APPLICATON OF SUPERCONDUCTORS IN MEDICINE*

K. Malinowski[a], K. Kozlowski[b,c], K. Roslon[c,d], H. Malinowski[c]

[a]Lublin Univeristy of Technology, Nadbystrzycka 38D, Lublin, Poland
[b]Nicolas Copernicus University, Gagarina 11, Toruń, Poland
[c]Joint Institute of Nuclear Reaserch, Joliot-Curie 6, Dubna, Russia
[d]Warsaw University of Technology, Plac Politechniki 1, Warszawa, Poland

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In present time, there are lot of devices based on strong magnetic field. Creation of strong magnetic field is possible thanks to superconductors which often are replacing classic electromagnets. Strong magnetic fields are used in medical diagnostics and testing such as nuclear magnetic resonance (NMR), construction of NMR device and picture formation. Another application of a strong magnetic fields in medicine is hadrontherapy. The theoretical principle of the method and the construction of the devices for hadron therapy has been presented. Comparison of the hadrontherapy with other radiotherapies has been demonstrated. The main topic of the paper has been the application of superconducting systems in medicine.

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1. Introduction

The superconducting technology is a very young field and yet it is applied in many areas. It is used mainly in particle accelerators as a more efficient substitute for classic electromagnets. Superconducting electromagnets have also found its place in fields of medicine such as magnetic resonance or detectors for astrophysical purposes. While being interested in medicine, it is essential to know about magnetic influence on life. It is not an easy task to research as all life forms on Earth live in natural magnetic field generated by our planet and it is impossible for us to detect any signs of magnetic field changes due to the fact that we do not have such receptors. But we know that there is such influence because of experiments on life forms. It is also known that high frequency electromagnetic field can generate large amount of heat in organisms.

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Magnetic applications in medicine are not very common but very effective in some medical branches [1]. One of them is medical scanning, specifically in nuclear magnetic resonance (NMR) which gives the best images of patient body. Next branch that gives wide area for superconductive technology application is hadrontherapy used in cancer treatment. Development of these two branches was a big step for the medicine as with the MRI, it is possible to detect abnormalities in a patient's body that no other method can detect and Gantry System is used for the cancer therapies with one of the best results [2].

2. Hadron therapy

2.1. Classic Gantry

Focusing on Gantry System, there are two possible variants of construction. The first one is the classic Gantry built with the application of conventional electromagnets. This technology is not new but it has a few disadvantages. The main flaw is a significant size. In order to generate a sufficient magnetic field to lead ion beam, a very big electromagnets are required as it is known that they have a low current density. In addition, a whole ion channel needs to be shielded and possesses the ability to turn around from 0 to 180 degrees [3]. One therapeutic chamber constructed with the use of this technology is the size of a small house and the whole surrounding facility is much bigger [4].

2.2. Super Gantry

To solve this issue, there was the second variant proposed with the application of superconductors instead of a classic wiring. This method significantly reduces the size of the construction and helps to overcome many other problems. Superconductors can be also used for replacing iron shielding which leads to the further size reduction. Super Gantry is much more efficient and does not occupy that much of a space. According to expectations, it should not exceed the size of a regular room.

Additionally, the shielding has to be used in order to prevent magnetic field from influencing other devices in its range. In classic (non-superconductive) Gantry System, a large iron shielding is applied thus the size, cost and weight of the construction increases [5].

As it was stated above, Gantry System leads the ion beam to the patient via ion channel. To curve the beam, a high value set of the magnetic field is required. To keep the beam in the centre of channel, magnetic field needs to change because energy of the beam depends on a kind of tissue [6].

3. Shielding

3.1. Closed shielding

The application of superconductors is not restricted only to high magnetic fields creation. Superconductors can replace iron shielding due to the fact that they are ideal diamagnetics. There are closed and non-closed types of a superconducting shielding. Closed shielding occurs in a form of a tube wrapped in superconducting foil. This architecture prevents the magnetic field from penetrating the shielding. It can reduce the size of the whole construction. Nowadays, mounting composed shields can reduce external magnetic field down to 0.002 T which is an excellent result as targeted external field has an approximate value of 0.2 T.

3.2. Unclosed shielding

It is known that high magnetic fields can be used for a very high resolution body scan. This resolution depends on many factors but two of them are essential. These are the value of magnetic field and its homogeneity. It is very diffucult to achieve a high homogeneity. Generated magnetic field needs to be analyzed and calibrated in all of the points where any noises are appearing. This reparation is provided by mounting additional coils (shimms) on the magnet system. This procedure is repeated until the systems magnetic fields homogeneity will reach the level of 10^{-3} [ppm].

The unclosed type of shielding can be used in MRI. Superconductive unclosed shields can be very profitable in improving the fields homogeneity. This type of shielding significantly reduces the radial component of the magnetic field. This method can greatly reduce the time of the MRI. The fact that shims are not essential makes the construction less complex (see Fig. 1).

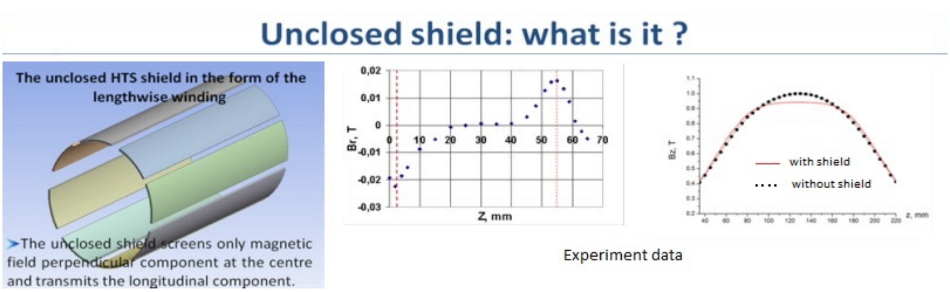

Fig. 1. General overlook on unclosed shielding characteristic.

4. Conclusion

It has been shown that superconductors application in the medical field is still very young but very promising. For now, it has proved its reliability by reaching a much higher treatment results. The development of this technology should be continued because it may be a key to completely reduce the cancer threat.

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