INVESTIGATION OF THERMAL EFFECTS OF MOBILE PHONE TO THE HUMAN HEAD

V. Pitkevicius, D. Kybartas, L. Svilainis, A. Lukosevicius, V. Dumbrava

Signal processing department, Kaunas University of Technology,
Studentu str. 50, LT-51368 Kaunas, Lithuania
T. +370 37 300532; F. +370 37 753998;
E. darius.kybartas@ktu.lt / linas.svilainis@ktu.lt / arunas.lukosevicius@ktu.lt / vytautas.dumbrava@ktu.lt

Abstract

An influence of electromagnetic waves radiated by mobile phones to the temperature of the human head is discussed in this paper. Several phones and thermovision camera was used in experiments and it was found a 1-2°C increase of temperature in zones where mobile phone was applied. Thermal images showed also a significant increase of temperature of mobile phone. An additional antenna and generator was used in order to separate thermal effects of the absorption of microwaves and heat radiation by case of mobile phone. Experiment was carried out with antenna on ex-vivo beef tissue sample. No thermal effect was observed. It can be concluded, that main thermal effect occurs due thermal radiation of mobile phone battery and transmitter.

1. INTRODUCTION

Influence of electromagnetic (EM) waves radiated by mobile phones to the human health and physical processes is a popular object for investigations. Microwaves are penetrating into human tissue and significant attenuation occurs due EM wave loses in water which is main component of tissues. So energy of microwaves is converted to thermal energy. This thermal effect of microwaves to the biological tissues is well known and it is widely used, e.g. in food industry for heating or cooking [1].

There is a hypothesis that use of mobile phone can heat up soft tissues of head and such influence can cause some diseases or irreversible changes in brain [2]. On of the most evident factors of influence is thermal photography. Many investigators observed increase of temperature of skin on human face after long use of mobile phone [3],[4]. On the other hand, critics of this approach noted that the same thermal effect can occur with not-radiating mobile phone.

Absorption of EM waves in body depends on electric field strength and distribution in volume. It also depends on electric properties of body. Specific absorption rate (SAR) is a parameter which represents absorption of EM power in tissue. It is expressed as

$$SAR = \int \frac{\sigma(r)|E(r)|^2}{\rho(r)} dr , \qquad (1)$$

where $E(r)$ is distribution of electric field (V/m), $\sigma(r)$ is distribution of electric conductivity (S/m) and $\rho(r)$ is distribution of tissue density (kg/m^3). Usually SAR is represented by power of energy absorbed in 10 g of body mass and it is marked as SAR_{10g} (W/10g).

Temperature of absorbing body depends on SAR. Goal of presented work was to investigate temperature distribution on human face and head after use of mobile phone.

2. EXPERIMENTAL SETUP AND METHODOLOGY

Thermoimaging is an effective tool for investigation of human skin and blood vessels. It can be used, e.g., in mammography [5].

In this work thermovision method is used for evaluation of temperature distribution on human face. A 160x120 pixels thermovision camera Micron MicroShot-B was used to take and analyze pictures.

Three persons participated in experiments with two different mobile phones used. The phones with different SAR was Nokia 2100 (0,55 W/kg) and LG GT540 (1,3 W/kg).

Electromagnetic field strength was monitored using Chauvin Arnoux C.A 43 field meter.

Test period of 15 minutes was selected for experiments because such duration is typical for long conversation. Two different tests was performed. The first test was with non-radiating phone attached to the head for 15 min. The second experiment was with mobile phone in call and conversation mode. Thermoimages was taken before and after experiments.

In order to examinate thermal effect of GSM band microwaves, an experiment with *ex-vivo* beef tissue was performed. EM waves radiated from mobile phone and Agilent 8648C RF generator with external antenna was used.

3. RESULTS

Mobile phone radiates EM field in pulsed mode. Level of output power varies depending on distance to base station and received signal strength. Therefore maximal and mean electric field values were measured during experiments (see Table 1). It can be seen that maximal level of EM field in the beginning of call can be more than 10 times higher comparing to level at the steady period of outgoing call.

Table 1. EM field values during experiments

Call mode	Nokia 2100		LG GT540	
	E_{mean}, V/m	E_{max}, V/m	E_{mean}, V/m	E_{max}, V/m
Incomming	7,8	-	27,4	-
Outgoing (start)	10,4	39,2	20,9	> 200
Outgoing	7,4	-	11,9	-

Series of experiments with three different persons showed that increase of face temperature is 0,9 - 1,2°C when non-radiating phone is attached for 15 min. Use of mobile phone in call and conversation mode increases face temperature by 1,2 - 2,3°C. The most affected area is ear and cheek (Fig.1). This area is a contact zone of mobile phone and face skin. No correlation was found between EM field strength (SAR) and temperature increase comparing results obtained with different persons and different phones.

Temperature of mobile phones before experiment was equal to room temperature (24°C). Thermal images of mobile phone case were taken immediately after experiment. Increase of temperature up to 34,5°C was found in battery location place (Fig. 2).

A consequent hypothesis was that main thermal effect on human face is due the heat of battery and transmitter circuits. Therefore additional experiments were performed on beef tissue.

Mobile phones in call mode were placed on tissue for 15 min. Frequency of operation was controlled using frequency counter and it was in 900 MHz band.

Thermal images of tissue sample showed increase of temperature 5-6°C depending on phone used (Fig.3- A).

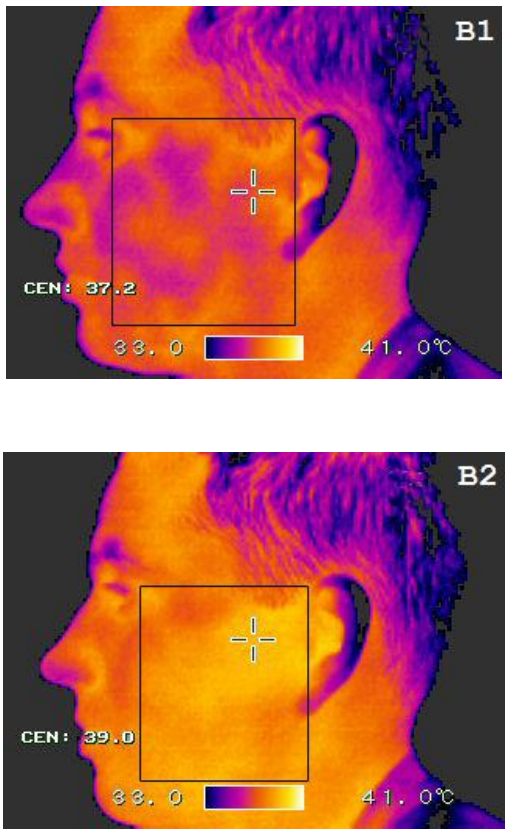

Figure 1. Thermal images of human face before (B1) and after 15 min of conversation (B2) using mobile phone Nokia 2100

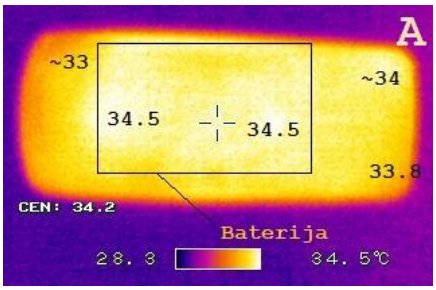

Figure 2. Thermal image of mobile phone Nokia 2100 after 15 min of call

Separation of thermal transfer effect from case of mobile phone to tissue and microwave heating effect was performed using external RF generator. A broadband antenna was used to investigate EM field absorption thermal effect. Antenna was placed on the tissue sample. RF power at 900 MHz was adjusted in order to correspond mean value of electric field (15,6 V/m) during mobile phone call. Time of this experiment was selected twice longer (30 min).

After 30 min of transmitting no thermal effect occurs in beef sample (see Fig. 3 B).

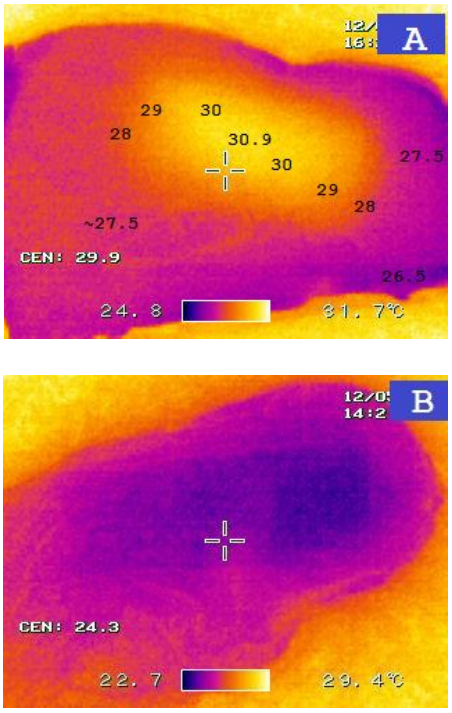

Figure 3. Thermal image of beef tissue after 15 min of exposure using mobile phone Nokia 2100 (A) and 30 min exposure using antenna and RF generator (B)

4. CONCLUSIONS

It can be concluded, that radio waves radiated by mobile phone are not able to heat up tissues. Transmitted power is too low to cause discernible thermal effect.

Effect of increase of face temperature by 1°C is related to disbalance of heat convection near skin when mobile phone case is attached to it.

The main increase of temperature on face and *ex-vivo* tissue sample is related to heat transfer from battery of mobile phone to the tissue. So it can be concluded that main source of thermal effects observed during mobile phone conversation is electronic circuits and battery of device.

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