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Conduction Heat Study of Different Coil Design of Electric Iron

Nurshaira Binti Mat Nasir[1,a], Ahmad Faiz Zubair[1,*], Ana Syahidah Mohd Rodzi[1,c], Rizal Mohamed Noor[1,d], Abdul Rahman Hemdi[1,e] and Pramodkumar Kataraki[2,f]

[1]Intelligent and Smart Manufacturing Centre, Center for Mechanical Engineering Studies, Universiti Teknologi MARA, Penang Branch, Malaysia.
[2]School of Mechanical Engineering, REVA University, Bangalore 560064, India.
Email: [a]shairansr@gmail.com / [*]ahmadfaiz@uitm.edu.my / [c]anasyahidah@uitm.edu.my / [d]reezal@uitm.edu.my / [e]abdulrahman643@uitm.edu.my / [f] pramodkumar.sk@reva.edu.in

Abstract

Electric iron pulls energy from the mains supply and heats a coil within then the heat is transferred to the bottom plate through conduction process which is placed against the wrinkled garment. The problem of existing dry iron is the heating element continues to get hotter until the power source is continuously drawn from electricity, do not heat up sufficiently, needed a continual charge from its platform every few minutes for prolonged use, cannot be heat up rapidly and fast aging problem. Hence, it is necessary to run the finite element analysis on electric iron part model. The simulation focusses on thermal analysis as it can ease the study related to the heat path and thermal design of simulated product that can be used to improve the efficiency of existing product. The 3D part models of electric iron and five different type of heating coil were designed. Rheological data and important properties of the electric irons were imported as a parameter database in the software to create the meshing on the model. The input parameters are heat power, heat flux and convection while the variable for the simulation process are design of heating coil, power supply, thickness of heating coil and material of soleplate. Based on the simulated part model, the features recommended is design coil 4 with power supply 1900W, coil thickness 0.0015m and ceramic soleplate as these variables has highest temperature and shortest steady state time.

1.0 Introduction

In this research work, finite element analysis on the iron part model have been done to overcome the problems of electric iron improvement so that the soleplate can be heated up quickly and wrinkles can be removed rapidly. electrical iron, heat power is necessary to break the links between long chain polymer molecules of the material fibers to remove the wrinkles from the fabric [1].

A common problem with existing electrical irons is the heating element continues to get more heated so far as electricity is continuously drawn from the power supply. This leads to plenty of energy waste, cloth deterioration and a disgusting mishap in the worst scene.

In addition, one of the most prevalent problems with dry irons is that they do not heat up sufficiently and for continued use, it required a constant charge every few minutes from its platform [2]. Iron soleplate also cannot be heated up rapidly. This situation causes the users take a long time to iron clothes and continue their ironing work. Next, an iron with thin soleplate will quickly breakdown [2]. This situation occurs because thin soleplate unable to accommodate large amounts of energy transfer.

*Corresponding Author

2.0 Background of Study

Conduction heat study of electric iron part model is investigated by finite element analysis [3]. Previous studies on FEA for home appliances had been done in [4]-[13].

The description of the electrical iron part is summarized in Table 2. The heating coil design is derived from [14][15][16]. Five types of coils are available that are flat and tube-shaped. These forms have their own strength and disadvantage affecting the efficiency and performance of electric iron [12].

Table 1: Part of electric iron

Part	Description
Soleplate	A metal plate that forms the electric iron base,
Pressure plate	Heat storage and heat, covering the heating element and to achieve a tight fit between the heating element and the sole plate
Handle	Insulation against heat and electricity.
Heating element	Transforms electrical energy into heat using the resistive method
Thermostat	Tracks the temperature invisibly and, with the help of other electric components, can turn the power on and off.

3.0 Heating Coil Design

Table 2 shows the 5 types of cooling coil design available in the market.

Table 3 shows the parameters assigned in the simulation and Table 4 shows the material and thermal conductivity.

Meshing parameter with maximum element size: 0.0373m, minimum element size: 0.0075m, min number of element in circle: 8 and element size growth ratio: 1.4.

Steel and alumina ceramic are the materials chosen for plates in this study.

Transient temperature for part model of heating coil 1 t 60 seconds. This situation can be said as the temperature obtained by electric iron part model at that time. The maximum temperature is -42.5392°C while the minimum is: -272.8987°C. The temperature will be increase with times and remain stable at steady state condition.

Table 2: Heating Coil Design

	Coil
1	
2	
3	
4	
5	

Table 3: Parameter assigned in the simulation

Parameters	Value
Heat power	1400W, 1700W and 1900W [17]
Heat flux Convection	10-500W/m^{2}K
Thermal conductivity of copper	390 W/(m·K).
Heat transfer coefficient, h	10 to 500 W/(m2·K)
The initial temperature	273.15K
Thicknesses of coils	0.0015m, 0.007m and 0.009m

4.0 Results

Four variables; the heating coil design, power supply, thickness of heating coil and material of soleplate has been analysed numerically. The results are presented in Figure 1 for the different of the 5 designs in the temperature versus time. Figure 2 shows the temperature against the power supply, Figure 3 shows the effect of thickness in time, while Figure 4 shows the effect in different material being used. To study these parameters in longer period, Figures 5 to 8 show the effect in 10 minutes period of time.

Table 4: Material and thermal conductivity for electric iron model

Part	Material	Thermal conductivity
Soleplate	Stainless steel	50 W/m·K
Handle	ABS	0.2256 W/m·K
Pressure plate	Cast iron	45 W/m·K
Heating coil	Copper	390 m·K

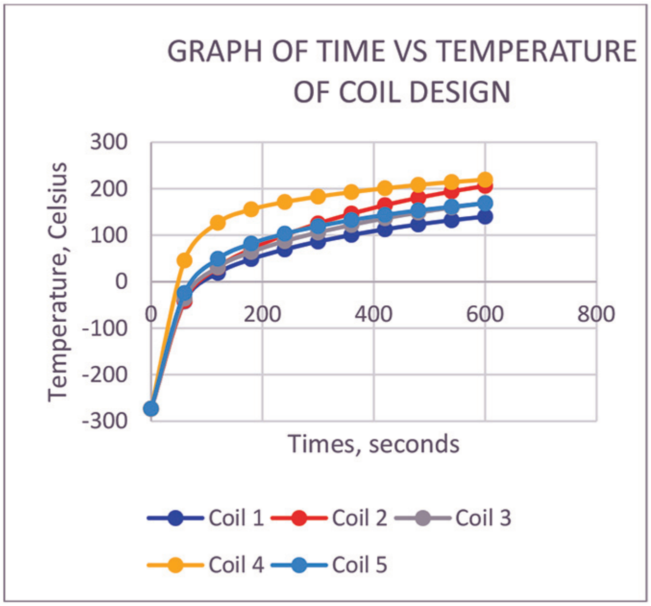

Figure 1: The graph of times against temperature for five designs of coil

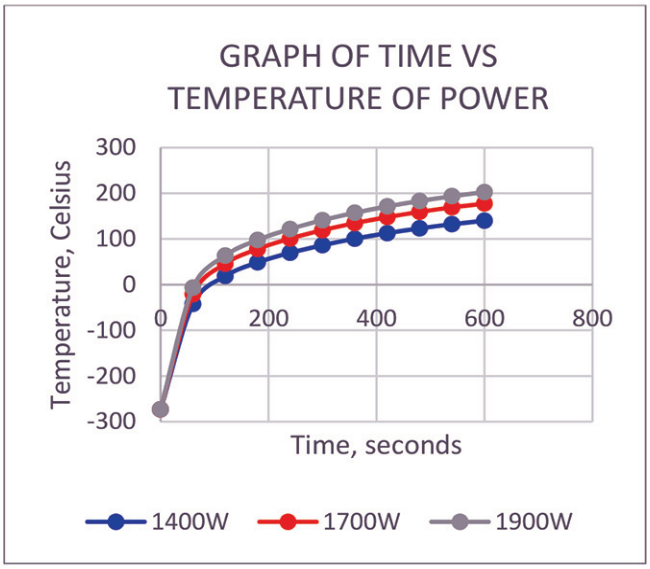

Figure 2: The graph of times against temperature for power supply

Thickness of heating coil

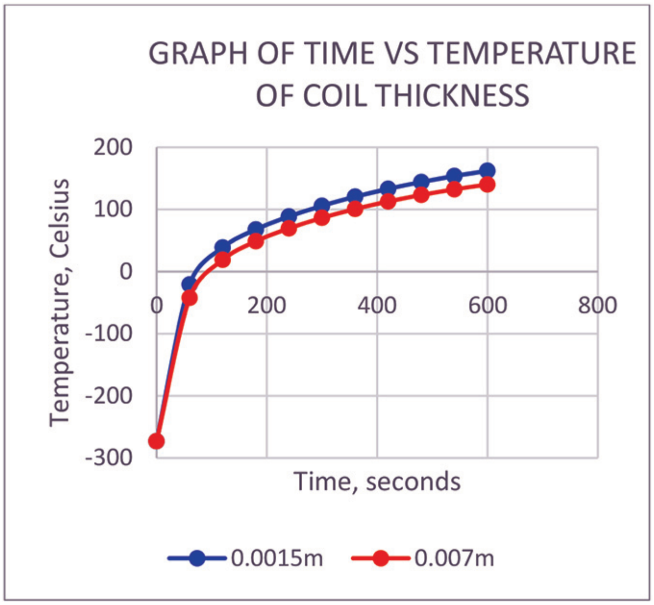

Figure 3: The graph of times against temperature for thickness of heating coil

Material of soleplate

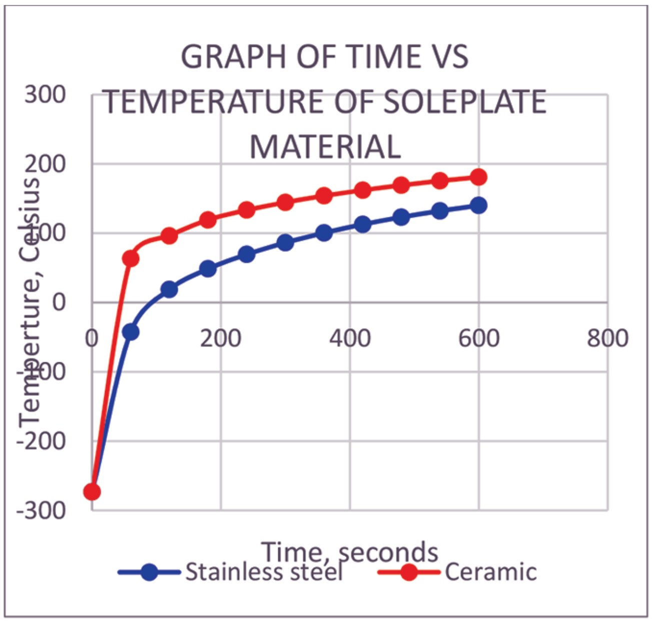

Figure 4: The graph of times against temperature for material of soleplate

Steady state time for heating coil

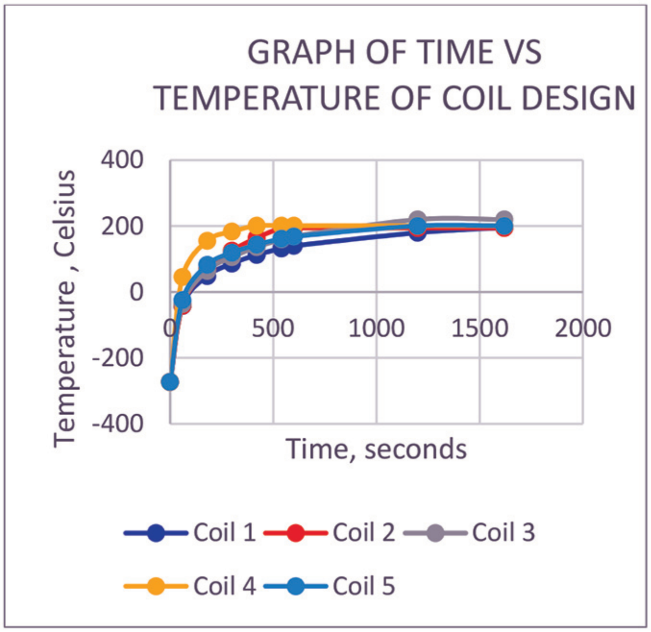

Figure 5: The graph of times against temperature for design of coil

Steady state time for power supply

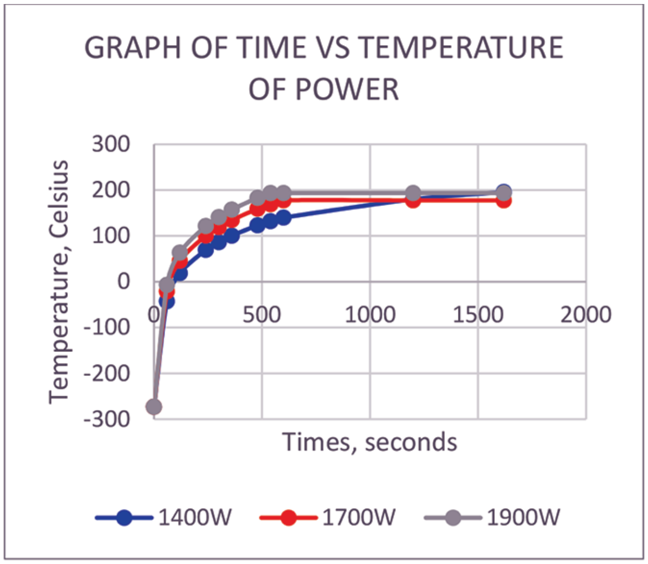

Figure 6: The graph of times against temperature for power supply

Steady state time for coil thickness

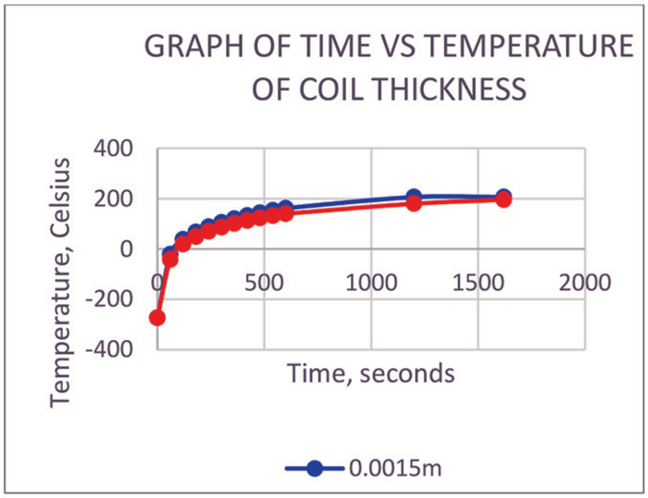

Figure 7: The graph of times against temperature for thickness of coil

Steady state time for soleplate material

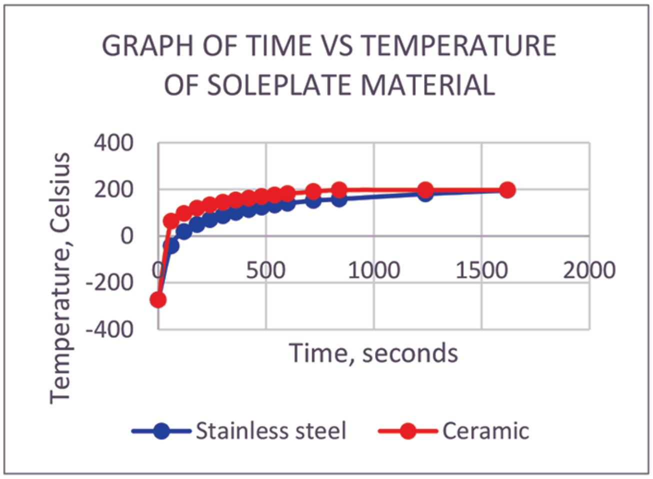

Figure 8: The graph of times against temperature for material of soleplate

5.0 Summary of The Results

From the simulation, the best element for each variable has been determined to improve the heating performance and efficiency of an electric iron product. The best features on every variable have been discussed and the result has been listed in Table 5.

Table 5: The best element for each variable

Variables	Element
Coil Design	Coil 4
Power Supply	1900W
Thickness of Coil	0.0015m
Material of Soleplate	Alumina ceramic

6.0 Conclusion

An electric iron part model with 0.108m width, 0.113m depth and 0.242m length was successfully designed by using finite element software in Solidworks. It used the thermal simulations to identify the temperature and steady state time of part model. The simulations were set up for four variables: design of coils, power supply, coil thickness and soleplate materials. The best condition and features of these variables were determined.

Based on the finding, the finite element modeling had the ability in predicting the thermal distribution on the electric iron part model by the various variables. The results from the simulation demonstrate that a tubular shape of coil is better than flat shape as it keeps and transfer more heat to the system especially to soleplate. This situation contributes to the higher temperature obtained.

Besides, the power supply of system is directly proportional to the temperature of part model. If the power increases, the temperature was also increased. Then, thickness of material is inversely proportional with the temperature gained as the thick material will produce low temperature. In addition, soleplate material with larger value of specific heat and lower thermal conductivity develops higher temperature as heat loss through convection at a slightly slower pace so that the material will keep the heat for longer time.

The steady state time was found to be shortest if the temperature obtained is high. It also found that the longer the simulation times, the higher the temperature achieved.

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