wakes are distinguished from their behaviours early after the start of the bunch distribution, presented in Fig. 5.

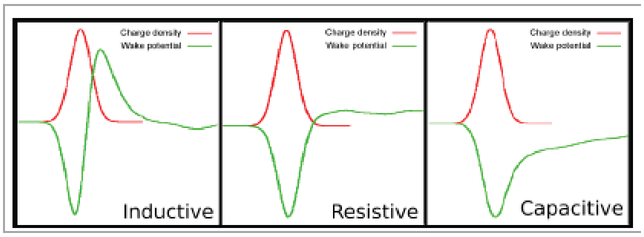


Figure 5: The longitudinal wakes for inductive, resistive and capacitive components, taken from Ref. [5].

Comparison of Fig. 3 and Fig. 5 indicate inductive wake function of the designed bellow. According to these diagrams, maximum value of the wake function is too small and is equal to 0.364977 (V/pC). The related loss factor and dissipated power are 2.752777 (V/pC*10^{-2}) and 8.8 (W), respectively, which are physically reasonable and acceptable. It may be noted that, up to 5 GHz, the higher order modes are negligible. From Fig. 4, it is seen that, the impedance of modes is significantly raised when the frequency increases. Because of small loss factor, this grow in impedances is not alarming.

ACKNOWLEDGMENT

The authors would like to specially thank Prof. H. Wiedemann for his several helpful comments. We are also grateful to A. Rusanov for his kind advises.

REFERENCES

[1] H. Ghasem, et al., *Beam Dynamics of the ILSF Storage Ring (Basic Design Report)*, ILSF-B-BD-SR00-DBS-01-000, (2014).

[2] H. Ghasem, et al., *Super Bright Lattice for the Iranian Light Source Facility Storage Ring*, This proceeding IPAC (2014).

[3] www.cecomweb.com

[4] D. Ramos, *Modelling of the RF-shield Sliding Contact Fingers for the LHC Cryogenic Beam Vacuum Interconnects Using Implicit and Explicit Finite Element Formulations*, EPAC08, Genoa, Italy, TUPD035.

[5] A. Rusanov, NSRRC, Hsinchu, *Impedance Study for the TPS Storage Ring*, (2007).

[6] K.L.F. Bane, *Bunch lengthening in the SLC Damping Rings*, SLAC-PUB-5177, 1990.