Design of the Magnets for the Synchrotron Light Source ROSY

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Abstract

ROSY, a 3rd generation light source has been proposed to be built at the Research Center Rossendorf/Dresden in Germany [1,2]. To obtain a compact, low emittance machine it was decided to use combined function magnets of two different lenghts. The gradient within the magnets is roughly the same as for the ELETTRA bending magnets, so the design of the ROSY bendings is based upon the the ELETTRA design. For the quadrupoles a comparison has been made between existing ones and it was choosen to take the ELETTRA quadrupoles too. The sextupoles and also the steerer magnets are based upon the APS design.

1. BENDING MAGNETS

In the past a lot of magnets for the different synchrotron light sources [3] and accelerators have been designed and built. However, in this case it is not possible to adopt a wellknown layout from an other machine. The special lattice [1] needs also a special gradient within the bending magnets. Hence the pole profile has to be calculated although the general cross section can be copied from an earlier design. Also in the case one wants to place a sextupole as near as possible to the bending magnet the arrangement of coils has to be modified.

ELETTRA [4] and ALS [5] are synchrotron light sources of the 3rd generation which use combined function magnets. The ELETTRA bending magnet has a field strength of 1.2 Tesla and a gradient of 2.86 T/m (E = 2 GeV). For the ALS magnet the values are: 1.58 T and 6.3 T/m (E =1.9 GeV). For the design and the specifications of the bending magnet the ramping range has to be considered. ALS is running at a fixed field, while ELETTRA is ramping from 1.2 to 2.0 GeV and for ROSY it is foreseen to use an energy range from 800 MeV to 3 GeV. To avoid the influence of the saturation effects during ramping it was choosen to have a nominal field strength of 1.4 T corresponding to a radius of 7.8 m. With this value the lattice requires a gradient of 2.8283 T/m [1]. This is roughly the same value as for the ELETTRA bending magnet.

The design of the bending magnet is based on the ELETTRA one, but in order to cut down the running costs the gap was reduced from 70 mm to 52 mm. The optimized pole profile of the ROSY bending magnet is shown in Fig. 1. and the results: dB/B, dG/G and dB/X^2 are represented in Fig. 2. These results are of the same order as for the ELETTRA design but much better as for the ALS design.

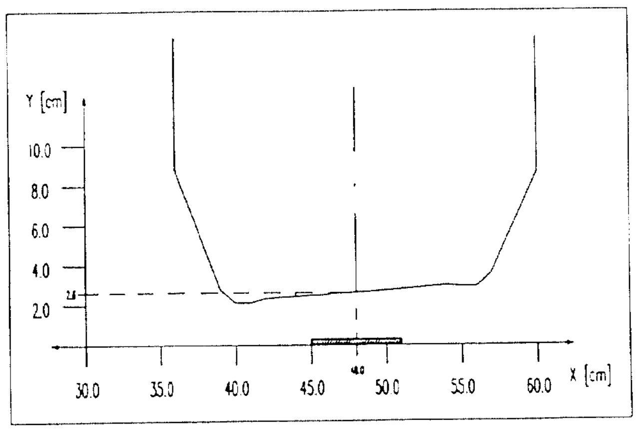

Fig. 1. Pole face of the optimized ROSY dipol

At fields higher than 1.2 T saturation occurs. This effect influences field and gradient in different ways, hence the quotient G/B is not constant during ramping and the working point will move, which has to be compensated by other quadrupoles. For the ROSY design the excitation curve of the quotient G/B is shown in Fig. 3. From B = 1.2 T to B = 1.4 T this ratio increases at 1.8 %, which is acceptable.

2. QUADRUPOLES

The main features of quadrupoles, sextupoles and steerers are bore radius, gradient (quadrupole), differential gradient (sextupole) or field (steerers). Bore radii do not differ very much between different machines. So this magnets could be copied more or less from existing designs.

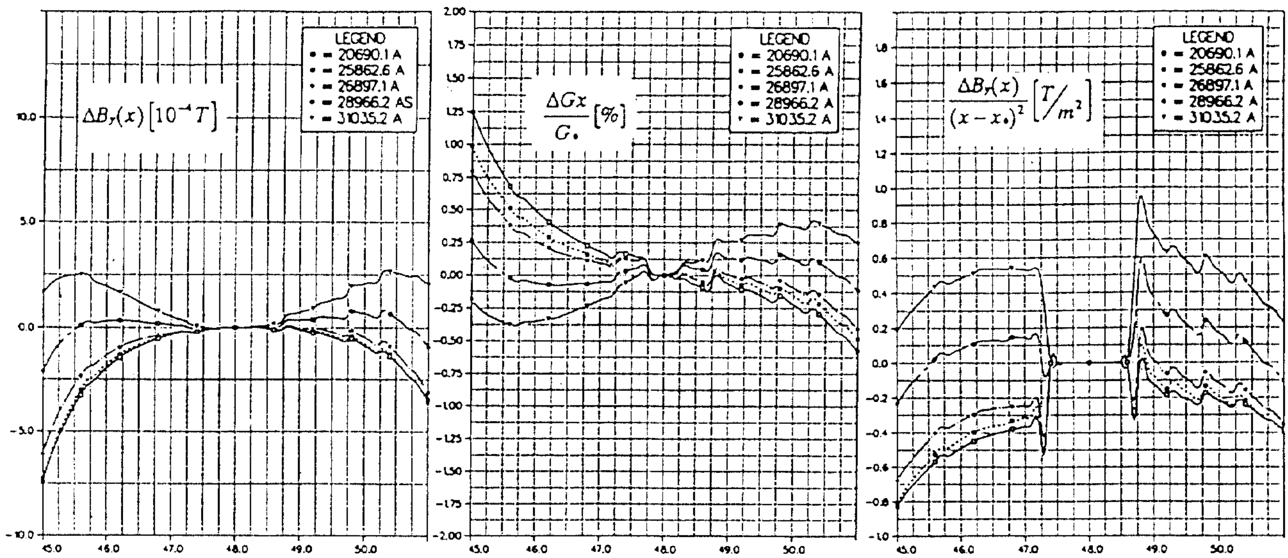

Fig. 2. Flux density and gradient deviations as well as sextupole component for the ROSY dipoles

We tried to get best specifications but took care of the power consumption, which is determined by the coil arrangement.

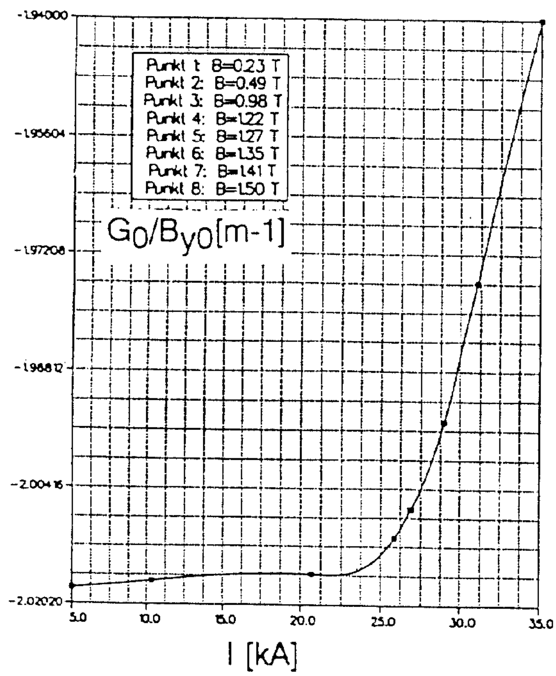

Fig. 3. G_0/B_{Y0} as function of the dipol excitation

To choose the best layout we made a comparison between the ELETTRA [6] and the ESRF [7] design. For both magnets we calculated the radial dependence of the gradient and the excitation curve of the gradient in order to see at which point the saturation takes place. For the ESRF design it is at a gradient of 15 T/m and for the ELETTRA design at 17 T/m (see Fig. 5.), hence the ELETTRA quads can be used for higher gradients.

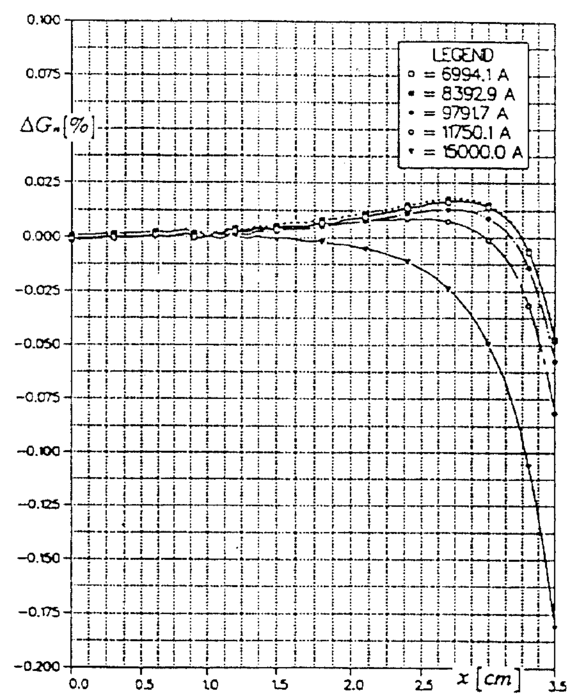

Fig. 4. Relative deviation of the gradient from the orbit value for different quadrupol excitations

Furthermore for ROSY we need quads of three different lengthes which are roughly the same as at ELETTRA.

So, we took over the ELETTRA design. and changed the coil arrangement to reduce the power consumption by a factor two.

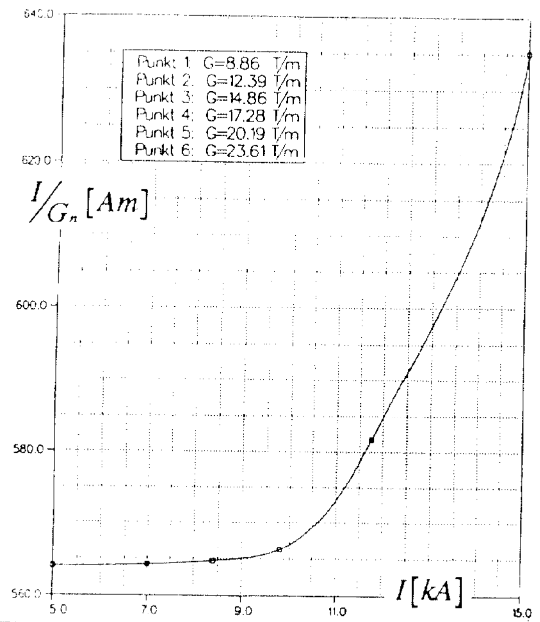

Fig. 5. Ratio of excitation current to orbit gradient for the ROSY quadrupoles as function of the excitation current

3. SEXTUPOLES and STEERERS

To realize the chromatic compensation for ROSY sextupoles with differential gradients of about 400 T/m^2 have been designed. Similar sextupoles are used in APS [8]. Modifications of the APS devices concerned aperture diameter and coil arrangement. Calculations established sufficient sextupole strength for the ramping range of ROSY. Also for the magnetic correctors APS components served as examples. The steerers for horizontal, vertical and simultaneous horizontal and angular correction allow angular corrections of 1.5 mrad for nominal energy. The field inhomogeneity of this devices is below 0.2 %.

The main parameters of the ROSY magnets are compiled in table 1.

Table 1 . Main parameters of the ROSY magnets

	DIPOLES		QUADRUPOLES			SEXTUPOLES	STEERERS		
							horiz.	vert.	hor&ver.
Number of units	12	8	8	16	32	48	24	24	24
Deflection angle [°]	20	15		-		-		-	
Magnetic length [m]	2.436	1.866	0.60	0.40	0.28	100	0.14	0.14	0.14
Gap/aperture [mm]	52			75		42	55	120	120/178
Flux density [T]	1.4			-		0.44 at pole tip	0.1	0.13	0.075
Gradient [T/m]	2.8283		17	18	18	-		-	
Diff. Gradient [T/m^2]	-			-		500		-	
Number of turns	48			39		25 per coil	60	120	80/140
kAmpere-turns	62.064		10.2	10.8	10.8	5.0	3.0	3.0	5.4/4.56
Power [kW]	38	29.7	3.64	3.05	2.42	1.2	0.193	0.225	0.71/0.89
Current [A]	1293		262	277	277	200	50	50	90/76
Water flow [l/h]	616		156	130	104	-	1.02	1.19	1.18/1.57
Water press. [kp/cm^2]	5.2		8.0	4.0	2.1	4.3	7.5	10	8.24/8.75

4. REFERENCES

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