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Portable Electronics Reimagined: Design, innovation, and user−centered solutions

Mădălina Elena Munteanu[1] and Patricia Isabela Brăileanu[2]

[1]Faculty of Mechanical Engineering and Mechatronics, National University of Science and Technology Politehnica Bucharest, Romania
[2]Faculty of Industrial Engineering and Robotics, National University of Science and Technology Politehnica Bucharest, Romania, ORCID: 0000-0001-8840-8606

E-mail: madalina.munteanu00@stud.mec.upb.ro, patricia.braileanu@upb.com

Abstract. Travelling is a fundamental activity for personal development, giving opportunities for exploring, learning and enrich the cultural knowledge. Especially for young travellers, the use of a backpack becomes a challenge due to its weight, limited space and the need of transporting only the essentials. In the same time, the reduce mobility and the insufficient comfort are elements that can cause the traveller experience. The project aims to reduce those obstacles by developing an innovating product which combines two of the most chosen electronics in travelling backpack: an iron and a hairdryer, integrating them into a compact, easy to carry and light device. This product not only saves space but also meets the need for comfort and convenience during travel. In technical terms, this project contributes to an ecological design process by reducing the materials used in manufacturing and minimizing the resources required for those products, individually. In a global context, where sustainability is crucial, the proposed project considers not only the immediate needs of users but also the protection of the planet's resources for the future.

Keywords: Hair dryer, iron device, portable electronics, industrial design.

1. Introduction

Travel is an activity that we all engage in at some point. It offers a multitude of benefits, and no one shies away from experiencing something different at least once, compared to what they already know. For the majority, especially young people, most travels involve a backpack and limited storage space. The travel designed products have two main purposes. First, it focuses on solving several challenges related to backpack travel, understanding the difficulties that can arise in these situations:

- *Weight* → if you bring too many items with you, the backpack can become very heavy, which can lead to fatigue and back pain during travel;
- *Limited Space* → a backpack has limited capacity, so if you take too many items, fitting everything can be challenging, and you may end up burdened with unnecessary things;
- *Limited Essentials* → when backpacking, it's important to focus only on essentials so you can travel more lightly and make the most of the travel experience;

- *Reduced Mobility* → if the backpack is too heavy or too full, it can be difficult to move around the city or manage public transportation;
- *Comfort* → when you have too many items with you, it's less likely that you'll feel comfortable and enjoy the journey.

Second, the current concept focuses on reducing materials used in the manufacturing of individual appliances. This process results in halving the energy and resources used, which is essential for the planet today. The development of products, ideas, and innovations has grown significantly over the past few decades since production and manufacturing became possible with the industrial revolution. All those products, materials, and resources we use today have consequences not only in the present but especially in the coming decades [1]. Because of this, there is an increasing search for methods to continue creating products and consumables that are essential to humanity, but in a way that supports the future of the planet, rather than overcrowding it or even shortening its lifespan.

Therefore, the designed product directly aids humanity, offering a two−in−one appliance, an iron and a hair dryer, which minimizes the storage space needed for both products, thus, it helps fulfil multiple needs with a single device. Indirectly, it extends the life on the planet and teaches humanity how to meet all their needs in a way that has a positive long−term impact.

2. Methods

By analyzing the essential components that power both the *Dyson Supersonic* hair dryer and the *Philips Steam & Go* garment steamer, we gathered the necessary parts to create a 2−in−1 product. This product aims to fulfill the same functions as the original devices while reducing the amount of material required for separate production, ultimately benefiting the planet. From the user's perspective, there is the added advantage of saving storage space in their luggage, especially when traveling with a backpack. Based on this study, an initial conclusion was reached that is possible to combine two partially different devices into a single unit by using two separate electrical circuits inside the device. Therefore, one circuit is dedicated to the internal components that aid in hair drying, while the second circuit is used to heat water and release steam for ironing.

2.1 Required components

- Power cords → Like any electric device, both the hair dryer and the iron, work based on the electricity supplied from an external source. These wires connect to the on−off button of the device and to the components necessary for the circuit are activated when the device is turned on;
- Air filter → This is an essential component in the operation of a hair dryer as it helps to introduce only clean air into the device;
- Water tank → Achieving the purpose of the garment iron, which is to remove cloths wrinkles, relies on the generation of steam during use;
- Electric motor → For water−heating devices, both vertical and horizontal steam irons, electric motors are used to extract water from the tank;
- Fan → To allow the air to enter into the hair dryer and circulate through the device, an absorption source from the outside is required. Therefore, a fan is necessary to draw air inside the device and send it toward the heating element;
- Heating element → An aluminium cavity is positioned near the end of the device. Here, water is heated with the help of electric power to a temperature higher than 100°C;
- On−off button → to turn on and off the device;
- Exhaust vents → Both steam and hot air need to exit the device properly.

2.2 Description of the internal circuits in the device

- Hair dryer → pink circuit (*Figure 1 a.*) – starts from the power supply of the device, which sends the electric power to the power button. The button needs to be set to reach the first circuit level, which represents the activation of the electrical components that make the device operate. Additionally, the power cord is connected to the electric heating element, which needs a power supply to start heating up. From the control button, the electrical power is sent to the fan, which is activated. From here, the operation proceeds automatically, with the fan drawing in air, passing it through the heating element, and expelling it through the designated vents. The circuit is turned off via the control button, that stops the power supply of the device.

- Iron → green circuit (*Figure 1 a.*) – starts from the power supply of the device, which sends the electrical current to the power button. The button needs to be adjusted to reach the second circuit level, that activates the electrical components that make the device operate. The power wire is also connected to the electric heating element, which heats the water in the reservoir to create steam. From the control button, the circuit is completed back to the power button, as no additional components are needed. From here, the operation continues automatically, with the electric heating element warming the water to form steam, which is passed through a specific tube and exits through the designated vents. The circuit is turned off via the control button, that stops the power supply of the device.

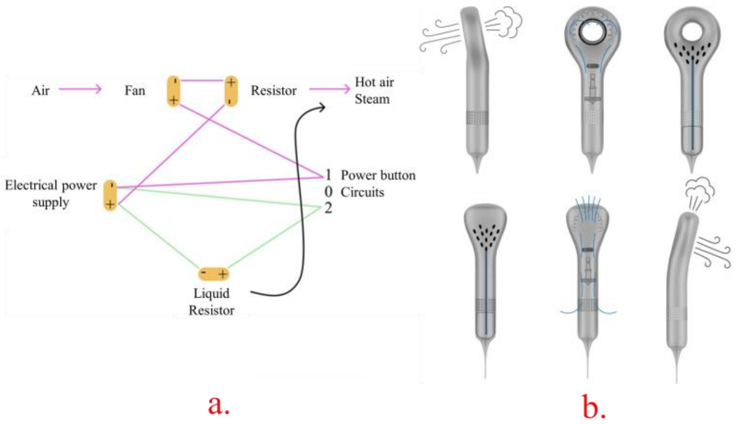

Figure 1. Product basic design: a. Internal circuit diagram; b. Examples of multifunction electronic devices.

2.3 The circuit required for the vertical iron clothes

- Power supply wires from the source → powered by 220V from the electrical socket;
- Circuit start button → essential for differentiating it from the other mechanism inside the device, namely the hair dryer;
- Water tank → used as both a container and cavity where the water is heated to turn into steam;
- Electric heating element for water → selected based on calculations to fit into the system;
- Temperature sensor → necessary to indicate when the water is heated, as well as a safety factor for releasing any excess steam left in the container;
- 12V transformer → to power the relay plate and valves;
- Relay plate → controls the depressurization of steam from the container;
- Steam valves → used to release steam from the container when needed;
- Steam trigger button → to manually control when to release steam from the device.

The simplest method for activating a duo−functional electric device is by setting up two different circuits that can be activated one after the other, depending on the desired function for each device.

For the iron – green circuit (*Figure 2 a.*):

- The process begins with the power supply that powers on the device, through the start button. The electric current power is 2200 Watts, from a household electric system with 220V and 10A;
- The button needs to be set for to the second circuit, which activates the electrical components that make this type of device work;

- The power supply wire is connected to the electric heating element, which uses a specified power based on the selected resistor, heating the water in the container to create steam;
- At 100°C, the water turns into steam, which is detected by a temperature sensor indicating that is ready for use;
- With the help of a specific circuit for this function and a relay, triggered by the sensor signal, but also with the additional steam trigger button, the valves in the tank can be opened to release the steam;
- These valves stay open for a short period and reactivate again when the steam trigger button is pressed;
- From the setting button, the circuit is closed in the power button, as no further components are needed;
- The process then continues automatically: the water is heated by the electric heating element, which forms the steam, and it passes through a specific tube and exits through the holes designed for ironing clothes;
- The circuit is stopped from the setting button, where the power supply to the device is turned off, and the electric heating element is also switched off.

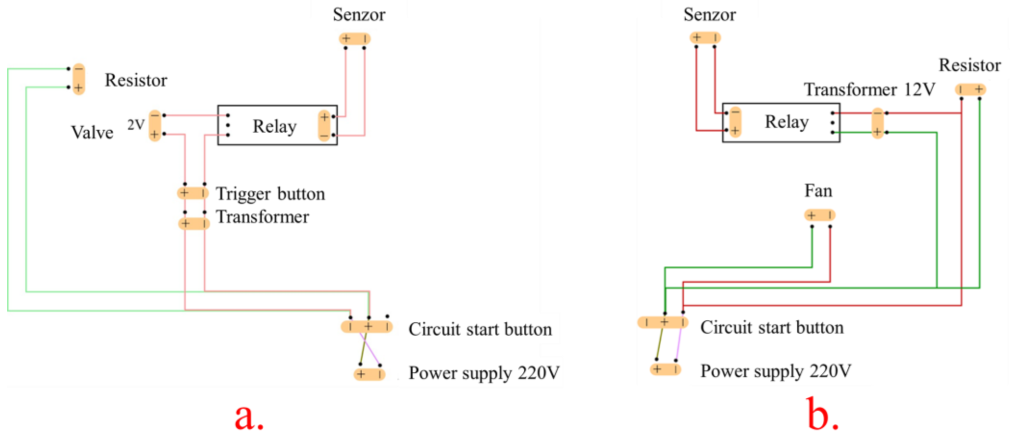

Figure 2. Electrical circuit diagrams: a. Internal circuit diagram of the vertical iron; b. Internal circuit diagram of the hair dryer.

2.4 The necessary circuit for the hair dryer

As shown in *Figure 2b.*, the following main components are used:

- Power supply wires from the source → powered by 220V from the electrical socket;
- Circuit start button → essential for differentiating it from the other mechanism inside the device, namely the hair dryer;
- Fan → serves to draw air from the outside and direct it through the device toward the electric heating elements that will heat it;
- Electric heating element → heats the air passing through and help the device achieve its function as a hairdryer;
- 12V transformer → some components require a lower voltage than that from the electrical socket, and this transformer converts it accordingly;
- Temperature sensor → used as a protection method to prevent overheating, a sensor that monitors the increase and decrease of temperature;
- Relay plate → connects the sensor control with the electric heating element.

2.5 Power calculations for the iron electrical resistor

To calculate the power required for a heating element in a steam iron, several variables are considered, such as the amount of water, the initial temperature of the water, and the desired temperature it should reach:

- Water temperature → the temperature of tap water is approximately 15°C;
- Amount of water → the reservoir used in this study has a capacity of 70 ml;
- Boiling temperature → the temperature at which water turns into steam is 100°C.

To heat the water at a specific temperature, enough energy must be supplied to raise the water temperature from its initial state to the desired temperature.

Thus, the energy required to raise the temperature of the water was determined as follows [2]:

$$Energy = Mass \cdot Specific\ Heat \cdot \Delta Temperature \quad (1)$$

$$Energy = 70g\ (70ml) \cdot 4186\ Joules/g°\text{C} \cdot (100 - 20)°\text{C} = 23\,441.6\ Joules \quad (2)$$

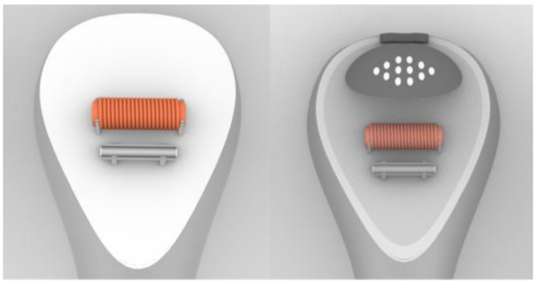

Figure 3. Device prototype details: a. Placement of the electromagnetic inductor; b. Steam valves located on the tank.

To heat this amount of water in a specified period, exactly 3 minutes (180 seconds), the required power is calculated using the following formula [3]:

$$Power = \frac{Energy}{Time} \quad (3)$$

$$Power = \frac{23441.6\ Joule}{180\ seconds} \quad (4)$$

$$Power \cong 130.23\ W \quad (5)$$

The results are showing that to heat 70 ml of water at room temperature to the boiling point in 3 minutes, approximately 130.23 watts of power would be required. Is considered that this calculation is based on the method of heating water using electric current directly in the water reservoir, and during the use of the device, the water must be maintained at this temperature and generate steam until the water runs out. Based on this calculation, an electromagnetic inductor is chosen to heat the 70 ml amount of water in the reservoir and maintain a heating power of 130W. The water reservoir is positioned in a fixed area to maintain constant contact with the water, so that regardless of how much water remains in the container, it will heat it and transform it into steam.

2.6 The components chosen based on the calculations for making the circuit

To continue the electric circuit after selecting the electromagnetic inductor, a preventive method is needed to announce when the electromagnetic inductor has fulfilled its purpose and when steam needs to be released from the reservoir. For this, a temperature sensor is used, that must also be in permanent contact with the water and measure the temperature fluctuations during use. This temperature sensor is a waterproof DS18B20 sensor, that remains in permanent contact with the water.

Product Specifications:

- Waterproof temperature sensor;
- Temperature range: -55°C − 125°C;
- Power supply: 12V DC;
- Sensor diameter: 6mm;
- Cable length: 1m.

Is important to note that the temperature sensor requires a 12V power supply, and currently, the electronic device is powered with 220V from the plug. Therefore, to properly power this temperature sensor, a transformer is required, which will convert the voltage from the plug to the necessary voltage for the selected sensor.

Product Specifications:

- Power supply voltage: 220V AC;
- Frequency: 50-60 Hz;
- Output voltage: 12V;
- Core: Copper;
- Dimensions: 30x30x27 mm;
- Mounting hole diameter: 3.3 mm.

This transformer continues its usefulness for the other selected components, namely the steam discharge valves. The role of the temperature sensor is to notify when the water reaches a temperature of 100°C, warning that steam is in the water reservoir and can be released. However, is essential for the steam to be released because the electric resistance continues to operate and turns the water into more and more steam, leading to overpressure. If the steam is not released, the device risks breaking and short−circuiting. Therefore, the role of the sensor is very important, and more importantly, it triggers the action to avoid the above−mentioned risks.

To release the steam, electrically operated discharge valves are used, connected to this temperature sensor. These valves do not have a pre−established geometry and can be adapted to any type of device with reasonable dimensions in the steam release area, but the activation method remains the same. When they receive a signal from the sensor that steam forms in the water reservoir, they open the holes in the reservoir that they initially covered, sliding over the hole's surface. These valves remain open for a short period, during which steam exits the reservoir, and then close, allowing the reservoir to be evacuated again.

Now that the electrical components have been selected to enable the device to function as a vertical steam iron, another component is needed to read the command to open the valves when steam is created in the reservoir, in this case, the relay component. A relay is an electrical device that acts as a switch controlled by another device. It works by using a small amount of power supply to control and open or close a separate electrical circuit, that may have a different voltage or power.

In the electronic device system, this relay is connected to the sensor that detects when the water has reached a temperature of 100°C, and on the other side, is connected to the steam discharge valves, meaning it receives the opening command. It requires a 12V supply, so is connected to the previously mentioned transformer.

The chosen relay is a thermal module with one channel, specifically designed for temperature sensors, with the following properties:

- Power supply voltage: 5V DC;
- Maximum switching current: 10A, 250V AC / 10A, 30V DC;
- LED indicator: for relay status (on/off);

- Dimensions (mm): 50 x 26mm;
- Measurement accuracy: ±0.5°C.

A command is used to open the steam discharge valves when the steam is formed in the cavity. However, using the device as a vertical steam iron means more than that, the user takes control over the steam created in the reservoir to use it when needed for ironing clothes and this is essential for making such a device.

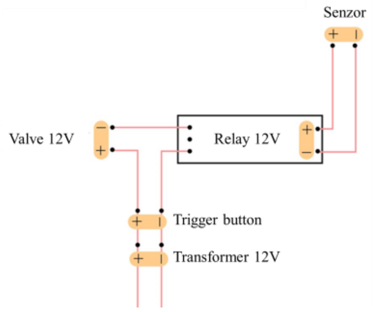

Figure 4 Steam exhaust electrical circuit.

To activate the device when needed, and to ensure that steam is present in the reservoir, an additional steam release button is added to the electric circuit, linked to the discharge valves. Thus, when the button is pressed, the valves open fully, releasing a larger amount of steam than what occurs during the depressurization of the reservoir, as commanded by the sensor for the valves. This button is designed specifically for this type of device and is placed in the electric circuit as shown in *Figure 4*.

2.7 Power calculation for the hair dryer electrical resistor

To determine the necessary power for an air heating electric resistance at a specific temperature, the following aspects need to be considered:

- Air volume → the amount of air passing through the hair dryer that needs to be heated;
- Temperature → the heated air temperature that pass through the resistor;
- Air density → can vary depending on pressure and temperature;
- Time → the time range in which the air should be heated as it passes through the device.

The formula to calculate the power needed to heat the air is [4]:

$$P = m \cdot \rho \cdot c \cdot \Delta t \tag{6}$$

Where:
P – required power;
m – air mass;
ρ – air density;
c – air specific heat (approximately 1.005 kJ/kg·°C for air at atmospheric pressure);
ΔT – temperature difference (final temperature - initial temperature).

2.8 Determining the amount of air passing through the device

Volume calculation of the spherical part – device head:

$$V = \frac{4 \cdot \pi \cdot [\left(\frac{L}{2}\right) \cdot \left(\frac{l}{2}\right) \cdot \left(\frac{h}{2}\right)]}{3} = \frac{4 \cdot 3{,}14 \cdot [\left(\frac{85}{2}\right) \cdot \left(\frac{85}{2}\right) \cdot \left(\frac{80}{2}\right)]}{3} = 302486.67\ mm^3 = 302\ cm^3 \tag{7}$$

Volume calculation of the cilindrical part – device heandle:

$$V = 4 \cdot \pi \cdot [(\tfrac{L}{2}) \cdot (\tfrac{l}{2}) \cdot h] = 4 \cdot 3{,}14 \cdot \left[\left(\frac{30}{2}\right) \cdot \left(\frac{30}{2}\right) \cdot 170\right] = 480570\ mm^3 = 480 cm^3 \tag{8}$$

Total exterior volume of the device:

$$V_{total} = V_{device\ head} + V_{device\ handle} = 302 + 480 = 782 cm^3 \cong 800 cm^3 \tag{9}$$

The interior volume of the device can be approximately calculated based on estimated measurements of the space between the internal components, as their geometry, volume, and space they occupy are not determined at this stage. The calculation is done to determine the necessary components that make the device work, and then recalculated based on the chosen components to get the actual value of the air volume and how the device will work under exact parameters. If 90% of the internal components occupy the device's external volume, the remaining interior volume through which the air passes can be calculated as following:

$$V_{inside\ air} = V_{outside\ air} - (90\% \cdot V_{outside\ air}) = 800cm^3 - (90\% \cdot 800cm^3) = 80000mm^3$$

The mass of air is converted into cubic meters:

$$m = \frac{80000mm^3}{1000000} = 0.08m^3 \tag{10}$$

2.9 Air density under certain environmental conditions

Air density can vary depending on pressure, temperature, and humidity [5]:

- Air density under standard conditions (1 atmosphere pressure, 15°C) is approximately 1.225 kg/m³ or 1.225 g/L;
- Air density with 1 atmosphere pressure and 20°C is approximately 1.204 kg/m³ or 1.204 g/L;
- Air density with 1 atmosphere pressure and 30°C is approximately 1.164 kg/m³ or 1.164 g/L.

We consider air density under standard environmental conditions:

$$\rho_{air} = 1.225\ kg/m^3 \tag{11}$$

Temperature difference:

$$\Delta T = final\ temperature\ -\ initial\ temperature = 100°\text{C} - 20°\text{C} = 80°\text{C} \tag{12}$$

Calculation of the value needed to heat air [2]:

$$Q = m \cdot \rho \cdot c \cdot \Delta T \tag{13}$$

To calculate the resistance required to supply this power at the desired temperature, we need to consider the voltage at which the circuit will operate. For the electronic device, the voltage is 220V.

$$Q = 0.08m^3 \cdot 1.225kg/m^3 \cdot 1.005kj/kg°\text{C} \cdot 80°\text{C} = 7.879kJ \tag{14}$$

Calculating the necessary power to supply the specific heat [6]:

$$P = \frac{Q}{T} = \frac{7.879kJ}{30s} = 262.63W \tag{15}$$

This calculation is performed for a static amount of air inside the closed device. The hair dryer principle operation is based on an air current that is continuously moving, with a specific speed determined by the rotational speed of the electric motor that drives the fan. To perform a real calculation, if the actual amount of air passing through the device in a specific range of time is up to 5 times larger than the static quantity, we recalculate the power needed for this volume of air:

$$Q = (0.08 \cdot 5)m^3 \cdot 1.225kg/m^3 \cdot 1.005kJ/kg°\text{C} \cdot 80°\text{C} \tag{16}$$

$$Q = 39.396kJ \tag{16}$$

$$P = \frac{39.396KJ}{30\ s} = 1313.2\ W \tag{17}$$

Calculating the resistance required to generate that power at 220V:

$$P = \frac{V^2}{R} \tag{18}$$

$$R = \frac{V^2}{P} = \frac{220^2}{1313.2} \approx 36.85\Omega \tag{19}$$

Using Ohm's Law was verified whether the voltage and current parameters from a standard household power source can generate this resistance and power in the calculated circuit:

$$V = I \cdot R \tag{20}$$

- V is the voltage in volts (V);
- I is the current in amperes (A);
- R is the resistance in ohms (Ω).

This formula is used to calculate the current:

$$I = \frac{V}{R} = \frac{220V}{36.85\Omega} \approx 5.97A \tag{21}$$

Thus, to heat a quantity of air of 0.08 m³ in a 220V electric circuit with a current of 10A, the resistance heats up to 36.85 Ω in 30 seconds, using a power of 1313.2 W to provide the required 39396 kJ of heat to this quantity of air passing through the device.

The length of the necessary heating element to achieve this heat in the given 30 seconds requires another calculation specific to the type of chosen electric resistance. The nickel−chromium (*Table 1* shows the physical properties of nickel-chromium resistance) resistance described fits the hair dryer circuit. The chosen electric resistance must have a power of over 1300W.

Table 1. Physical properties nickel-chromium resistance.

Properties	Value
Electrical resistance	1.05 ÷ 1,3 Ohm · mm²/m (depending on the alloy grade)
Working temperature	800-1100 °C
Melting point	1100-1400 ° C
Specific heat	0,45 kJ / (kg · K) la 25 °C
Density	8200-8500 kg/m³
Maximum tensile strength	0.65-0.70 GPa
Electrical resistivity	1,05-1,4 Ohm · mm²/m

Resistivity was calculated using the formula:

$$\rho = \frac{R \cdot A}{L} \tag{22}$$

Where:
ρ is the resistivity of the material: ρ = 1.08 Ω · mm² / m;
R is the resistance of the material in ohms (Ω): R ≈ 36.85 Ω;
A is the cross–sectional area of the material in square meters (m²);
L is the length of the material in meters (m).

The cross–sectional area of the resistor is a circle, so the area is calculated as following:

$$A = \pi R^2 = 0.33mm^2. \tag{23}$$

Calculation of the electric resistance length:

$$L = \frac{R \cdot A}{\rho} = \frac{36.85\ \Omega * 0.33\ \text{mm}^2}{1.08\ \Omega \cdot \text{mm}^2\ /\ \text{m}} = 11.27m \tag{24}$$

This length of material is arranged in the hair dryer, ensuring it covers as much of the airflow path as possible, while preventing the wire from touching or coming close to another part, as this could cause a short circuit during operation. The electric resistor heats up and reaches the necessary temperature to heat the air to 100°C when used at maximum power. However, currently, there is nothing to stop it from continuing heating to its specific temperature of 800°C. This could lead to the overheating of the electronic device; at a point it could melt or short circuit other components inside. To prevent this risk, a temperature sensor is used, that is in constant contact with the electrical resistance and measures its temperature. When the temperature reaches Q = 7.879J, the resistance is maintained within this temperature range. The sensor chosen for this circuit is the same as the one used in the vertical steam iron − DS18B20.

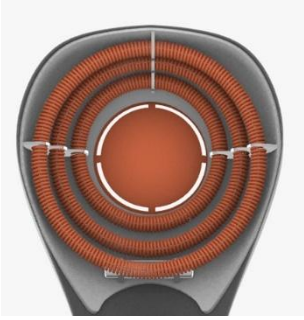

Figure 5 Dispose of electrical resistance in the cavity.

Product specifications:

- Waterproof temperature sensor;
- Temperature range: -55 – 125° C;
- Power supply: 12V DC;
- Sensor diameter: 6mm;
- Cable length: 1m.

Additionally, a transformer and a relay are needed to transmit and read commands from one component to another, like those used in the vertical steam iron described before.

2.10 Power calculations for the electric motor in the hair dryer

To determine the required airspeed passing through an electric resistance of 1300W to achieve a temperature increase of 80°C, we can use the basic thermal power relation to calculate the mass of air that must be heated.

The mass of air is calculated using the relation:

$$P = m \cdot c \cdot \Delta T \tag{25}$$

Where:
P is the thermal power of 1300W;
m represents the air mass passing through the resistance;
c represents the specific air heat, approximately 1.005 kJ/kg·°C;
ΔT is the air temperature change of 80°C.

$$m = \frac{P}{c \cdot \Delta T} = \frac{1300 \ \mathrm{kJ/s}}{1.005 \ \mathrm{kJ/kg \cdot °C} \ \times 80°\mathrm{C}} = 16.17 \ kg \tag{26}$$

This amount of air must be heated per second to achieve the desired 100°C of heated air.

The first section through which the air passes is the handle, where is drawn by the fan, and then further into the specific cavity of the hair dryer.

The cross–sectional area is given by the formula for the two surfaces:

$$A = (L \cdot l) + \frac{\pi \cdot r_1 \cdot \frac{r_2}{2}}{2} = (170 \cdot 30) + \frac{3.14 \cdot 10 \cdot 42.5}{2} = 5100 + 667.25 = 5767.25mm^2 = 0.57m^2 \tag{27}$$

Calculations to determine the speed of air flowing through the device [7]:

$$Air\ speed = \frac{Air\ mass}{\text{Air density} \cdot \text{Cross section}} = \frac{16.17\ kg/s}{1.204 \frac{\mathrm{kg}}{\mathrm{m}^3} \cdot 0.57\ m^2} = 23.55\ m/s \tag{28}$$

The selection of the electric motor is based on the speed it must support over time, including up to 1 hour, so that the continuous airflow required for drying the hair is generated.

Product specifications [8]:

- Nominal voltage: 12V;
- No-load speed: 9800 rpm;
- No-load current: 3.9 A;
- Package weight: 65.0 g;
- Dimensions: 55x30x30 mm.

Based on the chosen electric motor, a fan specific to this device is designed, so that can be mounted on the motor shaft and spinning in the device handle during the hairdryer. This element is made of aluminium and is essential for the functioning of the portable device.

3 Results

On each side of the device, ribs are designed to secure each component in its exact position, or specific cutouts are made in the structures that contain them. In this way, the assembly and retention of the components throughout the structure are controlled, and it later helps in case of maintenance and reassembly of each individual device part after the maintenance is concluded.

On the iron's half of the device, there is also a relay that is used to control the power supply to the resistor, in the hair dryer. This is placed on the iron's plate because is the only space left that can be used for it. The components require more space in the hairdryer, and additionally, space is needed for air circulation and heating to ensure the device functionality. For the hair dryer's half, the components are arranged in the designated space.

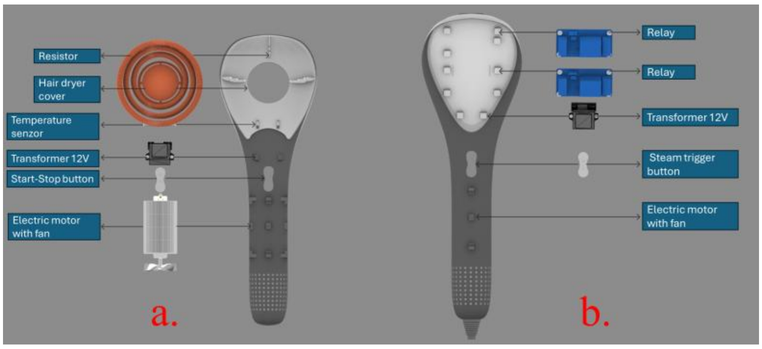

Figure 6 Product design: a. Iron component fixing ribs; b. Hair dryer component fixing ribs.

An important factor in choosing the layout of these components, the passage of air through the device. From the entry point through the designated holes, air is drawn by the fan, and it must have enough space to pass through the motor, which has a diameter almost equal to the device. This space is provided by the height of these ribs, which keep the motor centered in the handle, allowing air to pass through the sides and reach the 12V transformer and the electric resistance. From there, the air exits through the nozzle cover, a versatile component that can be mounted with a simple click.

The elements are assembled on these ribs using small screws, specifically designed for household electronic devices. *Figure 6* shows their final arrangement on both sides of the electronic device, secured with screws and fixed onto the ribs described above.

Additionally, the outer part of the vertical iron can be seen, with metal ribs containing the temperature sensor that needs to be placed in contact with the water, to control the relay when to stop supplying power to the electric resistance, and the electric resistance itself, which comes into contact with the water.

Figure 7 Portable electronic design: a. Hair dryer components; b. Vertical iron cavity.

Both device circuits are arranged within its body, powered by the same power source. The difference between the two circuits occurs when the device is powered on, as the start button can turn on the two circuits sequentially, never at the same time, by arranging the power supply on the negative side, on two different channels, each for a specific circuit. For the hair dryer, all components are in the device handle, in the spherical section, with only one component on the other half.

In *Figure 8*, the layout of the entire electrical circuit in the hair dryer's electrical system can be observed.

Figure 8 Electrical wire layout for the hair dryer.

For the vertical iron's electrical system, the components are fewer, with the power base being the same as the hair dryer system. In this circuit, the heating element and the temperature sensor are in the water reservoir (in direct contact with the water). To ensure the transition from the water reservoir into the device without leakage or electrocution risks, the wires are insulated with heat shrink tubing, sealed on the transition platform, and glued to these components.

Figure 9 Electrical wire layout for steam iron.

For the steam release valve system, the same wire insulation technique is used, with wires running through the steam storage cavity and exiting inside the device toward the steam trigger button.

The water supply of the reservoir is done directly into the cavity through a valve with opening–closing suction holes, strategically located at the device end, where water cannot reach during normal use. If water remains in the device after use, is recommended to remove it. If not, the internal components are protected by sealing the edges of the reservoir with gel, ensuring a safe cavity.

In *Figure 9 and 10*, the layout of the entire electrical circuit in the steam iron's electrical system can be observed.

Figure 10 Multifunctional iron–hair dryer device.

4 Conclusions

The design of a multifunctional device that combines the functions of a vertical iron and a hair dryer into a single unit is feasible and, moreover, manages to save storage space and reduce the complexity required to own and operate two separate devices. The design process involved identifying the most suitable components to meet the two desired functions and creating circuits that work together in a single device.

Although it has not been tested at this time, the selected components can fulfill the functions of both systems. By bringing together the common components and using the same methods and power sources, this space–saving design enables the creation of a multifunctional device. The use of materials such as ceramics, ABS plastic, polycarbonate, and stainless steel can contribute to the design process of a lightweight and durable device. At the end of its life cycle, all components made from these materials can be reused, recycled, or used in an environmentally sustainable way. Reducing the number of required devices contributes to a positive ecological impact by reducing resource consumption and waste generated by the production and disposal of electronic devices.
The multifunctional device provides users with a convenient product that reduces the time and effort needed for personal care activities, especially when it comes to storage and weight during travel. Mobility and ease of use are improved by the compact, intuitive design, based on existing knowledge of these types of devices.

5 References

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