ISSN: 2278 – 1323
International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)
Volume 2, Issue 3, March 2013

Investigation of SAR inside Different Enclosures and Reduction Techniques

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***Abstract*- Electromagnetic interface with a human head exposed to internal antenna is calculated. A human head phantom with dielectric properties inside an enclosure is designed. The radiation pattern of Planar Inverted F Antenna [PIFA] exposed to human head is analysed inside different shapes of enclosure namely cubical and cylindrical. The metallic enclosures have high values of SAR than the free space. It is found that the absorption rate is high for both the enclosures but cylindrical enclosure exhibit higher SAR values than cubical. Thus the high absorption rate in the metallic enclosure is reduced by using dielectric materials like ferrite and glass as an absorbing layer.**

***keywords*: PIFA, SAR, ENCLOSURES, RADIATION**

I INTRODUCTION

Mobile phone having Planar Inverted F Antenna exposed to a human head inside an enclosure is presented in this paper. Different shapes of the enclosure namely rectangular and cylindrical are considered. Human tissue that has high conductivity absorbs the radiation coming from the antenna. The absorption rate is extremely high when the human head phantom is place inside the enclosure. The electromagnetic absorption in the human tissue is calculated by a parameter called Specific Absorption Rate (SAR). SAR depends on the environment and it is less in free space and extremely high in enclosures made of metal. The enclosures made of metal without high dielectric loading like elevators hugely favours the increase of SAR [1, 2]. The structure of the enclosures also plays a role in the distribution of Electromagnetic Radiation. It is found that enclosures walls with curved geometry reflect the electromagnetic radiation more. In this paper it is observed that the curved cylindrical enclosures increase the absorption on human head than the cubical enclosure. If the absorption of Electromagnetic radiation is high on human head it leads to various health hazards. Therefore it has been aimed to reduce this high radiation in the enclosures by using microwave absorbing materials like ferrite and glass as a layer over the walls of metallic enclosures [3].

II SAR

The SAR (W/kg) at any point in the model can be determined from the calculated electric field E (V/m) and it is given by the following equation

$$SAR= \frac{\sigma E^2}{\rho} \text{ W/Kg} \qquad (1)$$

Where E is the internal electric field (V/m), SAR is the Specific Absorption Rate (W/kg), σ is the conductivity (S/m) of the tissue and ρ is the mass density (kg/m3).SAR values can be expressed over 1g or 10g mass and it is called as 1 g or 10 g spatial average SAR. The SAR limit specified in IEEE C 95.1: 1999 is 1.6W/Kg in a SAR1g averaging mass while that specified in IEEE C95.1: 2005 has been updated to 2W/Kg in a 10 g averaging mass[4,5].

III DESIGN METHODOLOGY

A. Human Head Exposure to Antenna

The human head simulated with tissue equivalent material is exposed to the antenna and it is shown in figure 1. For simulation of the electromagnetic fields in the human body the appropriate parameters such as relative permittivity 45.8, conductivity 0.77 and mass density 1030 at 900 MHz are used for the calculation [6].

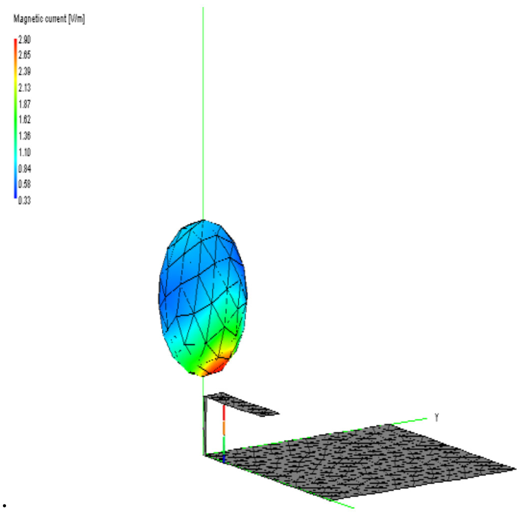

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Fig1. Human head exposure to antenna

B. Enclosure Dimensions

The metallic enclosure is considered to be made of iron. Two different geometry of elevator namely cylindrical and rectangular are analysed. A mobile phone with Planar Inverted F Antenna [PIFA] exposed to human head is placed inside the enclosure as shown in figure 2. The results are studied at 900MHz. Due to the complexity in the design, the dimensions of the enclosure is scaled down by the factor of 1/4. The design values are shown in table 1.

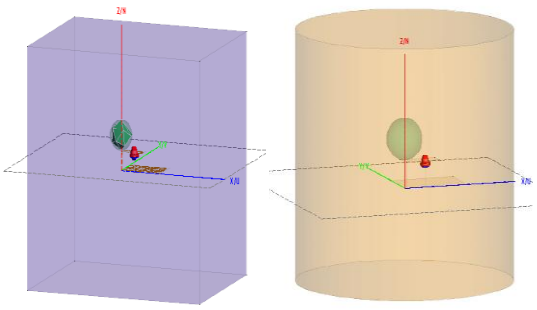

Fig 2.a) cubical 2.b) cylindrical Metal enclosures

Table1 Design parameters of enclosure

Metallic enclosure	For 900 MHz and 1800 MHz in meters
Length	0.4
Width	0.3
Radius	0.3
Height	0.4
Iron (σ)	1e7

IV SIMULATION RESULTS AND DISCUSSIONS

A . RADIATION PATTERN COMPARISON

The enclosure made of metal is made of millions of moving parts such as atoms, which has millions of resonance frequencies. Metallic structures are subjected to resonance. Here, the metallic enclosure acts as the resonators [7, 8]. It is found that the Planar Inverted–F-Antenna inside the rectangular geometry of enclosure has less backward radiation and low SAR values at 900MHz than the cylindrical enclosures [9, 10]. The Far-field radiation pattern of two enclosures is shown in figure 3.

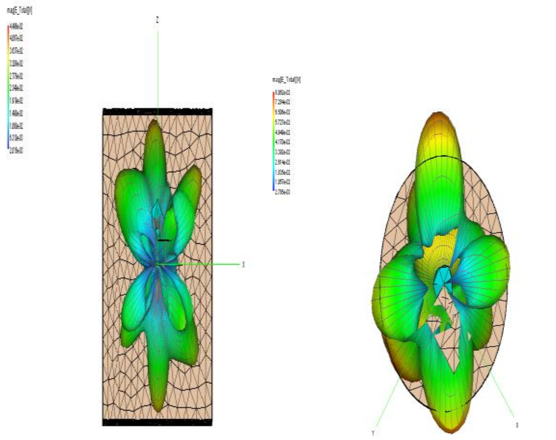

Fig 3 a) cubical 3b) cylindrical enclosures radiation pattern

Radiation pattern shows how the antenna radiates, the direction of radiation and its size. From the above radiation pattern in figure 3 it is observed that the radiation is more inside the cylindrical enclosures than the cubical one.

B.SAR COMPARISON

The SAR values are increased many times inside the metallic enclosure due to the resonance effects. 1g SAR at 900MHz is calculated in this paper. The results have shown that the SAR is exceeded inside the cylindrical elevator than the cubical. The simulated values in FEKO are shown in table 2.

Table 2 comparison of SAR at 900 MHZ

FREQUENCY (MHz)	SAR(W/Kg) in RECTANGULAR LIFT	SAR(W/Kg) in CYLINDRICAL LIFT
700	18.26	14.85
825	14.42	17.12
950	12.18	18.57
1075	12.95	13.14
1200	12.73	17.5

The simulated graph showing the comparison between two enclosures is given in figure 4. It is observed that the corners in the rectangular enclosures play a role in expanding the geometry thereby spreading the radiation. This result in less somewhat reduced absorption towards the passenger's head. Whereas the cylindrical enclosure increases the SAR towards the passenger because of its curved surface. The graphs showing the comparison between two enclosures are given below.

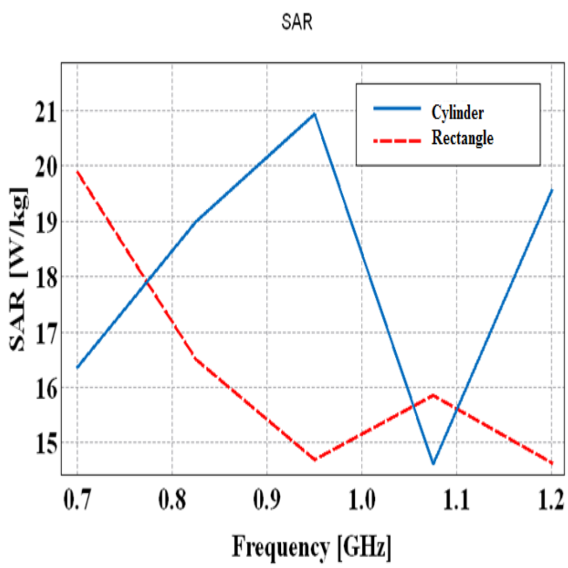

Fig 4 SAR comparison of two enclosures at 900 MHz

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V MEDICAL IMPLICATIONS

Exposure to electromagnetic fields (EMF) leads to a variety of adverse health effects such as childhood leukaemia, brain tumours, childhood brain tumors,genotoxic effects (DNA damage and micronucleation), neurological effects and neurodegenerative disease, immune system disregulation, allergic and inflammatory responses, breast cancer in men and women, miscarriage and some cardiovascular effects[11-17].

VI SAR REDUCTION

From the above obtained results it is found that cubical enclosures decreases SAR to some extent than the cylindrical ones.Therefore the cubical enclosure is considered for further study.

A.USING GLASS

Glass is used as a layer in the metallic enclosure. Glass that has poor conductivity absorbs the microwave radiation coming from Planar Inverted F Antenna. The results in table 3 shows the value of SAR obtained after using glass.Before using glass layer average SAR obtained at 900 MHz is 14.108W/Kg. After using glass the average SAR obtained at 900MHz is 1.196. Reduction of about 11 times is achieved using glass

Table 3 Reduced SAR at 900 MHZ using glass

Frequency (MHz)	SAR (w/kg)
700	0.3924
825	1.368
950	1.524
1075	1.172
1200	1.527

Comparing Figure 3.a with figure 5 it could be concluded that radiation is reduced after using glass.

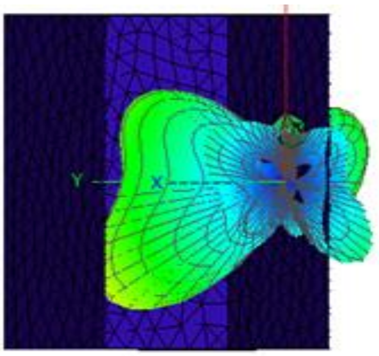

Fig 5 Radiation reduction using glass

The comparison drawn between metallic enclosure made of iron and the enclosure with glass layer is shown in figure 6.

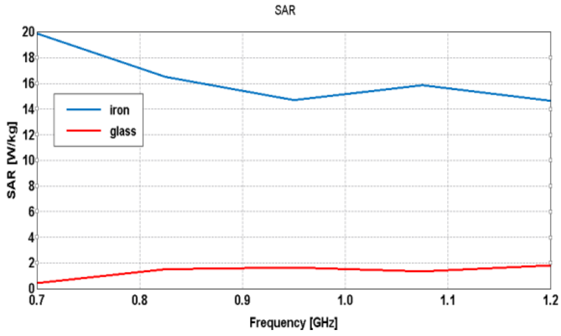

Fig 6 SAR comparison of metallic iron and glass.

B.USING FERRITE

Ferrite is commonly used for SAR reduction in antennas [18,19]. But in this paper ferrite is used as a shielding layer in the enclosure so that it benefits everyone in the enclosure.12 times reduction of SAR is obtained after using ferrite as a absorbing layer in the enclosure. The simulated values of SAR are shown in table 4.

Table 4 Reduced SAR at 900 MHZ using glass

Frequency (MHz)	SAR (w/kg)
700	1.064
825	1.267
950	1.302
1075	1.294
1200	0.8647

The radiation from the internal PIFA Antenna exposed to human head inside the enclosure after using ferrite layer is shown in figure 7.

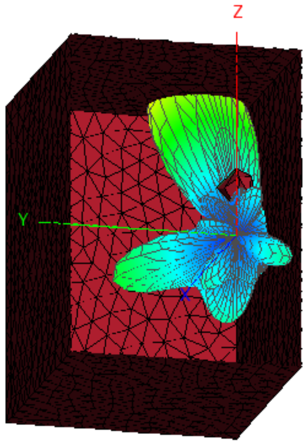

Fig 7 Radiation reduction using ferrite

The comparison drawn between metallic enclosure made of iron and the enclosure with ferrite layer is shown in figure 8.

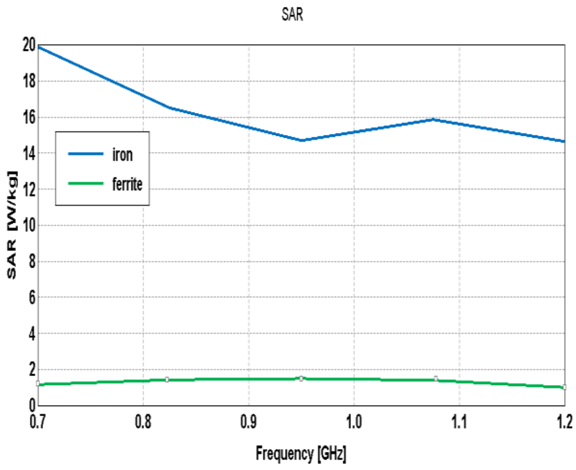

Fig 8 SAR comparison of metallic iron and ferrite

VII CONCLUSION

SAR induced in human head under different surroundings is evaluated using Method of Moments. It is found that SAR exceeds multiple folds inside the enclosure due to the resonance effects. In this work, it is observed that the structure of the enclosure plays a role in determining SAR. Among the two structures [cylindrical and cubical], it is found that the cylindrical enclosure has increased SAR values. The increased values of SAR are reduced 11 times by using glass and 12 times by using ferrite.

REFERENCES

[1] A. Hirata, S. I. Matsuyama, T. Shiozawa, "Temperature Rises in the Human Eye Exposed to EM Waves in the Frequency Range 0.6-6 GHz," IEEE Transactions on Electromagnetic Compatibility, vol. 42, no. 4, pp. 386-393, November 2000.

[2] Hirata, A., K. Shirai, and O. Fujiwara, "On averaging mass of SAR correlating with temperature elevation due to a dipole antenna,"Progress In Electromagnetics Research, Vol. 84, 221-237, 2008.

[3] Tang Chi Kit," Electromagnetic Field Human Exposure of using Mobile Phone inside Metallic Elevator," December 2008.

[4] IEEE standard -1528, "IEEE Recommended Practice for Determining the Peak Spatial-Average. Specific Absorption Rate *(*SAR*)* in the. Human Head from Wireless," December 2003.

[5] International Non-Ionizing Radiation Committee of the International Radiation Protection Association, "Guidelines on limits on exposure to radio frequency electromagnetic Fields in the frequency range from 100 kHz to 300 GHz," *Health Physics*, Vol. 54, No. 1,115-123, 1988.

[6] L. C. Kuo, and H. R. Chuang, "Design of a 900/1800MHz

[7] Dual-Band Loop Antenna Mounted on A Handset Considering the Human Hand and Head Effects," IEEE Antennas and Propagation Society International Symposium,June 2003.

[8] J. D. Krauss, "Electromagnetics," 4Ed, McGraw-Hill, ISBN 0-07-035621-1,1992

[9] Corbett Rowell and Edmund Y. Lam," Mobile-Phone Antenna Design," IEEE Antennas and Propagation Magazine, Vol. 54, No. 4, August 2012

[10] David O. Carpenter, cindy sage," key scientific evidence and Public health policy recommendations", July 2007

[11] Ebrahimi-Ganjeh, M. A. and A. R. Attari, "Interaction of dual band helical and PIFA handset antennas with human head and hand," Progress In Electromagnetics Research, Vol. 77, 225-242,2007.

[12] Erren TC, "A meta-analysis of epidemiologic studies of electric and magnetic fields and breast cancer in women and men", Bioelectromagnetics Supplement 5: S105-S119,2001

[13] Feychting M, Jonsson F, Pedersen NL and Ahlbom A, " Occupational magnetic field exposure and neurodegenerative disease", Epidemiology 14: 413-419,2003

[14] Foliart DE Pollock BH Mezei G Iriye R Silva JM Epi KL Kheifets L Lind MP Kavet R "Magnetic field exposure and long-term survival among children with leukemia". British Journal of Cancer 94 161-164,2006

[15] Fung, L. C., S. W. Leung, and K. H. Chan," Experimental study of SAR reduction on commercial products and shielding materials in mobile phone applications," Microwave and Optical Technology Letters, Vol. 36, No. 6, 419-422, Mar. 2003.

[16] Goedert M and Spillantini MG "A century of Alzheimer's Disease". Science 314: 777-784,2006

[17] Green L "Childhood leukemia and EMF" Cancer Causes Control 10: 233-243,1999

[18] Kouveliotis, N. K. and C. N. Capsalis, "Prediction of the SAR level induced in a dielectric sphere by a thin wire dipole antenna,"Progress In Electromagnetics Research, Vol. 80, 321-336, 2008.

[19] Hawang, J. N. and F.-C. Chen, "Reduction of the peak SAR in the human head with metamaterials," IEEE Transanctions on Antenna and Propagation, Vol. 54, No. 12, 3763-3770, 2006

[20] M. Okoniewski, and M. A. Stuchly, "A Study of the Handset Antenna and Human Body Interaction," IEEE Transactions on Microwave Theory and Techniques, vol. 44, no. 10, pp. 1855-1864, October 1996.

[21] Mahmoud, K. R., M. El-Adawy, S. M. M. Ibrahem, R. Bansal,and S. H. Zainud-Deen, "Investigating the interaction between a human head and a smart handset for 4G mobile communication systems," Progress In Electromagnetics Research C, Vol. 2, 169-188, 2008.

[22] T. Anita Jones Mary, S.Jemimah Priyadarshini and C.S.Ravichandran,"Analysis of SAR on Human head model in Metal Enclosures,"Dec 2010

[23] T. Anita Jones Mary, S.Jemimah Priyadarshini and C.S.Ravichandran,"Effects of Metal Slab on SAR effects in Mobile Antenna for Dual Band Frequency,"Dec.2010

[24] T. Anita Jones Mary, T. Joyce Selva Hephzibah and C.S.Ravichandran," SAR on Human head modeling with Inverted F Antenna in Cylindrical Enclosures,"2011

[25] Wang, J. and O. Fujiwara, "Reduction of electromagnetic absorption in the human head for portable telephones by a ferrite sheet attachment," IEICE Trans. Commun., Vol. E80-B, No. 12,1810-1815, Dec. 1997.

[26] www.bioinitiative.org/report/docs/section_17.pdf .

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