Journal of
Polymer & Composites
https://journals.stmjournals.com/jopc
ISSN: 2321-2810 (Online)
ISSN: 2321-8525 (Print)
Volume 14, Special Issue 4, 2026
January–December
DOI (Journal): 10.37591/JoPC
Research JoPC

Comparative Study on Design and Analysis of an Iron-Box Using Different Materials

B. G. Koujalagi[1,*], Nagaraj Kelageri[1], Manju Chikkaldinni[2], Abhishek A. Athanimath[2], Abhishek N. Galagali[2], Neelgagan Bhate[2], Anupama Lad[2]

Abstract

In this study, a steady-state thermal analysis of the soleplate is conducted using four different materials (Aluminium, Stainless Steel, Titanium, and Ceramics) using ANSYS Workbench. Also, it ensures that the design adheres to safety standards and promotes efficient energy usage while examining heat distribution. In electric iron, the soleplate is the crucial part, so an analysis is done on this part. Also, a change in design was made to increase safety. First, model the 3D part of the soleplate, then add the boundary conditions to it such as fixing the temperature, adding convection and insulation, and also the material properties. Modeling is done using CATIA software, and analysis is done using ANSYS software. Perform the analysis using Ansys on various materials and note the results for specific materials. Then compare the results and select the best material. A three-dimensional model of the iron box was developed and analyzed using ANSYS software to investigate the effect of material properties on heat transfer and temperature distribution. Thermal analysis was performed under identical operating conditions to evaluate the temperature behavior of each material. The materials were compared based on thermal conductivity, temperature distribution, heat retention capability, density, strength, and other relevant mechanical properties. This study, in terms of design and analysis, indicates how functionality and safety can be equally emphasized.

Keywords: Aluminum, ceramics, finite element analysis, safety, soleplate, stainless steel, temperature, titanium

INTRODUCTION

Electric irons are common in contemporary homes and help people effectively remove unwanted wrinkles and creases from fabric clothing. The soleplate is the part of the iron box that helps remove wrinkles. The materials considered for the manufacturing of the Soleplate are Aluminum, Stainless Steel, Titanium, and Ceramic. The selection of appropriate material for a soleplate is of substantial importance, given that each available option offers distinct advantages that contribute to the performance, durability, and safety of electric iron. In this context, an informed decision regarding material choice is essential for optimizing user satisfaction and achieving efficiency in the ironing process. In contrast to steam irons, which produce vapor created by water to achieve desired results, electric irons use direct element heating to reach temperatures hot enough to smooth fibers in fabrics. Nice and clean clothing is required to live a normal life. Therefore, the clothes iron was created and evolved from a charcoal iron to an electric iron to meet daily dressing needs. Yet the development is not yet perfect, and electric iron remains weak in terms of safety, price, efficiency, energy consumed, operation,

*Author for Correspondence
B. G. Koujalagi
E-mail: basu6714@gmail.com

[1]Assistant Professor, Department of Mechanical Engineering, KLE Technological University, Dr. M. S. Sheshgiri Campus, Belagavi, Karnataka, India
[2]Student, Department of Mechanical Engineering, KLE Technological University, Dr. M. S. Sheshgiri Campus, Belagavi, Karnataka, India

Received Date: September 02, 2025
Accepted Date: August 06, 2026
Published Date: August 08, 2026

Citation: B. G. Koujalagi, Nagaraj Kelageri, Manju Chikkaldinni, Abhishek A. Athanimath, Abhishek N. Galagali, Neelgagan Bhate, Anupama Lad. Comparative Study on Design and Analysis of an Iron-Box Using Different Materials. Journal of Polymer & Composites. 2026; 14(Special Issue 4): S192–S201p.

and others [1]. Earlier, steam irons were there. But nowadays, people prefer electric iron over steam due to some maintenance problems related to clogging. Since using steam iron, slowly and gradually, the minerals in water start collecting at the vents and block the path for water to pass. Such issues are not present in the case of electric iron. There are no vents inside that consist of a heating element. Having a safety iron is important for users and is responsible for the people around. Children have easily been injured most of the time and need a longer time for recovery. Injuries and clothes burning problems are caused by iron burns due to carelessness of using electrical irons and not keeping them in a safe place. To solve the safety problem, the electrical iron needs to keep on developing and make some improvements. Therefore, electrical iron should be developed with their safety features [2].

Figure 1 shows the working principle of a General Electric iron box. The base of the electric iron box is made up of different materials it is important to select the appropriate material based on its efficiency, cost, and Thermal conductivity [3]. There are various types of Iron designs. They should be designed in such a way that there should be no hand fatigue, which occurs because of the high pressure on clothes, so we should change the material so that it does not require pressure while ironing [4]. Charcoal cloth ironing utilizes the use of domestic coal. The underdeveloped cities suffer from a drawback of limited supply of domestic charcoal needed for heating the iron. Environmental pollution is brought about using charcoal for clothes ironing [5]. Burns from contact children frequently sustain injuries from irons. These injuries happen when children are in upright position and meet an unsupervised iron [6]. We frequently experience the issue of our clothes burning when being ignored. This generally occurs when the iron box is left unattended while taking calls or doing other tasks. Ironing functions by weakening the connection between long chain polymer molecules in the materials fiber [7]. An alternative pressing iron is required in developing nations due to the erratic and epileptic power supply caused by public power supply utilities incapacity to fulfil population demand. The main goal is to become a dependable pressing iron while addressing the drawbacks of other pressing iron varieties now on the market. The goal of the design is to be a dependable pressing iron type while addressing the drawbacks of other pressing iron types already in the market. The energy source used to provide the heat needed press the different materials taken into consideration in this study is butane gas which helps to accomplish goals. This gas is used for cooking and is widely accessible. Aluminum was utilized to construct the pressing irons foundation, whereas inexpensive stainless steel was utilized for the chamber's construction [8]. At some unspecified time during the Middle Ages, it was discovered that if material was damped and then subjected to heat under pressure, the cloth would be wrinkle-free when dry. What they were doing was that the textile filaments turn plastic when wet and can be molded as desired under pressure and hold that shape when dry [9]. A wireless power transfer idea is implemented on a cordless ironing system using induction heating methods to improve the portability of standard electric irons because of the limitation of the cable link. Induction coils are specially designed, and the coil inductances in free space are also computed and compared with experimental data. The finite element method (FEM) analysis is employed to investigate the inductance behavior of the coils under the realistic wireless power transfer challenge where the iron is positioned above the coils at various positions on the ironing board [10]. Engineering demands materials that perform under different factors like mechanical, thermal and environmental conditions. Selecting materials for the application depends on mechanical properties, constraints – such as weight and resistance – to environment conditions. Aluminum, stainless steel, titanium and ceramics are some materials which can perform well under these conditions, and these materials represent a foundation pillar to engineering materials. Lot of research is being carried out to come with different design of iron box, one of them is foldable iron box which is an optimized design which is different from existing iron box in the world. This research focused on iron box base plate focusing on the surface area of base plate, in this work the design was built using software CATIA and focused on industrial design of iron box. The work describes the reduction of weight and ergonomics of iron box and other parameters like cost, CO_2 emission, material, biodegradability, and recyclability [11]. One more study presented the problem overcome by dry iron which draws the electricity continuously and does not heat up sufficiently for which a finite element analysis of iron box is carried out to overcome the heating problem of soleplate for removal of wrinkles rapidly. In this work

Journal of Polymer & Composites
Volume 14, Special Issue 4
ISSN: 2321-2810 (Online) ISSN: 2321-8525 (Print)

a new iron-box design is done using solid works software and simulation was carried out for different variables such as power supply, design of coil, thickness of coil, and material of soleplate [12].

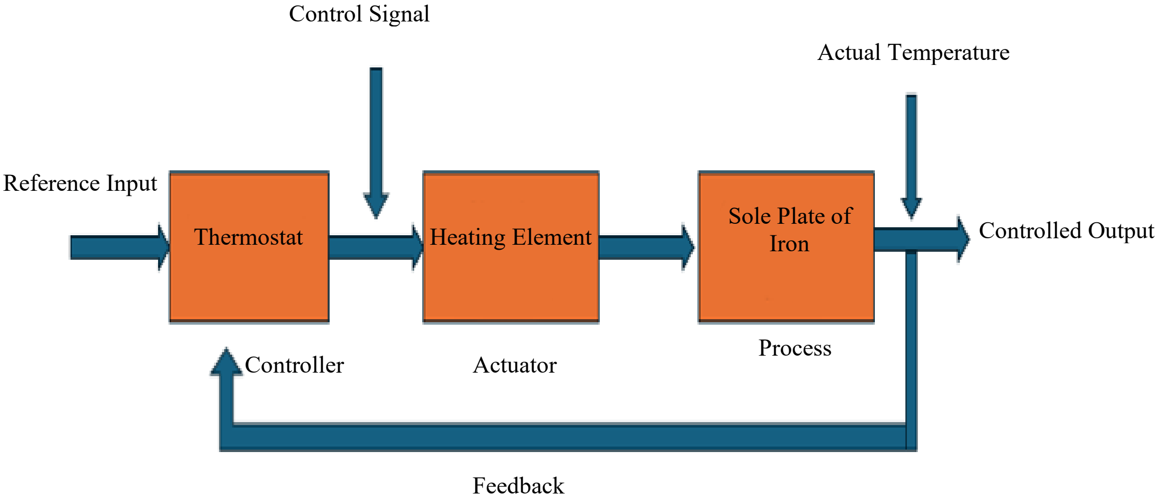

Figure 1. Working principle of the electric iron box.

METHODOLOGY

Modelling

The soleplate is the main component. It consists of the heating element, and other components are connected to the soleplate such as the Pressure plate, Case, and Heel plate. The design parameters are taken from the actual measurement of the soleplate using a vernier caliper, as shown in Figure 2. A 2D sketch was created based on the design guidelines, as seen in Figure 3. After that, modeling of the soleplate took place using CATIA V5 meshing of soleplate which is illustrated in Figures 4 and 5. The soleplate was then meshed, and a thermal analysis under steady-state conditions was carried out using ANSYS R2.

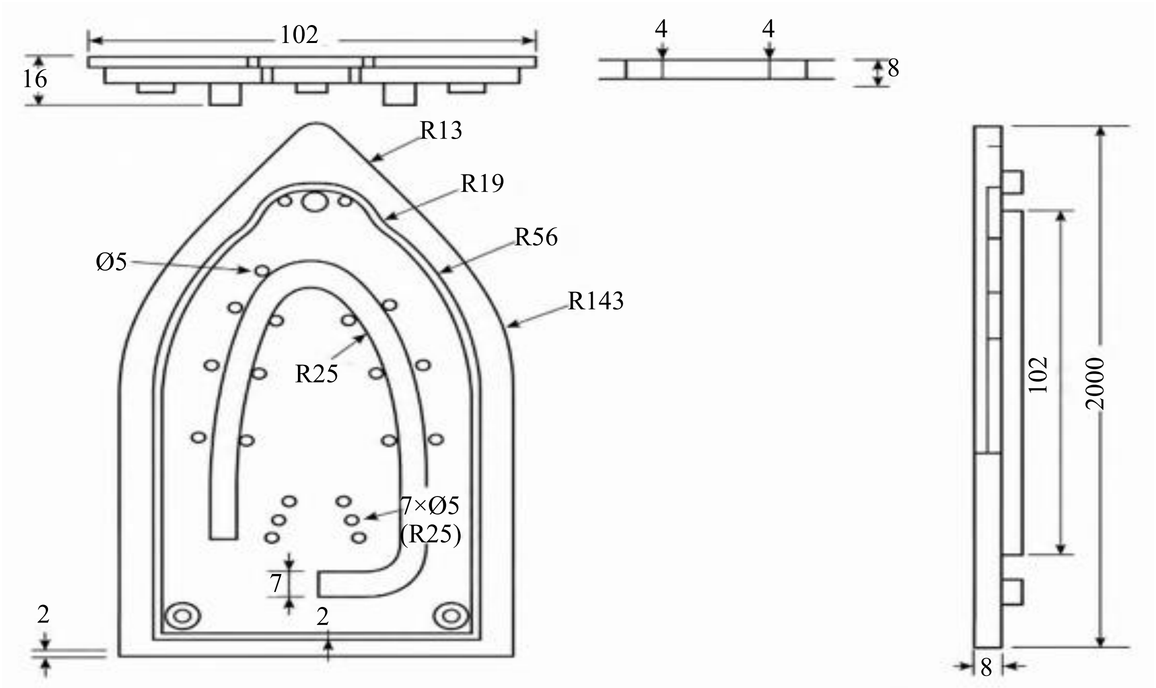

Figure 2. Hand sketch of soleplate.

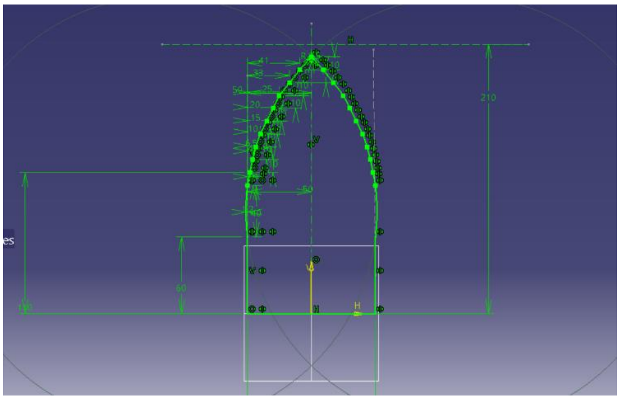

Figure 3. 2D sketch of soleplate.

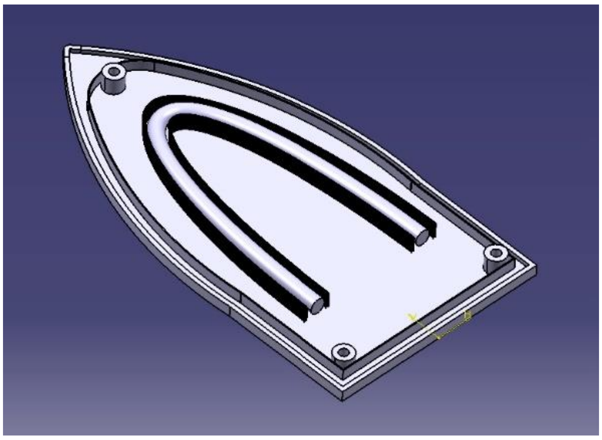

Figure 4. Model of soleplates.

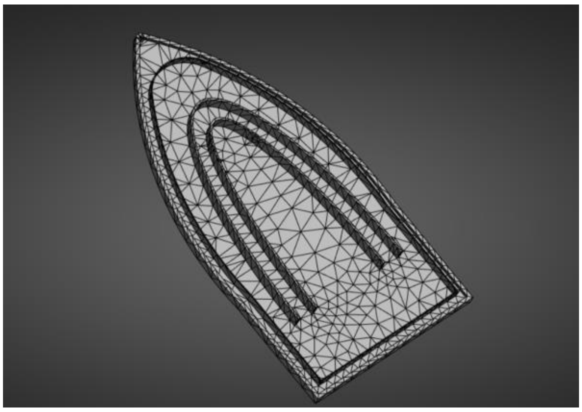

Figure 5. Meshing of the soleplate.

Boundary Conditions

The approach involves three boundary conditions that are considered in this effort.

- *B1. Temperature:* Fix the temperature to the coil of the iron box because, from the coil itself, the heat distributes along the soleplate as shown in Figure 6.
- *B2. Convection:* Convection is nothing but the process of transferring heat through air or fluid in this case the convection is added to the soleplate given that the coefficient film is 17.04 W/m² °C and the ambient temperature is given as 30°C so that the temperature raises from room temperature to its maximum temperature when the heating starts as shown in Figure 7.
- *B3. Insulation:* Perfect insulation is given to the soleplate, so the heat does not dissipate to the atmosphere, as shown in Figure 8.

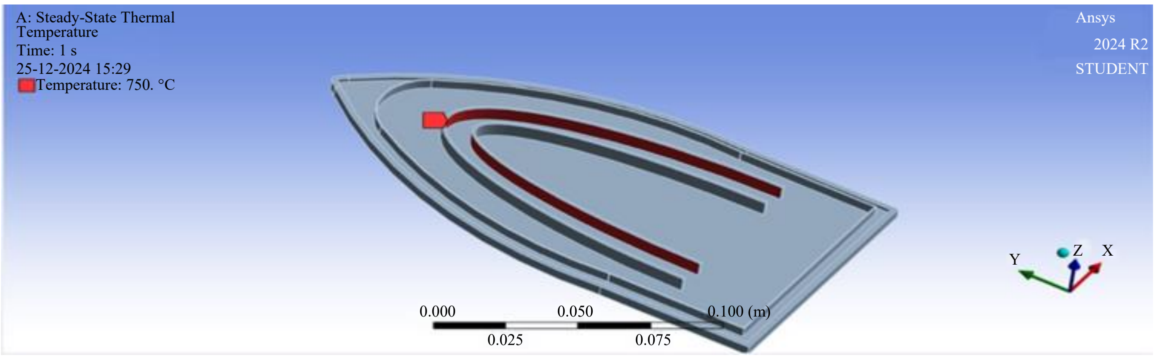

Figure 6. Fix the temperature (A): steady-state thermal

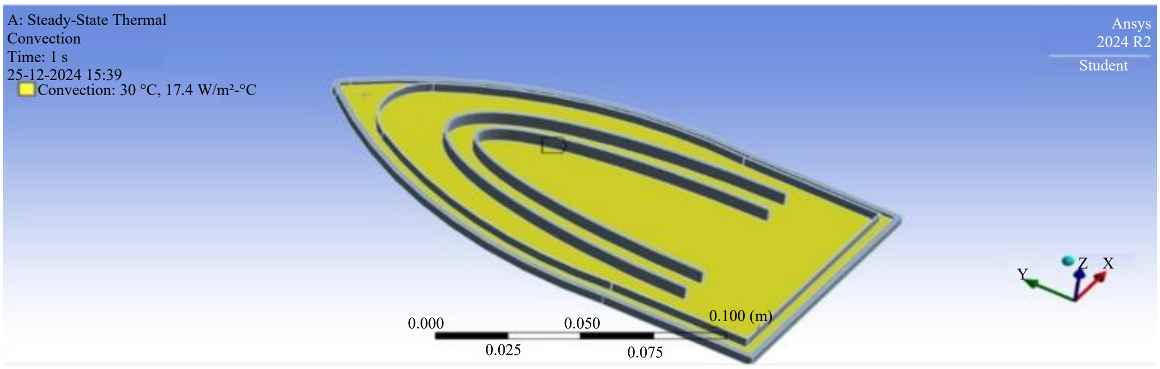

Figure 7. Convection.

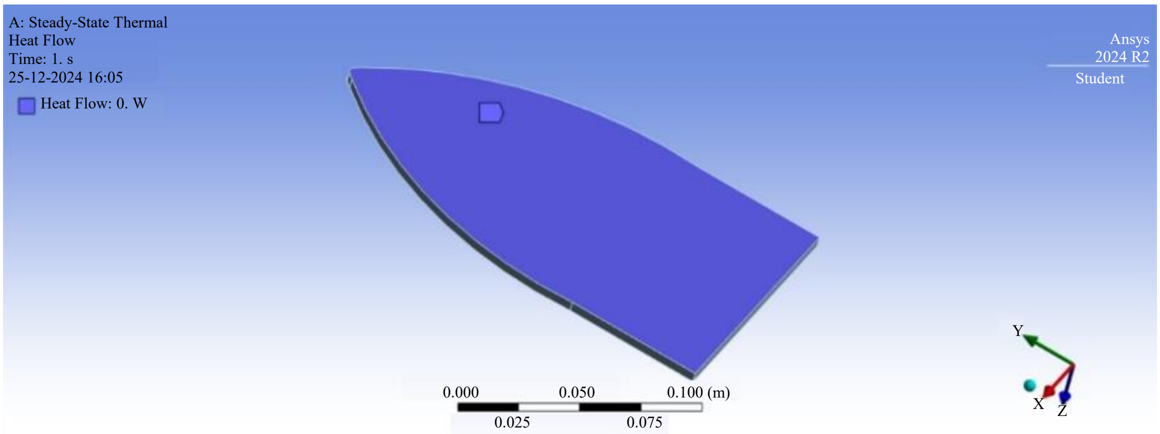

Figure 8. Insulation.

Material Properties

In making soleplates, various materials are used, including aluminum, stainless steel, titanium, and ceramic. The mechanical properties of these chosen materials, which are important for understanding temperature distribution in soleplates, can be seen in Table 1.

Table 1. Mechanical properties of the materials selected for the study of the soleplate.

Materials	Modulus of elasticity (GPa)	Poisson's ratio	Density (Kg/M^3)	Thermal conductivity (W/m K)
Stainless Steel	205	0.30	7800	15 W/m K.
Aluminum	72	0.33	2700	237 W/m K.
Titanium	95	0.36	4480	21.6 W/m K.
Ceramics	415	0.27	1800	1.5–2 W/m K.

RESULTS AND DISCUSSIONS

Analysis of Temperature Distribution in the Soleplate

Analysis of temperature distribution is carried out on the soleplate using different materials such as Aluminum, Stainless Steel, Titanium, and Ceramic. Different materials have different properties, so the temperature variations depend upon the material. The analysis of soleplate using aluminum material is shown in Figure 9. The analysis of soleplate using titanium material is shown in Figure 10. The analysis of Soleplate using stainless steel material is shown in Figure 11. The analysis of Soleplate using ceramic material is shown in Figure 12, respectively.

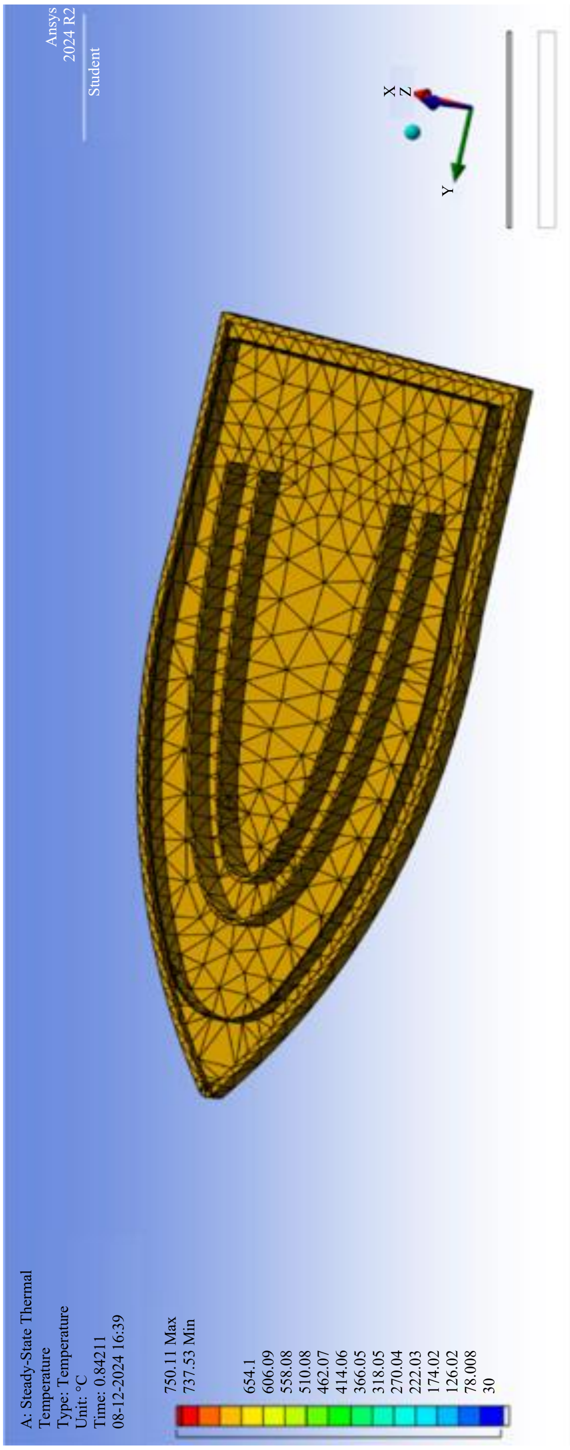

Figure 9. Analysis using aluminum material.

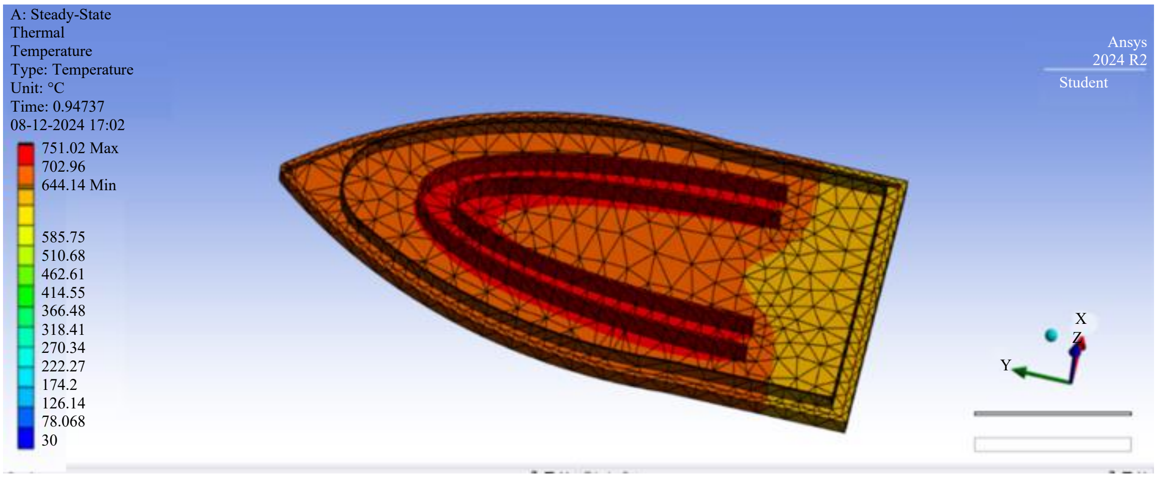

Figure 10. Analysis using titanium material.

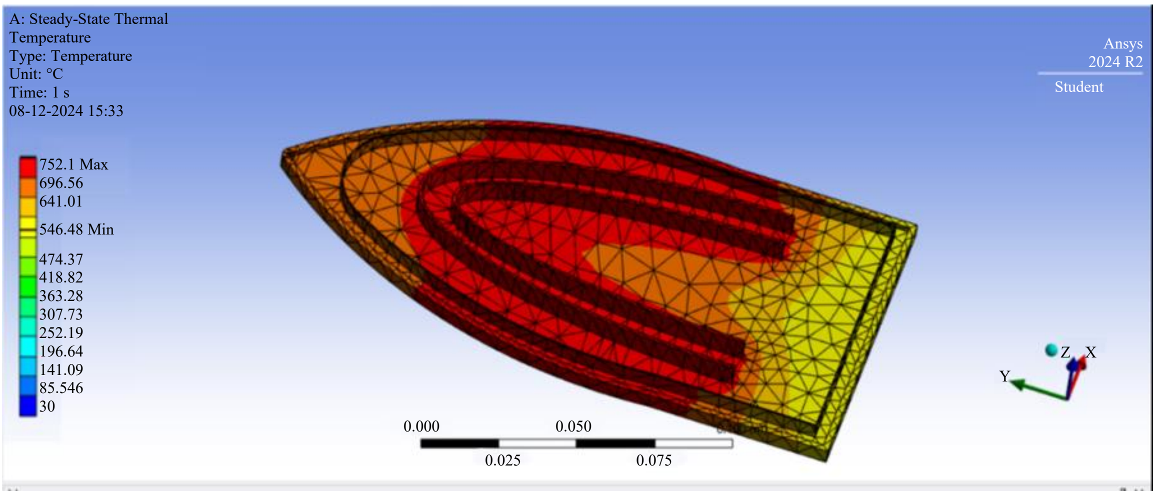

Figure 11. Analysis using stainless steel material.

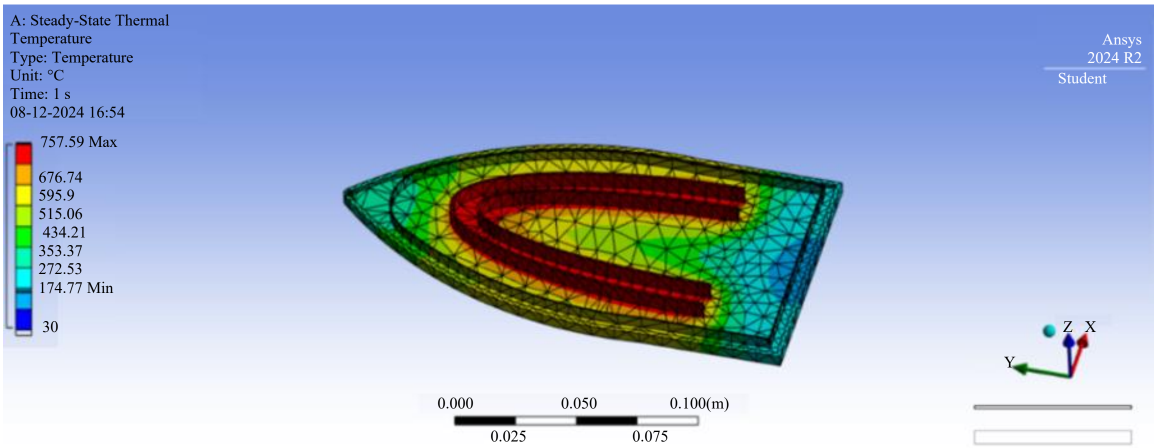

Figure 12. Analysis using ceramic material.

Here is a general comparison between materials used for Soleplates – such as Aluminum, Stainless Steel, Ceramic, and Titanium – which is shown in Table 2 titled “Comparison of materials”.

According to the analysis done, Aluminum material is best suitable for the manufacturing of the soleplate. Tables 2 and 3 show the general comparison and efficiency of the material. Temperature distribution along the soleplate using Aluminum as the material can be considered because the temperature distribution is quick when compared to other materials, such as Ceramics, Stainless Steel, and Titanium, and also the properties are moderate when compared to other materials

Table 2. Comparison of materials.

Property	Aluminum	Stainless steel	Ceramic	Titanium
Density	2.7 g/cm³	7.9 g/cm³	2.5–6.0 g/cm³	4.5 g/cm³.
Strength	Moderate (210–570 MPa, depending on the alloy)	High (520–1500 MPa, depending on grade)	Very high (up to 700 MPa, depending on type)	Very high (900–1200 MPa).
Tensile Strength	200–500 MPa	500–2000 MPa	High 500–700 MPa,	High (900–1200 MPa).
Hardness	Moderate (Brinell hardness 40–150)	High (Brinell hardness 150–400)	Very high (Mohs hardness 6–9)	Moderate (Brinell hardness 170–250).
Corrosion Resistance	Moderate (aluminum oxide forms a protective layer)	Excellent (especially in 304 and 316 grades)	Excellent (resistant to acids, chemicals, and high heat)	Excellent (corrosion-resistant in most environments).
Wear Resistance	Moderate	High	Very high	High.
Conductivity	High (good thermal and electrical conductivity)	Low (poor conductor of heat and electricity)	Very low (insulator)	Low (good heat conductivity but poor electrical conductor).
Weight	Lightweight (very low density)	Heavy	Variable depends on the type, generally low	Lightweight than steel, heavier than aluminum.
Malleability/Ductility	High (easy to form and shape)	Moderate (stiffer and harder to form)	Low (brittle and not malleable)	Moderate (tough but harder to work with compared to aluminum).
Cost	Low	Moderate to high (depends on grade)	Moderate to high (depends on type and application)	High (due to rarity and processing complexity).
Applications	Aerospace, automotive, packaging, construction	Medical tools, kitchen utensils, construction, industrial applications	Electronics, medical implants, cutting tools, aerospace	Aerospace, medical devices, high-performance applications.
Recyclability	High (easily recyclable)	High (recyclable, though difficult to separate)	Low (ceramics are not easily recyclable)	High (recyclable, though less common).
Magnetic Properties	Non-magnetic	Magnetic (can be magnetic depending on the alloy)	Non-magnetic	Non-magnetic.

Table 3. Comparison of soleplate efficiency.

Material	Thermal conductivity	Heat retention	Scratch resistance	Glide efficiency	Cost	Suitability for iron soleplate
Aluminum	High (237 W/m · K)	Moderate	Moderate (softer, prone to scratches)	Good (smooth glide, good heat distribution)	Low	Good for cost-effective irons with fast heating.
Stainless Steel	Moderate (15 W/m · K)	High	Very High (resistant to scratches)	Excellent (smooth glide, retains heat well)	Moderate to High	Very Good for premium irons. Retains heat well.
Ceramic	Low (1.5–2 W/m · K)	High (good heat retention)	Very High (scratch-resistant, harder)	Excellent (smooth, non-stick glide)	Moderate to High	Excellent for high-end irons. High heat retention, but lower thermal conductivity
Titanium	Moderate (21.9 W/m · K)	Moderate to High	Very High (extremely durable and scratch-resistant)	Good (good glide, though not as smooth as stainless steel)	High	Good for premium irons. Strong and durable.

Table 4 shows the comparison of materials used for Soleplate in terms of Voltage and Current we can observe that the thermal conductivity of Aluminum is higher than that of other materials. It can be suggested for the design of soleplate as this material uses less power consumption and is used in the conservation of energy. It can heat up quickly as the Thermal conductivity is higher which reduces the heating time. Also, it is cheaper and easily available in the market. It is best suited for customers who require quick ironing in less time and also at an affordable price.

Table 4. Comparison of materials in terms of voltage and current.

Material	Electrical resistivity (Ω · m)	Conductivity (S/m)	Voltage/current needs
Aluminum	2.82×10^{-8} Ω · m	High	Lower power needed.
Stainless Steel	~6.9×10^{-7} Ω · m	Low	Higher power needed.
Titanium	~4.2×10^{-7} Ω · m	Very Low	Higher power needed.
Ceramic	10^{12}–10^{14} Ω · m	Insulator	Higher power needed.

The durability of the iron box, constructed from aluminum, facilitates rapid heat conduction, thereby reducing the required force during the ironing process, and thereby prolonging the lifespan of the soleplate.

Design Changes in an Electric Iron Box

The design and analysis of an iron box are crucial for its efficiency, durability, and safety [2]. Safety is the important thing which should be considered when designing any product. Usually during the ironing process the wire of the iron box makes a disturbance, such as contraction, and it gets jumbled up which may lead to wear of the cable to overcome this problem we should design an Extension box in which only the required length of cable can be used and also after the ironing process when we keep the iron box vertically, there's a chance of falling due to the cable which is connected through Heel plate as shown in Figure 13, so to overcome this problem we should design a L bracket stand shown in Figure 14 which prevents the hot iron box from falling. The original design is shown in Figure 15. So, in final, it alters the design and dimension of the electric iron box which is shown in Figure 16.

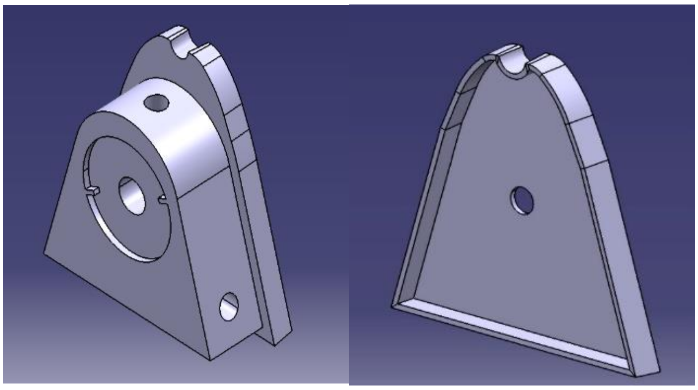

Figure 13. Extension box added to the heel plate.

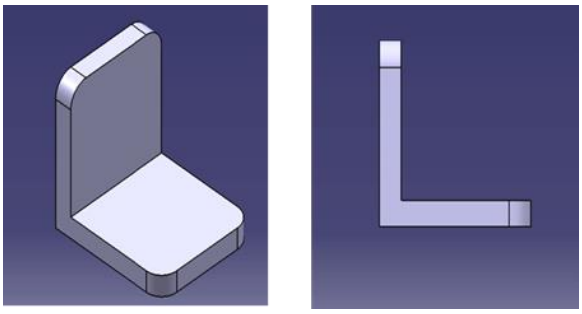

Figure 14. L Bracket which is added to the iron box.

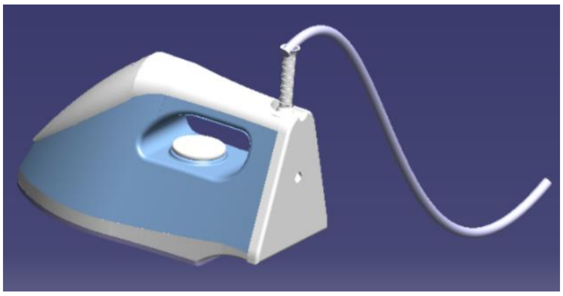

Figure 15. Original design of the iron box.

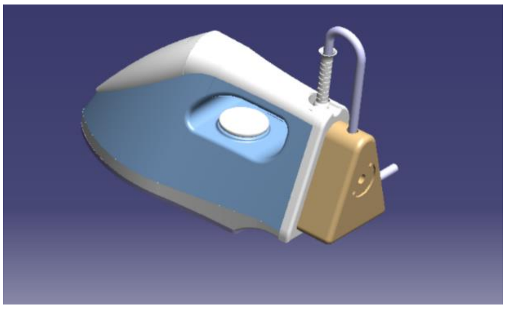

Figure 16. Additional components when added to the iron box.

CONCLUSION

In this study modeling and analysis of iron box using different materials is done using modeling tool and analysis software. The work presents the new design of iron box along with different parameter analysis. Key findings indicate that the material selection significantly impacts thermal performance and overall durability. The design of the soleplate was created using four different materials in mine: titanium, aluminum, stainless steel, and ceramics. Through the comparison of voltage and current for all the four materials, aluminum exhibited the higher conductivity with lower power requirement. Different materials have different properties, through the analysis we can conclude that the use of materials – such as aluminum for manufacturing soleplates – offers durability and excellent heat conduction properties it conducts heat quickly in less time with less power consumption, and also it is cheaper when compared to other materials. Additionally, the change in the design helps increase safety such as the L-bracket which prevents the fall of hot iron when kept vertically, and the addition of the extension box to the heel plate which prevents wear and increases the cable life.

REFERENCES

1. Sheng KB, Nasir SM, Shayfull Z, Fathullah M. Analysis on temperature distribution and efficiency of new electrical iron design. AIP Conf Proc. 2018;2030(1):020096.
2. Simons M, Brady D, McGrady M, Plaza A, Kimble R. Hot iron burns in children. 2002;28(6):587–590.
3. Glubiak E. Which soleplate is best for ironing. 2024 Dec 22 [cited 2026 Aug 8].
4. Balaji B, Porchilamban S. Conceptual design of iron box handles with ergonomic aspects. Appl Mech Mater. 2015;766:1103–8.
5. Ali MM, Rakesh N, Malavya U, Ajit K. Design, development and testing of solar iron box for smart home. 2022. doi: 10.1109/ICEARS53579.2022.9752076.
6. Beers R, Anthamatten M, Reid D, Kahn SA, Lentz CW. Development of a clothing iron safety device. J Burn Care Res. 2009;30(1):70–76.
7. Subash A, Jose A, Joy A, Sona MS. Smart iron box to prevent fabric damage. 2019;7(6):577–580.
8. Sunny A, Stella E. Design and fabrication of a gas pressing iron. J Multidiscip Eng Sci Technol. 2014;1(5).
9. Parr BF. Evolution of the modern automatic iron. Electr Eng. 1949;68(4):303–307. doi: 10.1109/EE.1949.6444711.
10. Meng L, Cheng KWE. Wireless power transfer technology for electric iron based on multi-coils induction heating design. 12(10):2566–2577. doi: 10.1049/iet-pel.2018.6305.
11. Shivappagoudar AR, et al. Design optimization of innovative foldable iron box. In: Deepak B, Parhi D, Jena P, editors. Innovative product design and intelligent manufacturing systems. Singapore: Springer; 2020. p.45–53. doi: 10.1007/978-981-15-2696-1_5.
12. Mohd Rodzi ANASYAHIDAH. Conduction heat study of different coil design of electric iron. J Mines Met Fuels. 2022;70(10A):194–198. doi: 10.18311/JMMF/2022.

