

DARKO ZIGAR¹
DEJAN KRSTIĆ²
UGLJEŠA JOVANOVIĆ³

^{1,2,3} Faculty of Occupational Safety,
Niš, Serbia
³ Faculty of Electronic Engineering,
Niš, Serbia

¹ darko.zigar@znrfak.ni.ac.rs

² dekikrs@gmail.com

³ ugljesa.jovanovic@elfak.ni.ac.rs

ANALYSIS OF MAGNETIC FIELD DISTORTION IN VARIOUS TYPES OF BEDS WITH FERROMAGNETIC MATTRESSES

Abstract: *Ferromagnetic elements in the furniture, especially beds, influence the changes in the magnetic field distribution in this area. In this way, an inhomogeneous magnetic field whose values are higher than the Earth's natural magnetic field is generated. The presence of humans or their body parts in anomalous magnetic fields has become the focus of health concerns. For this reason, the magnetic field for different types of beds with ferromagnetic parts, such as mattresses, has been calculated in this paper. Our results showed that exposure to magnetic fields revealed the zones with higher magnetic induction for some type of beds. In the end, new material and new design processes have been suggested in order to maintain a healthy lifestyle.*

Keywords: *beds with ferromagnetic mattresses, magnetic field calculation, anomalous magnetic field, health risk.*

INTRODUCTION

Electromagnetic sources and different types of ferromagnetic objects in modern living spaces generate changes in magnetic fields. Obtained magnetic fields that people spend most of their time are significantly different from Earth's natural magnetic field (EMF), and they are known as Anomalous Magnetic Fields (AMF). Spending a long period of time in the AMF can produce significant health effects according to existing scientific knowledge [1, 3, 5].

It is not difficult to verify that animals and humans are electromagnetic beings and it is logical that electromagnetic fields affect chemical, physiological and biological processes [2].

Unfortunately, the impact of electromagnetic fields at the cellular level and organelle-level up to the molecular level has not been fully explained, which certainly slows down the development of medicine. The cell metabolism is trained by an electric field on both sides of the cell membrane and magnetic properties of cell organelles and local magnetic fields in cells manage the functions of organelles and processes [7, 1, 9, 10], and the immune properties of the whole body [12, 5].

Generally, people spend a lot of time in beds, and if the body is in an anomalous position, electric and magnetic fields in biochemical processes in cell and cell organelles are not regular, which ultimately leads to histopathological changes in the cell. For all these reasons, it is important that humans remain in the natural fields, while in the modern living environment, we should take into account what kind of EM fields he/she lives in [6, 11].

Respecting the fact that ferromagnetic objects in the magnetic field can be magnetized and, in this way, change magnetic field and made different distribution

concerning the initial field, the goal of this investigation was to evaluate this effect. One way to determine the spatial distribution of these fields is the numerical calculation of the magnetic field using numerical methods, and another way is by measurement. This paper is focused on the calculation of the magnetic field for different types of beds with mattresses with ferrite core (springs).

MODELS OF BEDS

In general, there are three types of beds: single, bunk bed and sofa bed. All types of beds are shown in Figure 1 and Figure 2.

A bunk bed is a type of bed in which one bed frame is stacked on top of the other (Fig 1b). A sofa bed is typically a sofa or couch that, underneath its seating, hides a metal frame that can be unfolded or opened up to make a bed (Fig. 2).



Figure 1. *Types of bed: a) single bed, b) bunk bed*



Figure 2. *Sofa bed (unfoldable and foldable)*

Modern beds are constructed with parts of steel and mattress from springs. Bonnell spring mattress systems are the most traditional type of innerspring mattress. The Bonnell coil (spring) has an hourglass shape (wider at the bottom and the top than the middle) and is interconnected with a mesh of metal to make the spring system.



Figure 3. *Geometry of spring and mattress*

NUMERICAL CALCULATION OF MAGNETIC FIELD IN BEDS

A simplified model for each model of the bed has been made so that simulation could be performed. Simplified models fit beds with wooden construction without metal frames. In this construction, there are mattresses with a steel wire core with helical compression spring, usually from a ferromagnetic material. In Figure 4, there is a simplified model of bed without a frame which consists of 5x9 springs of 15 cm radius and 20 cm high.

Springs are helicoidal structures made up of 6 coils having approximately the same radius, with the central coils having about 10% smaller radius. The conductive material interconnects the springs, while the ends of the springs do not end at the same angle. This provides the reality of the wire core structure that is achieved in the production of this mattress. The mattress was set at a height of 25 cm from the ground.

To provide the reality of the initial data in the simulation model, the intensity of the magnetic induction of the natural Earth magnetic field by the proton magnetometer was measured in the area of Nis. The mean value of the natural magnetic field $B = 47,8 \mu\text{T}$ was measured. This value was used to determine the initiative magnetic field in the airspace

during the simulation. The springs (helix) and circular cross-section constructing profiles are made from ferromagnetic material with $\mu_r = 1000$, $\sigma = 1.04 \cdot 10^{-7} \text{ S/m}$. The magnetization curve for the helix material at the operating point are defined by values $H = 38 \text{ A/m}$, $B = 0.6 \text{ T}$. Earth is modeled as a parallelepiped bigger than the bed with electromagnetic characteristics $\epsilon_r = 2.53$, $\rho = 1550 \cdot \text{kg/m}^3$.

A preferred simulation method for calculating the magnetic flux density is the Finite Integration Technique. This method has been applied within the software package CST Studio Suite by CST - Computer Simulation Technology.

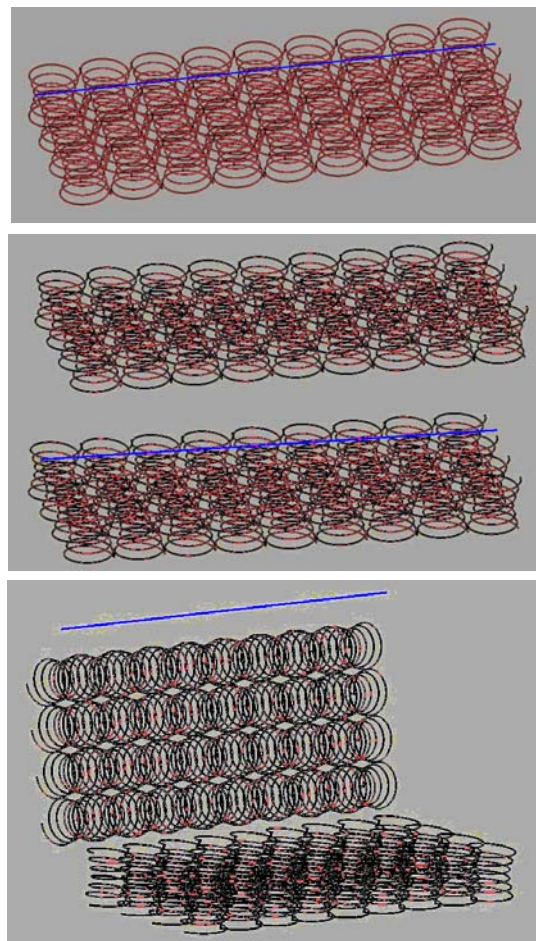


Figure 4. *The models of beds with mattress: a) single bed, b) bunk bed, c) sofa bed*

RESULTS OF SIMULATION MAGNETIC FIELD

For the simulated parameters, the calculation of the magnetic field in the immediate surroundings of the construction was carried out. Some of the results are shown in the form of a diagram of different cross-section bad and man in lying position which represents the distribution of magnetic flux density, and graphics and tables.

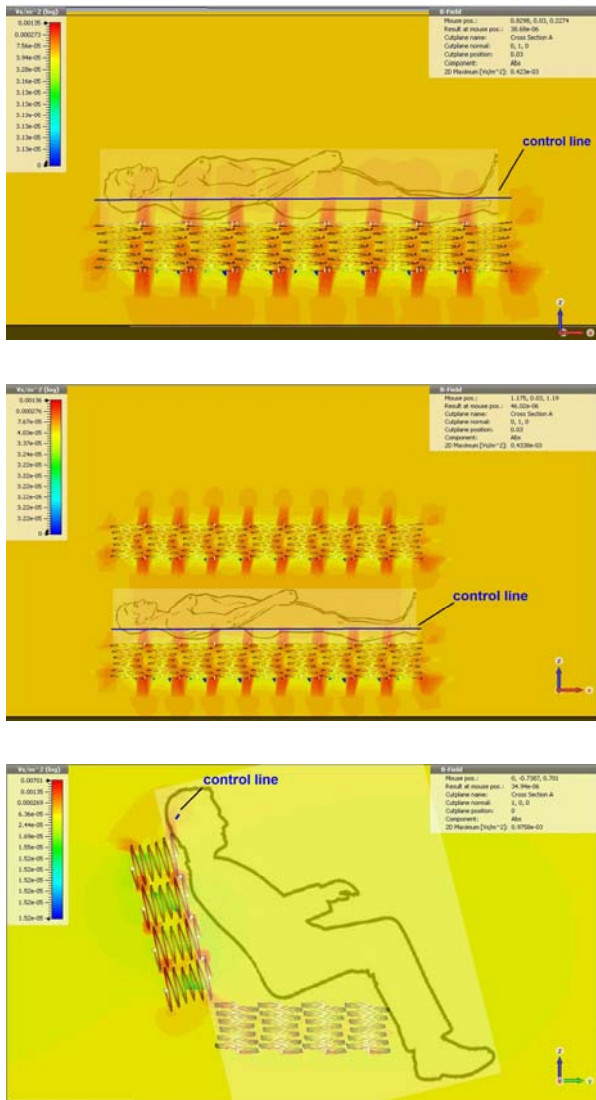


Figure 5. Magnetic flux density $B[\mu\text{T}]$ a) single bed model, b) bunk bed, c) sofa bed

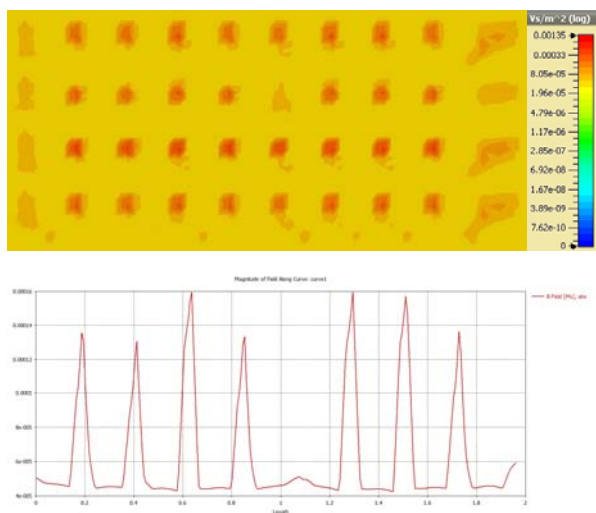


Figure 6. Magnetic flux density $B[\mu\text{T}]$ for a single bed at a distance of 5cm from the mattress core along the control line

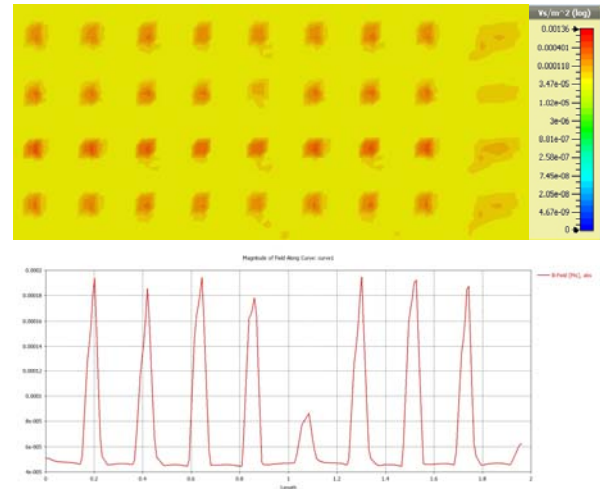


Figure 7. Magnetic flux density $B[\mu\text{T}]$ for bunk bed at a distance of 5cm from mattress core along the control line

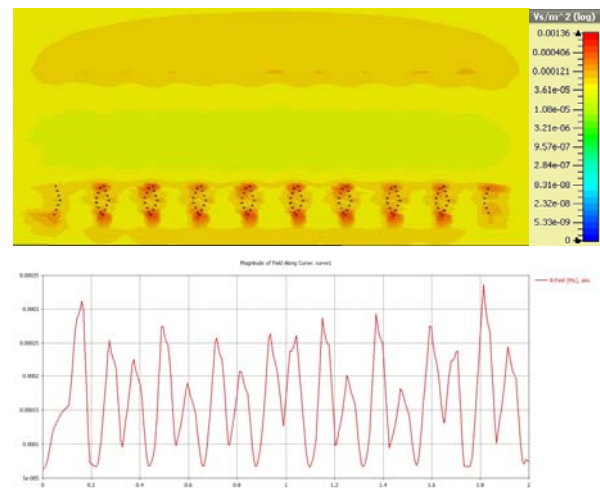


Figure 8. Magnetic flux density $B[\mu\text{T}]$ for a sofa bed at a distance of 5cm from the mattress core along the control line

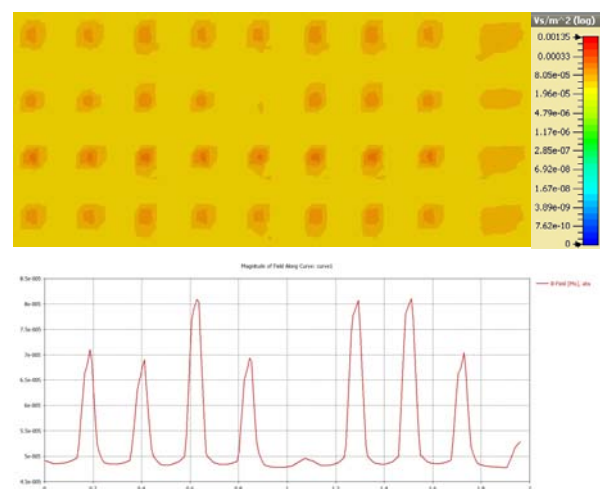


Figure 9. Magnetic flux density $B[\mu\text{T}]$ for a single bed at a distance of 10 cm from the mattress core along the control line

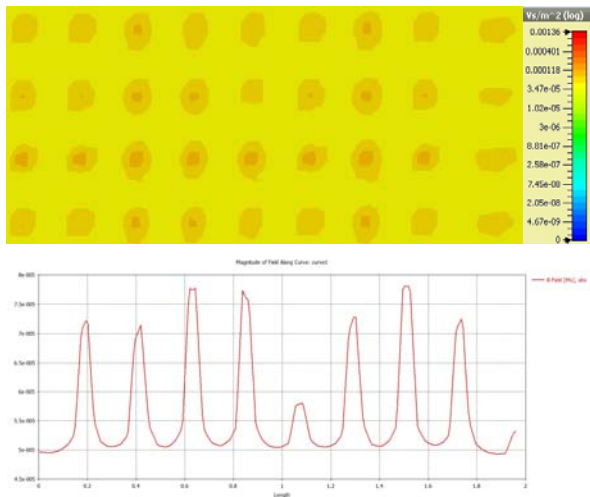


Figure 10. Magnetic flux density $B[\mu\text{T}]$ for a bunk bed at a distance of 10 cm from the mattress core along the control line

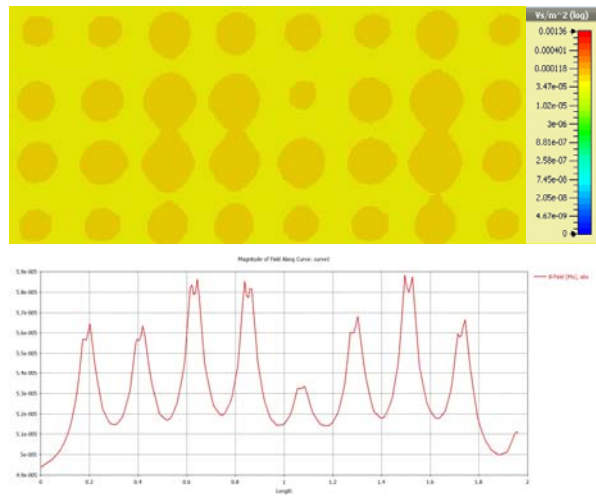


Figure 13. Magnetic flux density $B[\mu\text{T}]$ for a bunk bed at a distance of 15 cm from the mattress core along the control line

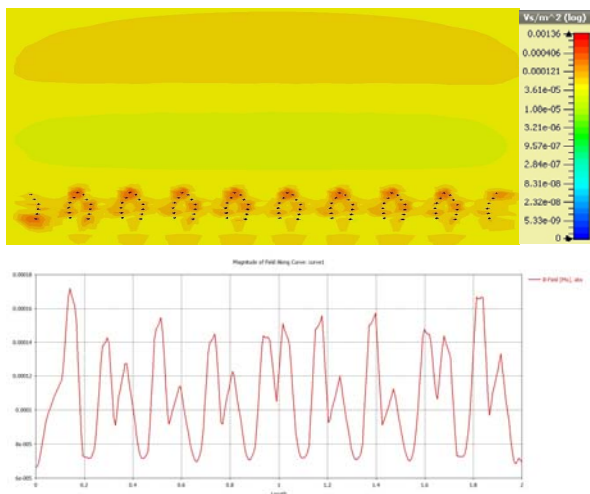


Figure 11. Magnetic flux density $B[\mu\text{T}]$ for a sofa bed at a distance of 10 cm from the mattress core along the control line

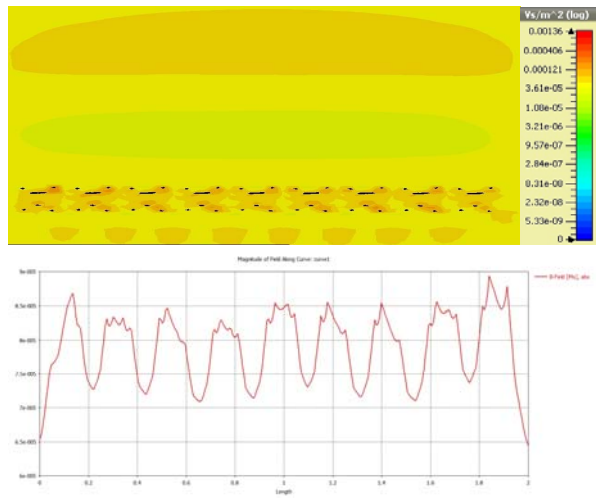


Figure 14. Magnetic flux density $B[\mu\text{T}]$ for a sofa bed at a distance of 15 cm from the mattress core along the control line

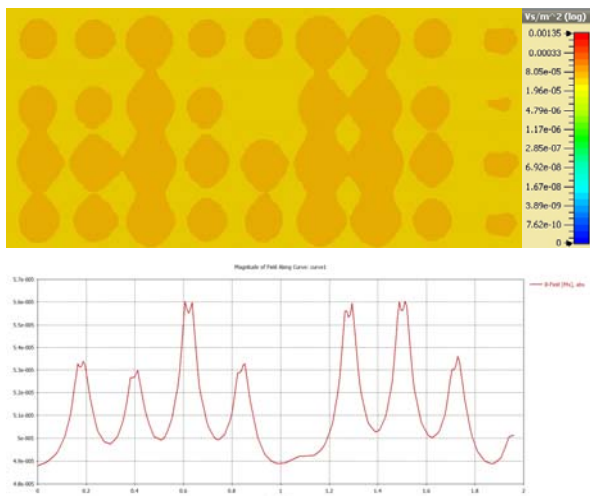


Figure 12. Magnetic flux density $B[\mu\text{T}]$ for a single bed, at a distance of 15 cm from the mattress core along the control line

Table 1. Magnetic flux density $B[\mu\text{T}]$, for different bed models, at a distance of 5 cm from the mattress core

Model of bed	$B_{\min}[\mu\text{T}]$	$B_{\max}[\mu\text{T}]$	$\Delta B [\mu\text{T}]$	$\frac{\Delta B}{B_{\text{Earth}}}[\%]$
Single	46.92	159.08	112.16	234.64
Bunk bed	47.85	194.51	146.66	306.82
Sofa*	68.82	338.21	269.39	563.57

* in the head area

Table 2. Magnetic flux density $B[\mu\text{T}]$, for different bed models, at a distance of 10 cm from the mattress core

Model of bed	$B_{\min}[\mu\text{T}]$	$B_{\max}[\mu\text{T}]$	$\Delta B [\mu\text{T}]$	$\frac{\Delta B}{B_{\text{Earth}}}[\%]$
Single	48.02	80.58	32.56	68.11
Bunk bed	49.50	78.12	28.62	59.87
Sofa*	69.41	172.61	103.2	215.48

* in the head area

Table 3. Magnetic flux density $B[\mu\text{T}]$, for different bed models, at a distance of 15 cm from the mattress core

Model of bed	$B_{\min}[\mu\text{T}]$	$B_{\max}[\mu\text{T}]$	$\Delta B [\mu\text{T}]$	$\frac{\Delta B}{B_{\text{Earth}}}[\%]$
Single	48.92	56.24	7.32	15.31
Bunk bed	49.88	58.82	8.94	18.70
Sofa*	71.56	89.02	17.46	36.52

* in the head area

CONCLUSION

The calculation of the magnetic field for three different types of beds in the immediate surroundings of the mattress was carried out.

The comparison of the values obtained by the simulation and the values obtained by measuring a similar physical model showed a satisfactory agreement.

The following figures show the distribution of magnetic flux density in the bed area where the human body rests.

The results show that the largest change in magnetic induction is relative to the natural magnetic field near the mattress, which can be seen in Table 1, where this relative deviation is 354% for the single bed, 306% for the bunk bed model and 563% for sofa bed. This means that a person while sleeping in such beds has a very inhomogeneous exposure of certain organs to the magnetic field, which will define different metabolic activities in certain parts of the organs. This certainly does not contribute to natural functions during the period of rest, which as a consequence, could bring about significant health effects.

Increasing the distance from the mattress leads to a decrease in the relative deviation, which can be seen in Table 2 and Table 3.

The spatial distribution of the magnetic field shown in the figures indicates the maxima of the magnetic induction for the springs axis and the ends of the springs. Analysis of the size of the springs to the relative deviation indicates that the springs of the smaller radius of the helicoid and the mass itself give lower intensities of magnetic induction (magnet flux density), i.e. it can be said that the magnetic field is more homogeneous compared to mattresses with larger springs.

For bunk beds, homogeneity can be observed over the entire height of the bed, i.e. deviations are far smaller compared to other bed models, Fig. 5b.

In the case of sofa beds, the results show that the maximum of the magnetic field is at the height of the head, i.e. approximately in the occipital part of the head. Some knowledge from the literature [6, 10, 14] indicates a possible impact on the clogging of blood vessels in the area of the nape and head and the increase in blood pressure.

In general, it may be noticed that the intensity of magnetic flux density decreases with the distance from the mattress, which will produce unequal exposure to the magnetic field of individual organs depending on the physiological position when sleeping.

It has been proven that ferromagnetic objects in human proximity lead to a change in the homogeneity of the natural ambient magnetic field and staying in an anomalous magnetic field can be considered undesirable.

Manufacturers of the ferromagnetic furniture should adopt new data about the health hazard of their products on the functioning of natural biological mechanisms.

Research should continue to investigate what level of anomalous magnetic fields in the sleeping space can be harmful to human health.

The research results should provide healthy electromagnetic conditions for people in their actual environment, similar to those generated in natural electromagnetic fields.

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BIOGRAPHY of the first author

Darko Zigar was born on April 16, 1973. in Pancevo, Serbia. He received B.Sc. degree in Environmental Protection and M.Sc. degree in Occupational Safety in 2002. and in 2007. respectively, from the University of Niš, Serbia. He has been with the Faculty of Occupational Safety, University of Niš, since 2008., where he is working as a researcher/assistant lecturer. He obtained a PhD degree from the Faculty of Occupational Safety, the University of Niš in 2015. His areas of expertise include numerical fire simulations, as well as investigations of possible adverse effects of electromagnetic field irradiation from mobile phones and wireless systems.



ANALIZA PROMENE MAGNETNOG POLJA U RAZLIČITIM TIPOVIMA KREVETA SA FEROMAGNETNIM DUŠEKOM

Darko Zigar, Dejan Krstić, Uglješa Jovanović

Rezime: Feromagnenti delovi nameštaja a posebno kreveti dovode do promene magnetnog polja. Na taj način se stvara nehomogeno magnetno polje čije su vrednosti veće od prirodnog magnetnog polja zemlje. Boravak dela tela ili celog tela u anomalijским magnetnim poljima se povezuje sa zdravstvenim problemima. U ovom radu se izračunava magnetno polje za različite vrste kreveta sa feromagnetnim delovima kao što je dušek. Prikazani su rezultati koji definišu oblasti u kojima je magnetna indukcijom povećana u odnosu na prirodno magnetno polje za neke vrste kreveta, a da bi kreveti omogućavali zdrave životne uslove neophodni su novi materijal i novi proces dizajniranja u procesu proizvodnje.

Ključne reči: kreveti sa feromagnetnim dušekom, proračun magnetnog polja, anomalijско magnetno polje, zdravstveni rizik.