AN UPDATE OF THE LATTICE DESIGN OF THE TAC PROPOSED SYNCHROTRON RADIATION AND INSERTION DEVICES

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Abstract

The Turkish Accelerator Center (TAC) is a project for accelerator based fundamental and applied researches supported by Turkish State Planning Organization (TSPO). The proposed synchrotron radiation facility of TAC was consisted of 3.56 GeV positron ring for a third generation light source.

In the first study, it was shown that the insertion devices with the proposed parameter sets produce maximal spectral brightness to cover 10 eV - 100 keV photon energy range. Now, in this study it is considered that the electron beam energy will be increased to 4.5 GeV, in order to obtain more brightness light and wide energy spectrum range, also the beam emittance reduced to 1 nm.rad.

INTRODUCTION

In the first study, it was shown that the insertion devices with the proposed parameter sets produce maximal spectral brightness to cover 10 eV - 100 keV photon energy range [1].

In this study, we have designed double-double bend achromat (DDBA) lattice with damping wigglers, in order to obtain ultra low emittance for the electron storage ring of TAC and determined properties of the radiation produced at undulators placed on it. In the next section, we present the effects of insertion devices (IDs) and damping wigglers (DWs) at the ring on the beam parameters and spectral brightness that obtained from IDs.

At the rest of the paper, we give the results of the study on DDBA lattice that has been investigated in order to provide more brilliance for the synchrotron radiation.

DOUBLE-DOUBLE BEND ACHROMAT

A DDBA lattice, separated function of bending magnets and quadrupole triplet, has been studied for 4.5 GeV storage ring of the TAC [2]. Table 1 present parameters of the storage ring and Figure 1 gives the behaviour of the lattice functions for 18 period DDBA lattice.

DAMPING WIGGLERS

Damping wigglers are proposed to reduce the emittance to a value of 1 nm.rad. Two damping sections in the long straights of TAC-SR have been assigned to accommodate four wigglers in total. The wigglers are placed in the long dispersion-free straight sections. Within the 8m long drifts between two quadrupoles, a 7m long wiggler segment is accommodated.

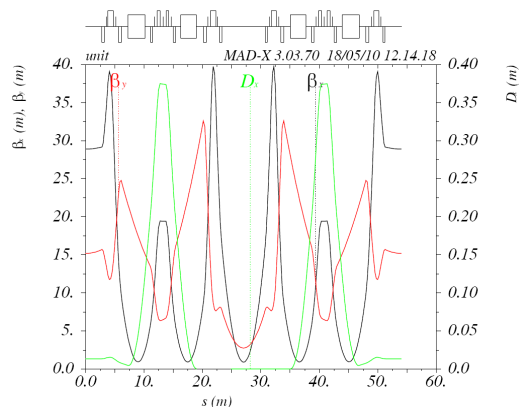

Figure 1: Lattice functions for 18 period DDBA lattice

Table 1: Main Parameters of the Storage Ring

Achromatic structure	**Units**		**DWs**	**DWs/IDs**
Nominal energy	GeV	4.5	4.5	4.5
Superperiod		18	18	18
Circumference	m	973.08	991.08	991.08
Max. Beam Current	mA	400	400	400
Energy loss/turn	keV	1144.5	2523	4477
Energy spread	%	0.0685	0.1061	0.1235
Horizontal-ε_x	nm·rad	3.121	1.28	0.725
Vertical-ε_y	pm·rad	31.21	12.8	7.25
Betatron tunes[Q_x/Q_y]		39.5/15	40.9/14	40.9/14
Chromaticities[ξ_x/ξ_y]		-110/-39	-141/-59	-141/-66
Beta functions at long straight section				
Horizontal	m	0.89	0.75	0.74
Vertical	m	2.75	1.48	1.04
Dispersion	m	0	0	0
Long straight section		18 x7.4m	18 x 8m	18 x 8m
Short straight section		18 x5.6m	18 x 6m	18 x 6m

EFFECTS OF THE DWs AND IDs ON THE LATTICE

We have investigated the effects of the DWs and IDs on the betatron tune, the energy spread, the emittance and beta functions. Table 2 presents parameters of the DWs and IDs in the storage ring.

Table 3 presents variations of the emittance, the energy spread, the horizontal tune and the beta functions that are obtained from numerical calculations performed by using of OPA [3] and MAD-X [4].

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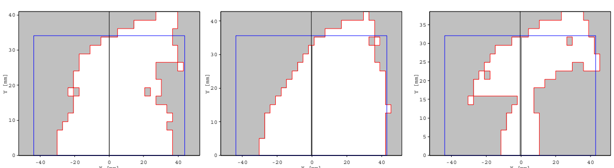
Table 2: Parameters of the IDs at the Ring

ID	Length (m)	Period Number	Mag. field (T)	$K_{max.}$
12-U	6.5	541	2.43	2.723
15-U	6.5	433	2.43	3.403
32-U	6.5	203	2.43	7.26
45-U	6.5	144	2.43	10.21
W_{DWs}	7.0	35	2.00	37.35

Table 3: Effects of the DWs and IDs on the Beam Parameters

	$\Delta\varepsilon/\varepsilon$	$\Delta\sigma_\varepsilon/\sigma_\varepsilon$	$\Delta\nu_x/\nu_x$	$\Delta\beta/\beta$
W_{DWs}	-60%	+54%	-3%	-16%
IDs	-76%	+80%	-3%	-19%

For efficient injection in the top up mode, the required dynamic aperture has to be larger. Figure 2 shows the dynamic aperture with ±1 dp/p



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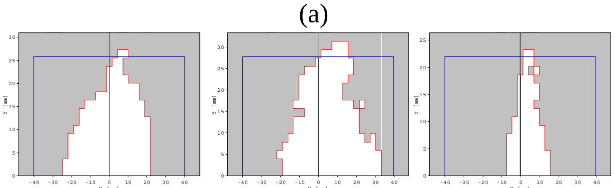

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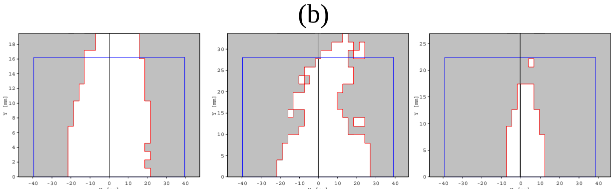


(c)

Figure 2: Dynamic aperture with dp/p respectively, 0, +1 and -1, a) no DWs and IDs b) with DWs, c) with DWs and IDs

Figure 3 shows the tune diagram of the storage ring and Figure 4 shows the lattice functions of the ring with relation to DWs and IDs.

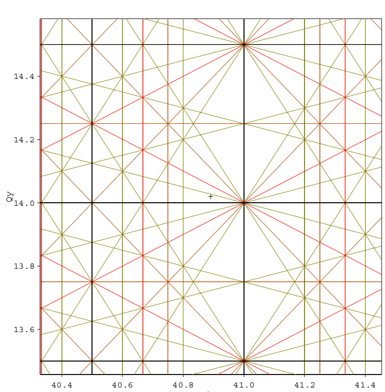
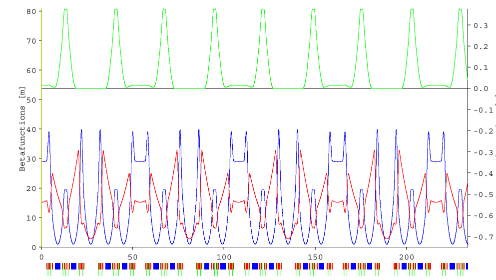


Figure 3: Tune diagram of the storage ring with DWs and IDs.



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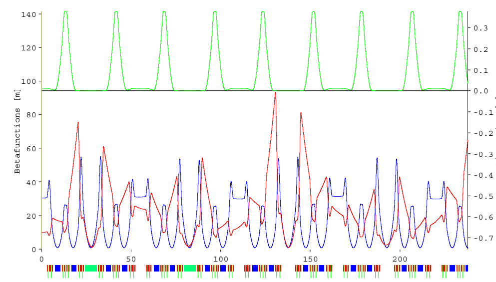


(b)

Figure 4: Lattice functions: a) no DWs and IDs, b) with DWs and IDs.

SPECTRUM OF THE RADIATION PRODUCED AT IDs

In this study, the lattice structure design of the storage ring is made to produce third generation synchrotron light. Four hybrid undulators using NdFeB permanent magnet at 100°K are selected [5-7].

The empirical formula for the peak field achievable in a hybrid insertion device using NdFeB is given by $B_{y0} = 3.44\ exp\ (-5.08\ g/\lambda_u + 1.54\ g^2/\lambda_u^2)$ which is valid over the range $0.07 < g/\lambda_u < 0.7$ [8].

The parameters of complementary undulators are determined. The flux density and brilliance of the synchrotron radiation emitted from the undulators at the TAC storage ring are presented in Figures 6 and 7, respectively. It is seen that the insertion devices with the proposed parameter sets produce maximal brilliance values to cover 10 eV – 100 keV photon energy range.

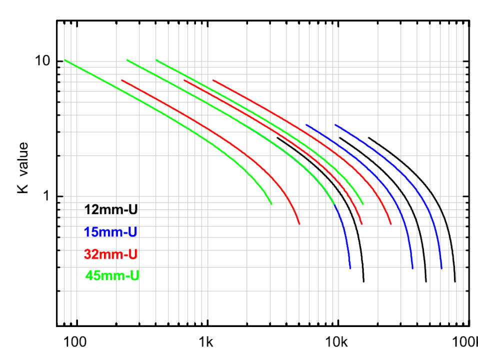
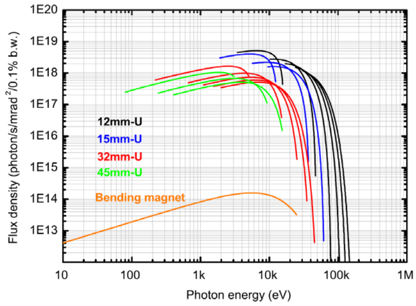


Figure 5: Undulator strength vs. photon energy of TAC undulators



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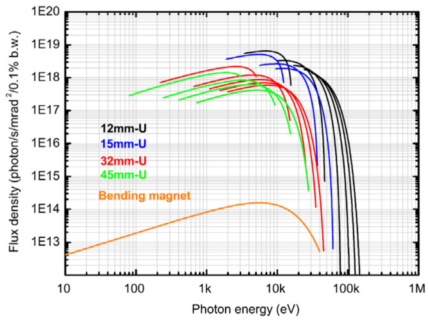
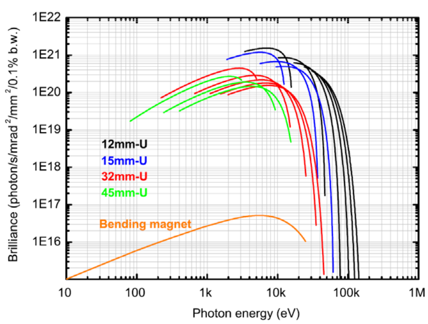


(b)

Figure 6: Flux density of the synchrotron radiation from IDs: a) no DWs, b) with DWs.



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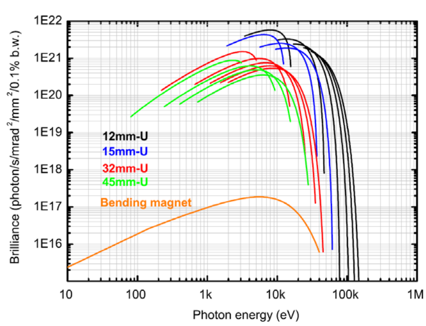

(b)

Figure 7: Brilliance of synchrotron radiation emitted from the undulators at the TAC storage ring: a) no DWs, b) with DWs.

As IDs change beam parameters, the spectral properties of SR produced by themselves are affected. The spectrums of the undulator radiations might improve or deteriorate under the changes.

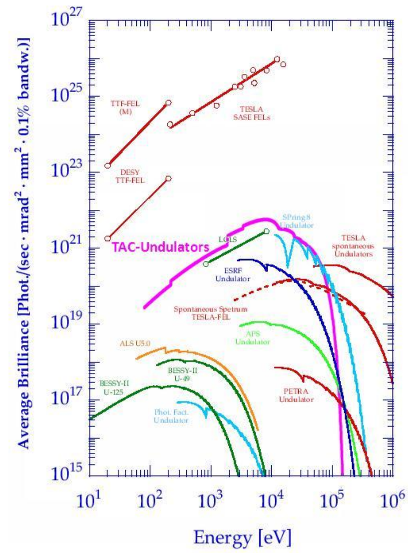

Figure 8: Comparison of TAC undulators with SR sources at the world.

CONCLUSION

In this study, a lattice for storage ring of the TAC is designed. The effects of IDs and DWs on both beam parameters and radiation properties are presented. The insertion of undulators to the storage ring seems to be tolerable. In addition, it improves radiation specs in general. However, one needs to look at other instability sources to determine if there is a need for optical correction.

ACKNOWLEDGEMENT

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