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NEW DESIGN OF ACCELERATING SYSTEM WITH AMORPHOUS IRON

Budker INP 2001-19

Novosibirsk
2001

New design of accelerating system with amorphous iron

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Abstract

In the work presented here a new design of the accelerating RF system for proton synchrotrons is considered. The amorphous iron is used in accelerating RF cavities. RF cavities are made as sections enabling the RF system desing with the lowest dimensions and minimum consumption RF power. The sectioned version enables the desing in the form of modules with the separate RF power supply from transistor amplifiers.

Аннотация

Рассмотрена новая конструкция ускоряющей системы для протонных синхротронов. В ускоряющих резонаторах применяется аморфное железо. Резонаторы выполняются виде секций, позволяющих выполнить ускоряющую систему с наименьшими размерами и минимальной потребляемой мощностью. Секционное исполнение позволяет выполнить ускоряющую систему в виде модулей с отдельным питанием от транзисторных усилителей.

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1 Introduction

In recent years in the frequency tunable RF cavities within the frequency range up to 10 MHz, the amorphous iron band magnetic circuit are used instead of ferrites [1].

However, the use of the amorphous iron encounters with the problems of its cooling. The use of the well-known cooling techniques for ferrites allowing to remove the specific losses of 1 W/cm^3 [2] turns out to be quite complicated in the case of the amorphous iron RF cavities. It is caused by the fact that unlike ferrites the amorphous iron core is not a homogeneous and solid body since it is made of a $20-25$ micron thick band by its winding. In order to eliminate the intracoil shortdowns the coils are insulated one from another. As a result, it turned out that amorphous iron cores have a high heat conductivity in the direction of a flat band and, probably, the low and hardly certified heat conductivity in the radial direction of the circular core with an account for a great number of band coils $(2000-3000)$ and the same number of insulation gaps.

In some versions of the RF cavity design [3], water flowing around amorphous iron is used for cooling. Cores are installed in the RF cavity housing with large gaps producing channels for flowing water. Such a design has inevitable problems with the corrosion of the amorphous iron and in this case special coating of iron, cleaning and control of water are required. The presence of water in the housing substantially increase active losses and the requir RF power supply. In this design the required RF power supply is increased about two times.

Another technique of cooling amorphous iron cores [4] consists in the that the cores are "inclosed inside a C form alumina box, insulated by a capton film. A sandwich of two magnetic cores, back to back on the two faces of a new designed copper ring in witch flowes the cooling water make an independant module. Six modules of this type are aligned around the beam pipe for each quasi-resonator". Thus, water turn out to be inside the cavity but it is shielded from the RF power and dose not contribute additional losses. At the same time, the alumina boxs and the copper rings placed inside the cavity increase the losses.

Note that the placement of large volumes and therefore weight of the amorphous iron inside the cavity as well as necessity to provide channels for flowing water leads to an increase in the size of the accelerating system thus making the desing bulky and complex in its manufacture and maintenance.

In this connnection, it seems quite reasonable a simpler design of the RF cavity with an amorphous iron which provides the efficient cooling of cores and does not contribute additional losses and enables one to make the cavity dimensions minimal as possible.

The main idea consists in that the accelerating system is made in form of a few of coaxial RF cavity sections correspondig to the number of amorphous iron rings. Each ring is glued with the heat conducting glue into the section housing which serves simultaneously functions of the RF cavity and heat removal, as is shown in Fig.1.

The RF power extraction in an amorphous iron is removed to the section housing through the end surfase of the ring in the direction of the core maximum conductivity. The thickness of glue between the ring and the housing does not exceed 1 mm. The glue provides also the electric insulation between the core and the housing.

The silicon organic compound "Elastoseal" with high dielectric and heat condactivity is used as a glue.

Each section can be cooled either with air or water. In the case of water cooling, pipes are soldered to the outer surfase of the section.

The sections are installed in successio one after another and connected both electrically and mechanically and tighten with bolts pro-

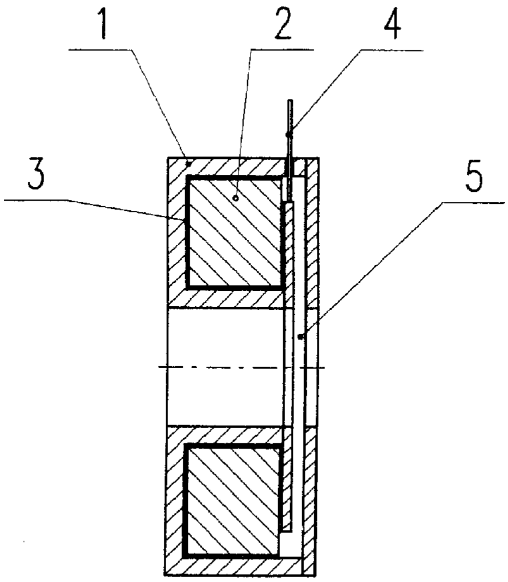

Figure 1: Design of accelerating section: 1 – housing, 2 – amorphous iron, 3 – glue, 4 – RF power input, 5 – accelerating gap.

ducing the unit design of the accelerating system. Sections can be placed in one or several places of the accelerator without rigid requirement to the size and place.

Each RF section has the accelerating gap whose voltage is lower than the total accelerating voltage by a factor equal to the number of sections form the accelerating system.

The specific feature of the design is the absence of high voltages at all the units of the accelerating device at high total accelerating voltage.

In such a design of the accelerating system RF power losses turn out to be the lowest since they are only determined by losses in an amorphous iron.

Each or a few sections connected in parallel to the RF power source.

Because of the fact that losses in one section do not exceed

$2-3$ kW it turned out be possible to use transistors with an output RF power of $5-10$ kW instead of conventional tubes in the finals stage of the RF power supply amplifiers. In this case, it might be reasonable to produce the accelerating system in the form of separate modules with the autonomous RF power supply of one or few sections.

For frequency tuning the biasing of amorphous cores can be produced similarly to that as it is achieved for ferrites in analogous devices [2,5]. One should note that in some applications [3] the RF cavity with amorphous iron cores provide the required frequency band even without biasing.

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Новая конструкция ускоряющей системы с аморфным железом

Budker INP 2001-19

Ответственный за выпуск А.М. Кудрявцев
Работа поступила 2.04.2001 г.

Сдано в набор 3.04.2001 г.
Подписано в печать 3.04.2001 г.
Формат бумаги 60×90 1/16 Объем 0.6 печ.л., 0.4 уч.-изд.л.
Тираж 100 экз. Бесплатно. Заказ № 19

Обработано на IBM PC и отпечатано на
ротапринте ИЯФ им. Г.И. Будкера СО РАН
Новосибирск, 630090, пр. академика Лаврентьева, 11.