THE NEW OPERATION MODE OF SYNCHROTRON "PAKHRA"

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Abstract

It was examined the change of the magnet power supply of synchrotron "Pakhra". To solve the new physical task it is advisable to reconstruct the working regime of alternating current component. It is allowed to accelerate the particles up to 650 MeV for 5 msec and to hold them further with the help of constant energy more than 1 second. In this case synchrotron "Pakhra" can by effectively used as a synchrotron radiation source.

The electron synchrotron "Pakhra" of P.N.Lebedev Physical Institute RAS is a main tool to conduct researches in the Department of Physics of High Energy.

The accelerator with the energy of 1.2 GeV consists of 4 bending magnets divided by straight sections. The radius of the equilibrium orbit in the magnet is $R_0=400$sm, the length of each straight section is $L=190$sm. Today together with the extracting electron beam and the gamma-ray beam it is intended to use the synchrotron radiation and for this aim the cannel for the research in the sphere of the vacuum UV is built. The magnetic field of the synchrotron changes with the frequency of 50Hz (synchronized with the industrial frequency) it is not suitable to conduct work with the synchrotron radiation. It is important to change the power supply of the electromagnet for the work with the SR to deduct electrons during 1sec on the orbit of constant energy.
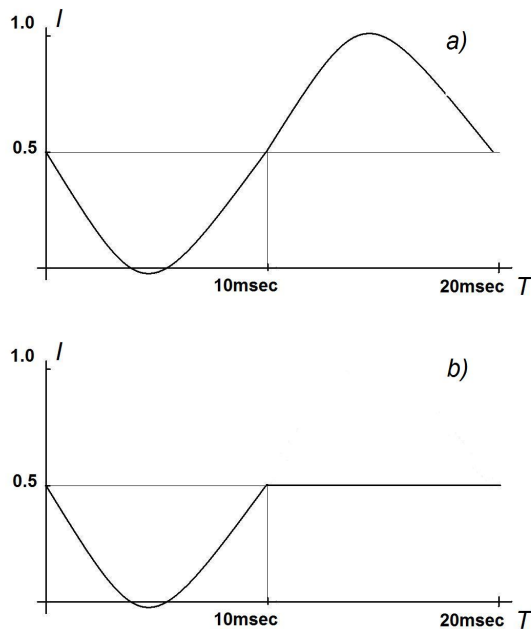
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Figure1. The dependence from the time of the current flowing through the magnet in old a) and new b) power supply.

Let's describe in short the peculiarities of work of the power supply in the traditional for the synchrotron the regime of acceleration. The current flowing through the magnet winding has two components: DC component and AC sinusoidal component with industrial frequency 50Hz. The quantity of the DC and AC can be regulated independently from each other. The first Fig.1a shows the dependence of current in the synchrotron's magnet. In this case the quantity of the magnetic field changes. By the energy 1.2 GeV the magnetic field is 1T.

The principle scheme of the power supply is shown in Fig. 2. Course of the DC is the rectifier RD , which gives the current in the electromagnet EM through the reactors RC_1,RC_2. To receive the AC component current the electromagnet EM and the capacitor banks $C_1C_2C_3$ form the oscillating counter, stimulated by autonomous inverter of the current IT [1].
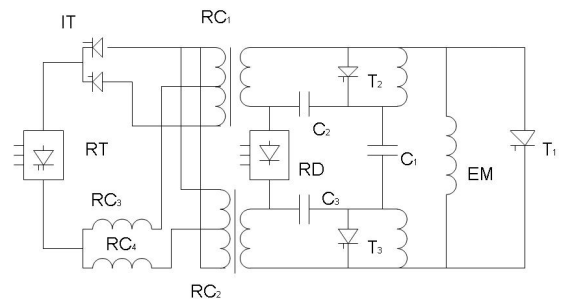
Figure 2: Magnet power supply.

EM-electromagnet.	$L=25\times10^{-3}$ H	$R=32\times10^{-3}$ Om.
C_1,C_2,C_3-capacitor banks.		$C=400\mu$F.
RC_1,RC_2-reactors.	$L=55\times10^{-3}$ H	$R=18\times10^{-3}$
RC_3,RC_4-reactors.	$L=6.27$ H	$R=3.75$ Om.
RD-rectifier.	$I=3000$A	$U=300$V
RT- rectifier.	$I=300$A	$U=4000$V
IT- inverter		
T_1,T_2,T_3-thyristor units.		

In some physical experiments it is necessary to have constant energy in the synchrotron during a long time in compare with the length of the acceleration. The power supply allows to make the flat-top of the magnetic field in 3ms. To receive the flat-top and to synchronise with the industrial frequency $T_1T_2T_3$ are used [2,3].

For the work with the synchrotron radiation it is necessary to transfer the magnet power supply into the pulse operation. In this pulse operation the dependence from the time of the current flowing through the magnet is shown in the Fig. 1b. As in the traditional regime of

work in the pulse operation the DC flows from the rectifier RD into electromagnet through the reactors RC1,RC2. The current pulse of the 10ms length is put on the direct component.

The current pulse can go with the period from 200ms up to some seconds. The electrons accelerate up to the energy conforming to the current direct component and then they are kept by this energy. The energy can be changed from 100MeV up to 650MeV. The scheme of the magnet's pulse system is shown in the Fig.3.
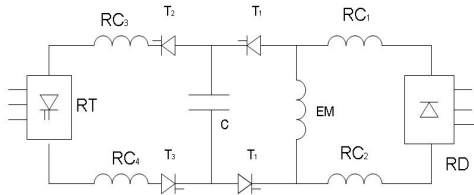

Figure 3: The scheme of the new pulse power supple.

It is important to underline that in both power supply the same elements are used and the transition from one system to another is possible after short erecting works (2-3 days).

During the pulse regime of work the capacitor bank C charging from the rectifier RT discharges through the thyristor unit T1 on the winding of the electromagnet EM. After the ending of the pulse current the voltage on the capacitor bank reverses its polarity. In this moment the thyristor units T2,T3 are triggered on and from the thyristor rectifier RT through the reactor RC3 and RC4 the recharging of the capacity takes place. In the stable regime the voltage of the rectifier is drop in voltage on the capacity for one cycle of charge and discharge. The length of the charge of the capacity C is $T/2 = \pi\sqrt{L_{RC3}L_{RC4}C}$ =0.22sec, after that the capacity stays charging for next cycle. The damping decrement of the charging and discharging counters is Δ=0.14. During the work under the energy 650MeV the voltage on the capacity is 25kV. The voltage of the rectifier has to be 3.5kV.

The electromagnet and capacity bank were done in such a way that their middle points must have zero potential. That's why the scheme of the power supply is symmetrical according to its points, the resistance of the thyristor units must be equal to each other.

The described pulse magnet power supply of the synchrotron's magnet was made, its tests were led. The spacing frequency of the current pulse was the multiple frequency of the industrial network for the stability of the accelerate beam. The period of the current pulse was from 400 msec up to 2,5sec. The voltage and current when the tests were made conformed to the accelerator's regime of the particles up to the energy of 225MeV. It is the third part from the planning maximum energy. The main aim of the test was the checking of the working efficiency of the suggested scheme and the correspondence of the done calculative. Testing the system the rectifier was powered from the network 380V through step-up transformer. The high voltage 8 kV on the capacity C was received under the voltage of the rectifier 1.2kV. The length of the charging current was 220 msec, the length of the discharging current was 10msec. The tests showed the difficulties of the working synchronisation of the keys T2 and T3 with the control current of the thyristor rectifier BI. During the gate trigger current, the current in the thyristor units did not reach the "hold current". That was why the thyristor units were changed by the diode assemblies.

After the changing of the working regime of the RF system and the injector the electrons' acceleration in the pulse regime with the frequency 2Hz under the energy 220MeV was made on the synchrotron "Pakhra". The tests of the particle dynamics in this regime were led. The further works will depend from the plans of the synchrotron's reconstruction.

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