STUDY OF ELECTROMAGNETIC FIELD EFFECTS ON HUMAN

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Abstract— Electric and Magnetic field from the power transmission line is an important issue. The possible health effects on humans have arised. The magnetic field in turn induces the current in the human body. It is very necessary to compute the induced current and specific absorption rate to evaluate the effects associated with the electromagnetic fields. Hence in this study an attempt has been made to study the electromagnetic field effects on the human body under EHV transmission lines. Human body is modeled and the simulation is done using Finite Element Method. The human model is placed under 380kV lines the Magnetic field and induced current is found with the help of ANSOFT 2D software.

Index Terms— Electric field intensity, EHV transmission line, ELF & VLF Magnetic field, Health effect, FEM, Human body modeling, Magnetic fied intensity.

1 Introduction

Power frequency electromagnetic field draws attention of many researchers worldwide to investigate harmful effects on human. Due to the population increases the demand for electricity increases and an Extra High Voltage power transmission has come in to the practice. There is a situation for human to live under the EHV lines or near to those lines. The Overlap between the power transmission lines and the settlement areas causes problem to the human body.

The increase in the demand of electrical energy has raised the operating voltage of high voltage lines and as a consequences raised in series questions regarding potential health and environmental effects associated.

AC electric and magnetic field induced charges on the surface of the human and weak current flows. Currents from 50Hz to 60Hz EMF is weaker than natural currents in the human body. The maximum body current induced by electric field from transmission line is much greater than body current.

There are clear hazards posed by induced current densities sufficient to produced disturbance in rhythmic cardiac function such as extra systone and ventricular fibularation. Induced current from electric field is more important than the current induced by the magnetic fields. The distribution of electric and magnetic field strength varies along the surface of the body.

The electric field and currents induced in biological tissues by electro magnetic field could result in a variety of physiological or psychological responses. A low level exposes causes any consistent effects on heart, lunges, blood or immune system. The major concern in recent year has been the possibility that low intensity electric and magnetic field may influence the development of cancer.

This paper describes the applicability of FEM to analysis of interaction between human and electric and magnetic fields. The simple human body is used. This model is axi-symmetrical and made up of biological organism, whose conductivity, permittivity, permeability is on the same order of human body tissues.

2 Finite Element Method

High voltage line electric field can be calculated by various numerical techniques such as finite element method, finite difference time demine method, charge simulation method. In this paper finite element method is used.

Governing equations

Eddy current solver

Maxwell equation is given by

$$\nabla \times H = J + \frac{\partial D}{\partial t}$$

We know that B= μH

$$\nabla \times \frac{B}{\mu} = \sigma E + j\omega\varepsilon_r E$$

The concept of vector magnetic potential A is introduced because of the solenoid nature of B, that is

$$\nabla \times B = 0$$

Therefore,

$$\nabla \times A = B$$

For a time varying magnetic field E depends on both scalar potential φ and, magnetic vector potential A and also the electric field E also called Maxwell's electric field, corresponds to the sum of the coulomb electric field and the induced electric field, i.e.,

$$E = -j\omega A - \nabla\emptyset$$

Hence,

$$\nabla \times \frac{1}{\mu_r}(\nabla \times A) = (\sigma + j\omega\varepsilon_r)(-j\omega A - \nabla\emptyset)$$

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This is the governing equation for the eddy current problems.

Boundary condition

The choice of boundary condition not only influences the final solution but also cause further reduces the domain under study. Hence the boundary condition chosen is the drichelt's condition. Since the primary variables are given constant values common to object the homogeneous drichelt's conditions.

Finite element model of the human body

The dosimetry study has largely examined the effects of vertical electric field from on overhead source for a standing person. As a vertical orientation results in the maximum induced current exposure to the electric fields of horizontal or sagittal orientation results in smaller induced currents. The human body is modeled by a sphere for head, a thin cylinder for neck, a thick cylinder for waist, and a thin cylinder for legs.

Electrical constants of human body

From the macroscopic point of view, the human body can be regarded as a medium whose electrical properties are characterized in terms of conductivity and permittivity. It is found that the permittivity of light tissues extremely large at low frequencies and frequency dependence is remarkable; on the other hand the frequency dependence of conductivity is small.
It is assumed in this study that the human model is uniformly field in the medium having relative permittivity 56 and the conductivity 0.5semens/meter.

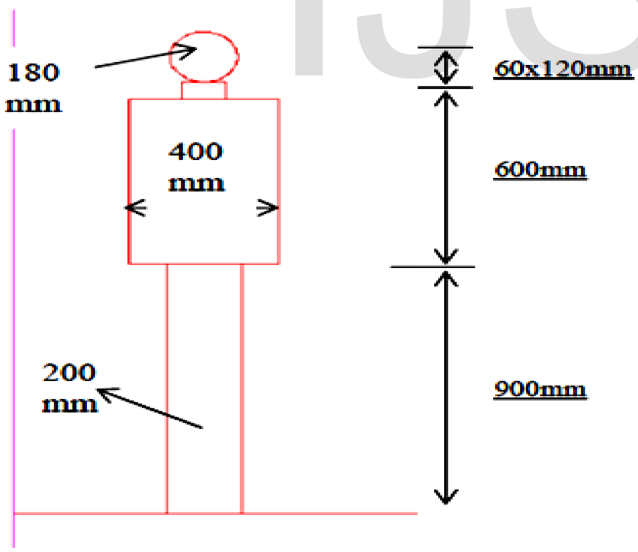

Fig.1: Hman Body Modelling

380 kV systems

The height of three phase 380 kV line over the ground plane h=10m. The diameter of the conductors D=28cm. the horizontal distance between phase line is 5m. The human body is assumed as having zero potential. Figure shows flux lines on the presented model. It is clear that the field lines near the human body to be perpendicular to the ground and the surface of the human body.

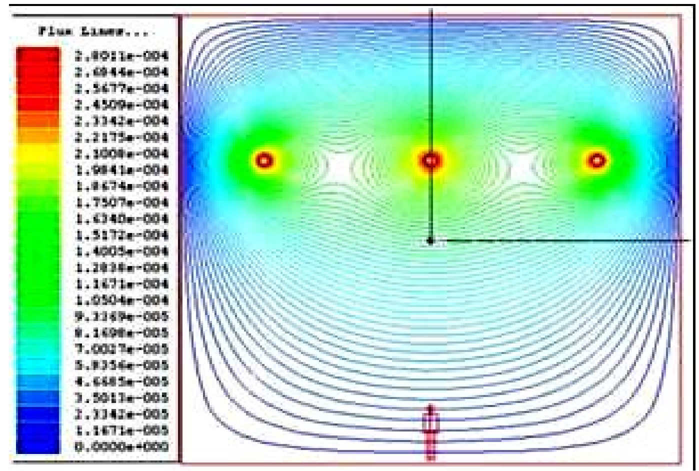

Fig.2: Magnetic flux density for 380 kV system

TABLE 1

RESULTS FOR 380 KV SYSTEM

Parts of the human body	Magnetic flux density in µT	Induced current density in µA/m^2	Electric field in kV/m	Induced current in nA
Head	11.7	2.35	0.7	59.8
Neck	11.6	2.13	0.637	46.02
Waist	11.5	1.99	0.595	477
Leg	11.2	1.29	0.38	228.6

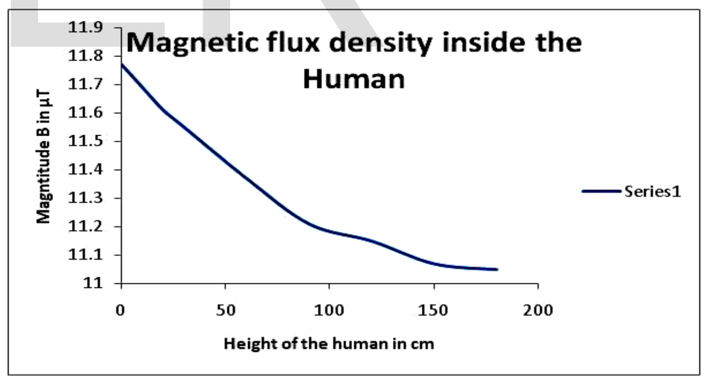

Fig.3: Magnetic flux density Variation with human height

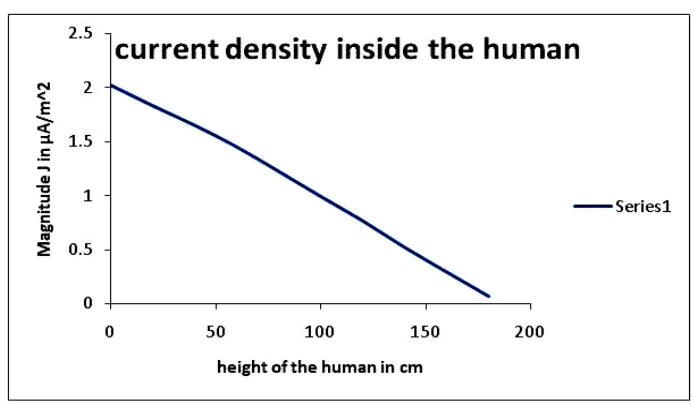

Fig.4: Induced current density for 380 kV system

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Table 2
RESULTS FOR 765 KV SYSTEM

Parts of the human body	Magnetic flux density in µTesla	Induced current density in mA/m^2	Induced current in µA
Head	15.65	5	127
Neck	15.4	4.6	99.36
Waist	15.3	3.6	864
Leg	15.2	1.7	306

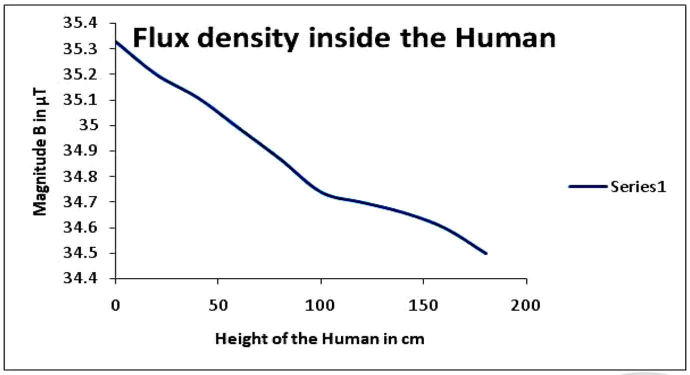

Fig.5: Magnetic Flux Density for 765 kV system

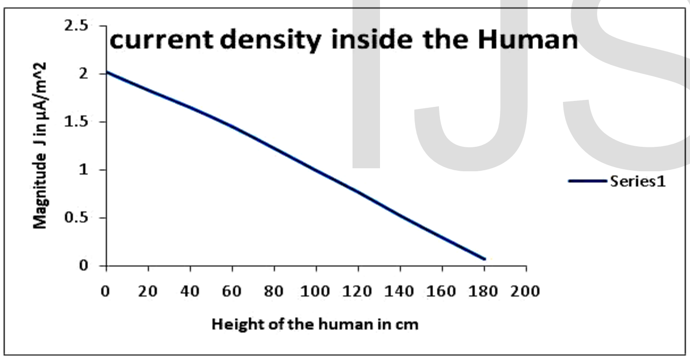

Fig.6: Induced current density for 765 kV system

DISCUSSION

Electromagnetic fields

When exposed to electric and magnetic fields and electromagnetic waves – more generally to electromagnetic fields, there is no bipolar contact but currents are induced in the body and therefore energy is delivered inside the body. The safety and health effects of this energy deposition in the body are controversial. The non ionizing electromagnetic frequency spectrum is usually subdivided into low frequency from 0 to 3 kHz (US) or 10 kHz (EU), and high frequency or radiofrequency from 3 kHz – 300 GHz (US) or 10 kHz – 300 GHz (EU).

The guidelines of WHO (World Health Organization) which promotes the guidelines of ICNIRP (International Commission for Non Ionizing Radiation Protection) are now considered as the global framework to protect workers and the general public in electromagnetic fields.

Biological effects

High rates of any energy applied on an object produce heat, ionization and destruction. In living organisms, the incidence of low to reasonable energy rates of non-ionizing electromagnetic energy induce electric current density which deposits a certain amount of energy. This energy has two effects, exactly the same as an electric current through the body: a physiological effect and a thermal effect.

Electric and magnetic fields means energy and physical forces on charges. However, in the body, there are no free electrons and conduction is due to charges bound on massive particles: ions and organic ions. Low frequency fields cause ion migrations modifying the normal ion concentrations leading to physiological effects. In the body, nerve impulses and muscle contractions can be triggered with an electrically generated ion flux. At high frequency, because of the large ion masses involved, the distance over which ions migrate forward and back is small, less than the diameter of molecules. The ion fluxes do not result in changes of ion concentrations and no physiological effects can take place. Because of their movements to and fro (and collisions), the kinetic energy of the ions and molecules increases which means temperature, a thermal effect. At low frequency the physiological effect dominates. At high frequency and at microwaves, dipole molecules such as water do not migrate but rotate. This rotation is also an increase of kinetic energy and it is a thermal effect.

It is well established that exposure to low frequency fields in the induction of electric fields and currents in biological tissues. If the fields are sufficiently intense, stimulation of nerves and muscles will occur, while at lower intensities modulation of activity within the brain and spinal cord may result. Magnetic phosphenes, faint, flickering visual sensations in the periphery of vision are an example of the latter. They were first described by the French scientist D'Arsonval in 1896, and are believed to be caused by field-induced currents affecting the normal electrical activity of the retina. Visually similar effects may be elicited by gentle pressure from the fingers on the closed eyes. The threshold for phosphene induction is dependent on frequency, and at 50 Hz is about 15 mT, so that fields capable of generating phosphenes are unlikely to be encountered except in a very few occupational situations. It is also well established that electric fields induce alternating electric charges on the body surface, which can cause the vibration of hairs on the body. The threshold for perception of hair vibration in humans shows wide individual variation, and occurs in ten percent of adults exposed to a 50 Hz field at about 12 kV m-I, and in five percent exposed at about 3 kV m-', a level that can be found under overhead power lines. This effect is not considered hazardous but may become stressful if exposure is prolonged. The threshold for annoyance for most people is reported to be between 15 and 20 kV/ m.There is very little information on the effects of exposure to intense fields, although headaches and alterations in the visual evoked potential response have been reported in volunteers with acute exposure to magnetic fields above 60 mT.
It is clear that weak magnetic fields have no effects on the ear-

ly stages of the signaling pathways, although fields above 100-200 µT may lead to activation of certain enzyme systems and increased production of specific messenger molecules including calcium ions. Other studies have followed the signaling pathways to the nucleus and examined the expression of genes associated with cancer. There is little question that weak and even moderate strength fields have no effect, but very intense fields (at about 20 mT) may enhance gene expression.

However even these changes tend to be very small compared to those produced by other agents, like growth factors. Further studies have measured the rates of proliferate in cultures of field-exposed cells. No sustained proliferative responses have been seen even Using very intense fields (20 mT). This tends to suggest that the small field-dependent changes seen in some of the earlier events of the signaling pathway are not of biological significance, and they may simply reflect some transient, non-specific stress response.

HEALTH EFFECTS

Human studies have consistently shown that there is no evidence that prolonged exposure to weak electric fields results in adverse health effects. However chronic exposure to weak magnetic fields is equally harmless remains an open question.

RESIDENTIAL EXPOSURES

Exposure levels around the homes are in the range of0.01-0.25 µT (microtesla = 0.1 - 2.5 mG). For homes near power lines, these levels may be as high as 0.5 – 1 µT (5-10mG) Immediately under the power line, magnetic field levels of 6 - 10 µT (60 - 100 mG) may be found.

Some individuals can perceive an external 60 Hz field of 2.5 kV/m and exposure of human volunteers to a 9 kV/m field, simultaneously with exposure to a 20 µT magnetic field (at 60 Hz), resulted in significant slowing of heart rate and some changes in mental alertness, reaction time, and brain physiology.

When σ = 1 S/m, a 10 mV/m field corresponds to a current density of 10 mA/m^2 which is about the lowest value which has been shown to affect the firing pattern of an Aplysia pacemaker neuron and current densities of about 1 mA/m^2 external to nerve cells accompany the normal activity of the human brain. But the external field of the order of 10 kV/m necessary to produce a 10 mA/m^2 current density inside the body is probably high compared with the levels normally encountered in electric engineering laboratories, except near setups for high voltage experiments.

Since the magnetic permeability of mammalian tissue is virtually the same as that of free space, magnetic fields are not attenuated by the body (most organic substances are diamagnetic, though some iron-containing molecules, such as hemoglobin, are slightly paramagnetic). It can also be shown that the distortion of the applied magnetic field by “eddy currents,” induced in the tissue, is negligible at ELF.The fact that results for leukemia based on proximity of homes to power lines are relatively consistent led the U.S. National Academy of Sciences Committee to conclude that children living near power lines appear to be at increased risk of leukemia (NAS 1996). Because of small numbers, confidence intervals in the individual studies are wide; when taken together, however, the results are consistent, with a pooled relative risk of 1.5 (NAS 1996). In contrast, short-term measurements of magnetic field in some of the studies provided no evidence of an association between exposure to 50/60 Hz fields and the risk of leukemia or any other form of cancer in children. The Committee was not convinced that this increase in risk was explained by exposure to magnetic fields, since there was no apparent association when exposure was estimated from magnetic field meter readings in the homes of both leukemia cases and controls. It was suggested that confounding by some unknown risk factor for childhood leukemia, associated with residence in the vicinity of power lines, might be the explanation, but no likely candidates were postulated.

Small changes in cardiac function occurred in human volunteers exposed to combine 60-Hz electric and magnetic fields (9 kV/m, 20 mT). Resting heart rate was slightly, but significantly, reduced (by 3–5 beats per minute) during or immediately after exposure. This response was absent on exposure to stronger (12 kV/m, 30 mT) or weaker (6 kV/m, 10 mT) fields and reduced if the subject was mentally alert. None of the subjects in these studies was able to detect the presence of the fields, and there were no other consistent results in a wide battery of sensory and perceptual tests.Thresholds lower than 100 mA/m^2 can be derived from studies of visual and mental functions in human volunteers. Changes in response latency for complex reasoning tests have been reported in volunteers subjected to weak power-frequency electric currents passed through electrodes attached to the head and shoulders; current densities were estimated to lie between 10 and 40 mA/m^2 (Stollery 1986, 1987). Finally, many studies have reported that volunteers experienced faint flickering visual sensations, known as magnetic phosphenes, during exposure to ELF magnetic fields above 3–5 mT.These visual effects can also be induced by the direct application of weak electric currents to the head. At 20 Hz, current densities of about 10 mA/m^2 in the retina have been estimated as the threshold for induction of phosphenes, which is above the typical endogenous current densities in electrically excitable tissues. Higher thresholds have been observed for both lower and higher frequencies.

Effects of ELF and VLF magnetic fields
Conclusion

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With the help of computer program, based on the finite element method. The electric field, magnetic field, induced currents and current densities on human body standing beneath a 380 kV, 765kV three phase high voltage overhead transmission line and the most important results are as follows:

- Induced current density values increase along the length of the body.
- Total induced current on the grounded human body is also well below the 1 mA level in all cases study.
- For overhead transmission line the induced current on the human body increases as the horizontal distance between phase lines increased, and the height of the conductor's line over the ground plane decreased. However, if the horizontal distance between phase lines is so large and the height of the conductor's line over the ground plane is so small, then the computed values of induced current might exceed the safe limit.
- For human body the induced current on the human body increases as the body size, the body head size and the waist dimensions of human body increased. However, if the body size is so large, the body head size is so large, the waist diameter and height of grounded body is so large, and then the computed values of induced current might exceed the safe limit. $10 mA/m^2$.

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