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WIRELESS IRON USING INDUCTION

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Abstract

Wireless Systems have become popular due to its benefits such as cleanliness and most importantly, safety. Induction heating is also an advance procedure having pros over traditional heating ways such as efficiency, safety, cleanliness and performance. Combining these two superior systems, a new heating technique has been implemented. This paper proposes a safe and clean wireless ironing system using electromagnetic induction. It is based on the principle of induction heating. This paper aims to take the process of ironing fabric to next level, where user safety and user friendly interface for the operator is prioritize. The block diagram of the system is developed. In this paper we propose an iron where the power supply is connected to the ironing board, thus reducing the chance of electric injuries to the operator. Induction heating can become popular in ironing fabric processes due to its benefits. The heat is generated in the element which is to be heated. Through this paper we propose to elevate the standard conduct of ironing cloths.

Index Terms: *Induction heating,Eddy current,Skin effect,Joules Law.*

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1. INTRODUCTION

Ironing fabric is the process in which we remove wrinkles in fabric through heat. Back in old days, ironing was performed using heavy charcoal iron press which was very difficult to operate due to smoke, its size, lack of control over heat and due to disposal of ash. As technology grew, we shifted over electric irons which were using electricity for heating the iron. Theseirons have a heating coil which produces heat energy when electric current flows through it. They were based on Joules heating principle. With advancement in technology, various features were added to the iron. For different type of fabric different temperature setting were provided. With time more user friendly irons were invented using advanced techniques to facilitate the process of ironing fabric.

This paper is an attempt for another such advancement to bring revolution in the process of ironing fabric.News of injuries due to electric shock while ironing are encountered very often. As the heat in iron is directly proportional to the square of current through the coil so a very high current flows through the iron.

This paper aims to take the process of ironing to a next level using Induction heating. We create a wireless iron in which the supply would be given to the ironing board. The root principle behind this project is principle of induction heating and eddy current.

In this paper we have spotted light over the concept of induction heating. Also the effect of frequency and the importance of proper frequency selection is discussed. In section of system architecture a detailed description is given over every important component of proposed wireless iron. A separate section is allotted to describe the working of wireless iron.

2. INDUCTION HEATING

Induction heating is widely used heating technique for industrial as well as domestic applications. It is combination of electromagnetic induction, skin effect and principle of heat transfer. All induction heating applied systems are developed using electromagnetic induction, first discovered by Michal Faraday in 1831. Induction heating refers to the generation of heat energy by the current and eddy current created on the surface of a conductive object(according to Faraday's Law and the skin effect), when it is placed in the magnetic field, formed around a coil, when the AC current flows through (Ampere's Law) the coil.

Induction heating is comprised of three basic factors: electromagnetic induction, the skin effect, and heat transfer. The fundamental theory of Induction Heating,

however, is similar to that of a transformer(**Fig-1**), where the primary is the working coil and the secondary is the heating element. The primary current flows through the working coil and the secondary current is in the form of eddy current on the surface of the heating element. The heat produced in the heating element is directly proportional to the square of the eddy current generated in it. The relation of skin effect and eddy current are discussed below.[1][3]

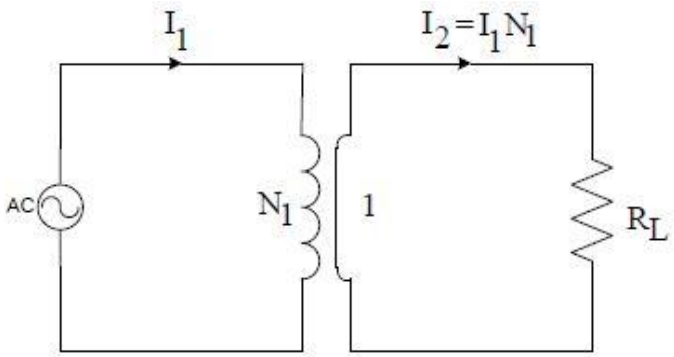

Fig-1: Equivalent circuit of transformer where secondary is short circuited

- Skin Effect:-When a sinusoidal current flowing through a conductor and creates a sinusoidal magnetic flux within the conductor which is perpendicular to conductor axis. This magnetic flux produces eddy current this is how skin effect occurs. Eddy current flows in the direction opposite to that of the main current flowing through the conductor. Skin depth is normally expressed as

$$\delta = \sqrt{\frac{\rho}{\pi \mu f}} \qquad (1)$$

Where, δ = skin depth (m)
μ = magnetic permeability
f = frequency (Hz)
ρ = electrical resistivity of material (Ωm)

- Eddy current:-Metal contains large number of free electrons which are free to move, the moment it is exposed to varying magnetic field all the electrons gets into an organized motion termed as eddy current. This current generates heat in iron. The relation describing the power due to eddy current is described below.

$$Pe = f^2 Bm^2 \qquad (2)$$

Pe= Power produced by eddy current(W)
f= frequency of the alternating magnetic field(Hz).
Bm= Magnetic field density (Wb/m^2)

Induction heating is popular as it is efficient, fast and easily controllable heating technique. As the frequency of magnetic field plays a very important role proper frequency selection is very important.[1][4]

3.FREQUENCY SELECTION

The operating current frequency is an important factor to consider in order to produce heat energy more efficiently. This can be easily concluded from equation (2).In which the power is directly proportional to the square of the frequency of the varying magnetic field. The acoustic noise generated in the power supply and the heating element i.e. iron in our case at fundamental and second harmonics determines the lower limit of frequency. Thus the lower limit is set at 20 kHz. The upper limit of frequency depends on the practical limitations of the power semiconductor switching device used. Also the efficiency and the stability decreases with higher frequency, so the upper limit is kept around 50 kHz.[1]

4. SYSTEM ARCHITECTURE

The proposed system comprises of various components like ironing board, iron, working coil and frequency changing unit. Every section has its role in proper working of the device. Each of these components are described in this section.

4.1. IRONING BOARD

The dictionary describes the ironing board as a flat, cloth-covered board, often foldable and have in legs,on which clothing, linens, or similar articles are iron ed. The general dimensions of ironing board is considered, 90-100 cm in length, 25-30 cm in width and 67-90 cm high as shown in **Fig- 2.**
The modifications done in a regular ironing board are stated below:-

- The solid base is made up of insulating substance like plywood, hard plastic etc.
- The solid flat base of ironing board is having holes (apertures) throughout its surface. This holes will help to liberate excess heat produced in working coil.
- The working coil (induction coil) is spread over the ironing board as shown in **Fig-2** so as to create a uniformly spread varying magnetic field over the ironing board. The detail about the coil is mentioned in upcoming section.
- A layer of insulator is spread over the coil. To prevent the user from electric shock and the clothes from getting burnt in case of any fault.
- A layer of cotton fabric is spread over the insulator to provide a gentle surface for ironing fabric.

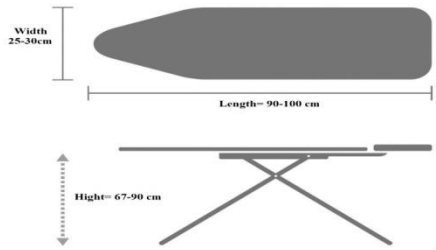

Fig-2: Ironing Board

4.2. IRON

The physical dimensions of iron are same as that of traditional iron. The major difference is that it has no electrical circuit and it does not have any kind of heating element as present in traditional iron. The base of iron should be made up of magnetic material like stainless steel.

The eddy current is produced in the lower surface of the iron and its depth is given by equation (1). This width is very small thus the material required for this iron is less as compared to traditional iron, and the weight of the iron is reduced thus facilitate in ironing the fabric.

4.3. WORKING COIL

The working coil is made up of stranded copper wire. It is spreads over the induction board in form of a pancake coil but with larger difference between two consecutive turns. The coil is placed in a way so as to obtain a uniformly spread magnetic field over the ironing board. As the coil is made up of copper which offers least resistance, the heat produced by the coil is less.

4.4. FREQUENCY CHANGING UNIT

The operating frequency of wireless iron is much more than the frequency of the domestic power supply. So, we cannot directly connect the working coil to regular power supply. We need to convert the frequency of the domestic power from 50Hz to20-50kHz, as discussed in above section. This is achieved using power semiconductor switching devices. The structure of the circuit is as shown in the **Fig-3**.

In order to increase frequency of the supply from 50Hz to 20-50kHz we initially convert the alternating current to direct current. This is done through the rectifier circuit. The rectifier is followed by inverter circuit. In inverter circuit the dc is again converted back to ac of

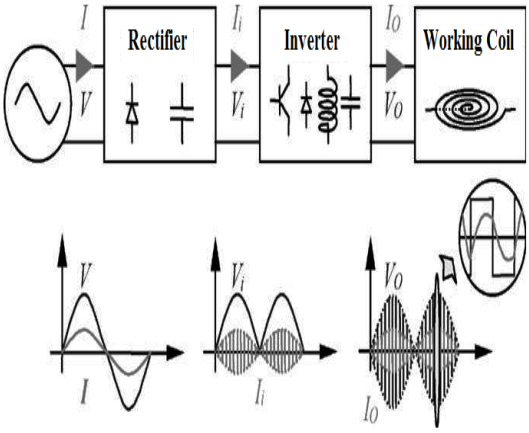

Fig-3: Structural diagram of frequency changing unit

the desired frequency. This is done using power semiconductors switching devices, operated through proper gate pulse. To obtain frequency as high as 50kHz, high speed switching devices such as IGBT and MOS-FET must be used. The produced high frequency current is fed to working coil, which produces required high frequency alternating magnetic field.[2]

5. WORKING

The wireless iron proposed is based on induction heating principle. The block Diagram is as shown in the **Fig-4**.The main components of the wireless iron are the frequency changing unit, ironing board with working coil and the iron without any electrical circuit.

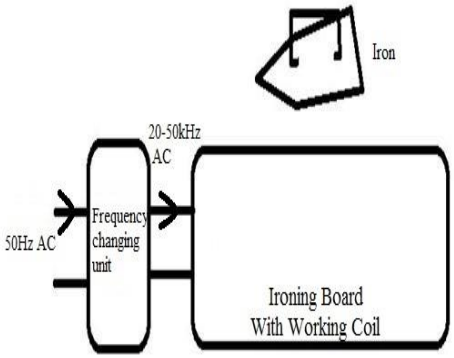

Fig-4: Block diagram of wireless iron.

The frequency changing unit is connected to regular domestic supply of 50Hz, it gives the output at a very high frequency between 20kHz to 50kHz. This high frequency ac current is fed to the working coil. This working coil is placed over the ironing board, there by producing a high frequency magnetic field over the surface of the ironing board.

The iron which is made up of magnetic material, does not have any heating coil in it. While ironing a fabric the iron base is magnetically coupled with the working coil. Due to the magnetic field eddy current is produced in lower surface of the iron, the depth of this layer is given by equation (1). The metal offers resistance to the eddy current and thus heat is produced by Joules law. The power produced by the eddy current is given by equation (2). As the ironing board has magnetic field all over it, the iron is magnetically coupled with power source. Thus the fabric is ironed.

5. FUTURE PROSPECTS

For further improving the fabric ironing process we can add various features as discussed:

- Steamer can be provided in the iron, which gives better result on some fabric.
- We can regulate the heat produced in the iron. By varying the gate pulse to the switching device we can regulate the frequency and thus the control over the heat is obtained.

This would help the user to iron the fabric according to the need of fabric .Thus improving overall usability of the product.

6. CONCLUSION

Thus we can conclude that the process of ironing the fabric can be taken to a next level using induction heating principle, where the user safety and user friendly interface helps to ease the process of ironing fabric.

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