MECHANICAL DESIGN CONSIDERATIONS FOR SESAME MAIN SUBSYSTEMS

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Abstract

SESAME* will become the first 3rd generation light source in the Middle East, located in Allan, Jordan. The main ring design has energy of 2.5 GeV, an emittance of 26 nm.rad and 12 straights for insertion devices. The conceptual design of the accelerator complex has been frozen and the detailed engineering design started. The SESAME building construction is in progress and the beneficial occupancy is expected by the end of 2007. In this paper we present some results which are relevant from a mechanical point of view to the design of the main ring subsystems.

INTRODUCTION

SESAME main storage ring consists of 8 cells each of which contains 2 dipole chambers, 2 pre dipole chambers, 2 post dipole chambers, 1 short straight chamber and 1 long straight chamber. In the table below (Tab.1) are shown the main parameters that characterize the vacuum and mechanical design of the storage ring.

Table 1: Main SESAME parameters.

Energy (GeV)	2.5
Beam Current (mA)	400
Circumference (m)	133.12
N. of Dipoles	16
Dipole field (T)	1.455
Radius of curvature (m)	5.72958
Field index n	11
Central Gap (mm)	40
N. of Sextupoles	64 (2 families)
N. of Quadrupoles	64 (2 families)
Dipoles radiated power	240 kw

VACUUM CHAMBER DESIGN

Chambers Geometrical Constraints

The design of the stainless steel vacuum chamber is based on the *chamber-antechamber* concept, with OFHC crotch absorbers. The required stay clear aperture of the chamber is 70 mm in the horizontal plane and 30 mm in the vertical one. The chamber wall thickness is 3 mm, while the antechamber dimension, in the radial direction, can arrive, depending on the position, up to 25 cm. The material for the vacuum chamber will be 316ln stainless steel.

Fig. 1 shows a typical cross-section of the Vacuum Chamber inside the Dipole and it points out that deformation is one of the most critical design aspects, since the *minimum clearance* inside the Dipole is only 1.22 mm.

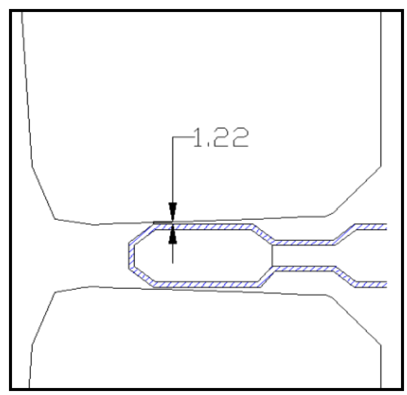

Figure 1: Vacuum Chamber minimum clearance (cm) in the Dipole.

For completeness, in Tab. 2 we summarize the minimum vacuum chamber clearance inside all the magnetic elements for half SESAME Super period as well as the main chamber parameters.

Table 2: Critical clearance values between chamber and different magnetic elements.

Magnetic Component	Critical Clearance Value & Location	Allowable Distance From Center
Sextupole F/D	1.1mm / slot zone	220 mm
Quadrupole F/D	2.4mm / slot zone	210 mm
Dipole	1.224mm (Fig. 1)	N/A
Inner Dimensions	30 mm x 76 mm	N/A
Slot Height	12 mm	N/A
Chamber Thickness	3 mm	N/A

Deformation Analysis

A 3D view of half unit cell of the storage ring is shown in Fig. 2. Each unit cell is isolated by two valves and contains four bellows located at the ends of the straights.

* Synchrotron-light for Experimental Science and Application in the Middle East (SESAME) is an International Organization founded by UNESCO according to the model of CERN. Jordan is the host State and has granted special privileges to SESAME. It involves at the present the following Member States: Bahrain, Cyprus, Egypt, Israel, Jordan, Pakistan, Palestinian Authority and Turkey.

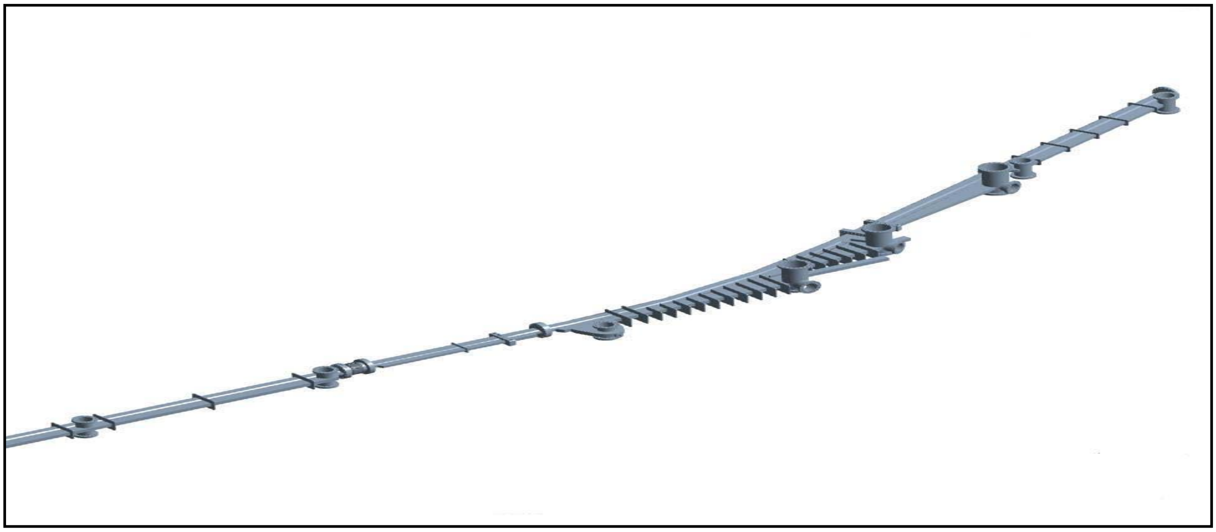

Figure 2: 3D view of SESAME Half Cell Chamber.

Parametric studies have been performed in order to optimize the location, the shape and the thickness of the ribs. The last step of the optimization process consists in an iterative solution especially for the post dipole section: this is because the ante chamber span is wide and close to the pumping port; moreover there is location constraint due to the closed space between magnets.

In Fig. 3 are shown the Maximum deformation results for the Dipole chamber, after the strengthening with ribs and plates. The maximum deformations due to the application of atmospheric pressure were 1.9 mm and 0.42 mm before and after strengthening respectively.

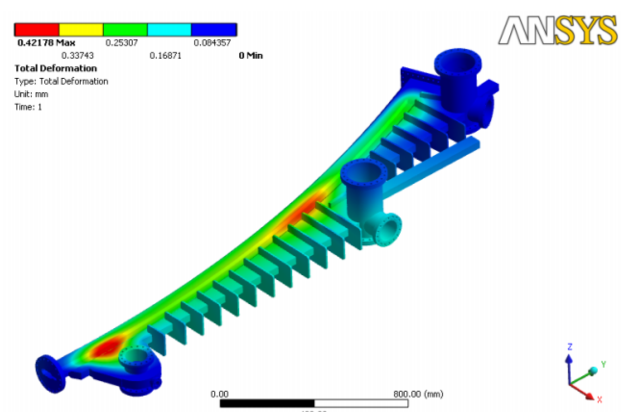

Figure 3: Dipole Chamber deformation.

SESAME Magnets

SESAME has 16 dipoles, 32 F-quadrupoles with a magnetic length of 30 cm, 32 D-quadrupoles, 32 D-sextupoles and 32 F-sextupoles with a magnetic length of 10 cm. For quadrupoles and sextupoles a design identical (apart the length) to the one adopted for ANKA has been chosen [2]: the max gradient is 19T/m for the quadrupoles and 220T/m^2 for the sextupoles. For the dipole magnet also if a design similar to the ANKA one has been adopted, a modification of the pole profile has been carried out to incorporate the vertical focusing gradient.

For the Dipole magnet we have calculated the deformations resulting from the magnetic force, especially those at the minimum clearance zone between the pole surface and the dipole chamber surface (see Fig. 1). FEA analysis has been performed in order to evaluate the magnetic forces; then the deformation resulting from these forces has been calculated. It has been found that the resulting deformation at this zone is about 34 µm (see Fig. 4).

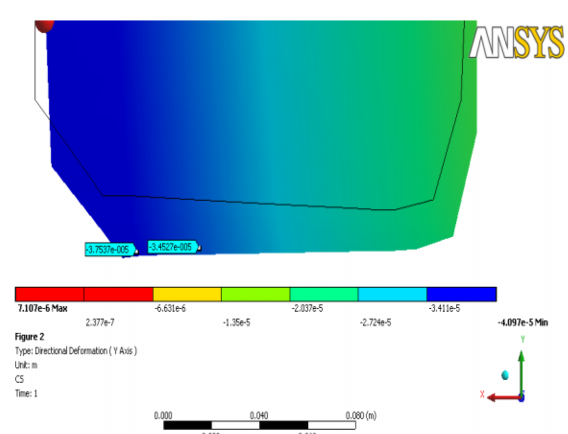

Figure 4: Deformation of the dipole pole due to magnetic forces.

GIRDER SYSTEM DESIGN

The first step in the design of the girder system consisted in the analysis of two existing designs customized for SESAME

The first one is the ANKA design which is basically based on three vertical supports and three strut systems with the dipole girder separated from the multipole magnets girder.

The second one is the ALBA design in which the half cell magnets are fixed on the same girder. In this case the magnets are fixed on a precisely machined plate and the girder is supported on three pedestals. Six vertical jacks and three struts are utilized: one is located on the beam direction and the other two on the horizontal plane.

Requirements for the Alignment of the Ring

The accelerator physics studies [3] impose the acceptable r.m.s. errors for each magnetic element along six degrees of freedom with s, x and z being the beam longitudinal, horizontal and vertical direction respectively and θs, θx and θz the rotation around s, x and z. These r.m.s. values are summarized in Tab.3.

Table 3: Magnets r.m.s. maximum acceptable errors.

Dipole				
σ_x	σ_z	$\sigma_{\theta s}$	$\sigma_{\theta x}$	$\sigma_{\theta z}$
0.2 mm	0.2 mm	0.2 mrad	0.2 mrad	0.2 mrad
Quadrupole		Sextupole		
σ_x	σ_z	σ_x	σ_z	
0.2 mm	0.2 mm	0.2 mm	0.2 mm	

To achieve the position requirements the magnets will be fixed to a precisely machined plates, the alignment will be directly linked the magnets definition as mush as possible.

Vibration and Magnets Stability

The electron beam stability is correlated to the stability of the magnets which in turn are affected by the girder system design. During the design phase the different external and internal vibration sources must be defined and treated. FEM techniques could be used to perform different analysis, including static, modal and PSD, on the two design proposals that are being processed. At the moment static and modal analyses have been carried out. In the next phase site vibration measurements and further vibration and dynamic analysis will be performed.

Static and modal Analysis Results of ALBA Girder Design customized for SESAME

The static analysis for the ALBA Girder design when customized for SESAME revealed a maximum deformation of 0.07 mm and the first four natural frequencies are listed in Tab.4. In Fig. 5 a 3D model of the design customized for SESAME is represented while Fig. 6 shows the first four modes of vibration.

Table 4: First 4 natural frequencies.

Mode	1st	2nd	3rd	4th
Frequency (Hz)	23.68	26.65	32.72	57.25

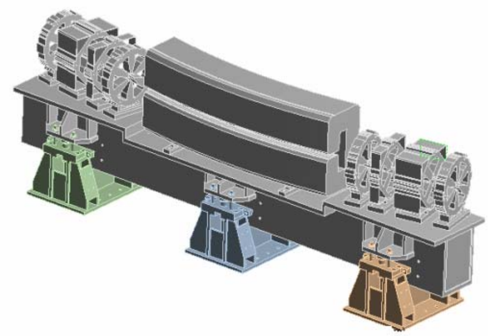

Figure 5: Girder 3D Model

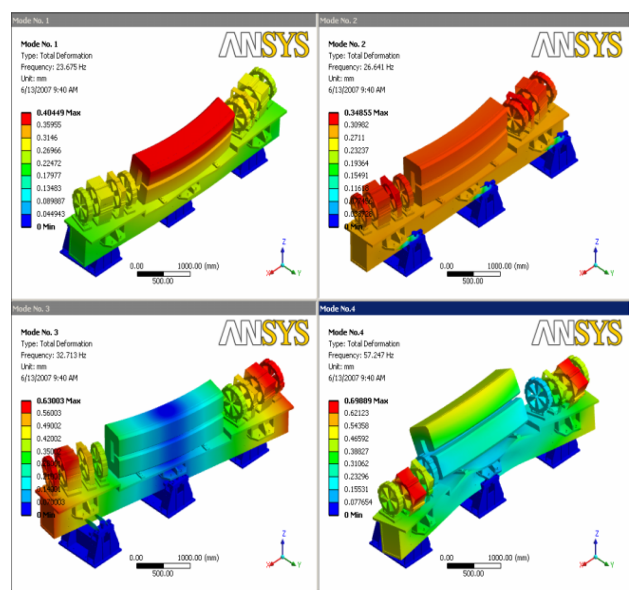

Figure 6: The First 4 Modes Vibration Shapes.

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