**2. DESIGN REQUIREMENTS/CONSTRAINTS**

IntelliRoast must successfully roast 120 grams of coffee beans based on a predetermined roasting profile selected by the user via a smartphone application. To accomplish this, it must heat the bean roasting chamber to 300°C while retaining a surface temperature of less than 60°C. IntelliRoast must agitate the beans during the roasting process and eject them from the roasting chamber at the conclusion of the roast. These combined aspects ensure IntelliRoast roasts coffee beans both quickly and safely. Additionally, IntelliRoast provides a cost-effective alternative to existing products with similar feature sets.

The sections of the design constraints below discuss IntelliRoast’s technical and practical constraints, as well as engineering standards it must follow. Technical constraints refer to the essential needs of the design, while practical constraints refer to the operational requirements and regulations during usage.

**2.1 Technical Design Constraints**

Table 2.1 contains the five technical design constraints that must be adhered to upon completion of this product.

**Table 2.1 Technical Design Constraints**

|  |  |
| --- | --- |
| **Name** | **Description** |
| Power Draw | IntelliRoast must draw under 15A at 120V to comply with NEC standards for kitchen circuit current limits [1]. |
| Roasting Temperature | The heating element must heat the roasting chamber to 300°C. |
| Surface Temperature | IntelliRoast must comply with ASTM C1055 standards to protect the user from irreversible injuries [2]. The device’s exterior enclosure must not exceed 60°C. |
| Bean Agitation | IntelliRoast’s fan must lift approximately 120g of beans to agitate during roasting and eject from the chamber after the roast is finished. |
| Wireless Distance | IntelliRoast must connect to the user’s smartphone from a maximum distance of 3 meters. |

**2.1.1 Power Draw**

IntelliRoast must not exceed 15 amps, the average current draw for kitchen appliances. The National Electrical Code (NEC) specifies that the average kitchen should have, at a minimum, two circuits rated for 20 amps at 120 VAC [1]. The general practice for current rating is that the continuous draw should not exceed 80 percent of the rated capacity. At 20 amps, the continuous current draw rating equals 16 amps. IntelliRoast’s constraint of 15 amps adheres to NEC specifications and still operates within homes which do not meet this specification.

**2.1.2 Roasting Temperature**

IntelliRoast must sustain an ambient temperature of 300°C within the roasting chamber. Depending on the roast level, the process of roasting coffee requires the beans to reach an internal temperature of 205°C-250°C [3]. This target temperature will roast the beans within the target timeframe of 10-12 minutes.

**2.1.2 Surface Temperature**

IntelliRoast’s exterior enclosure must not exceed a surface temperature of 60°C. ASTM C1055 standards specify the surface temperature of 70°C as the upper limit for safe operation, as temperatures exceeding this maximum presents a burn risk for the user. IntelliRoast’s constraint of 60°C adheres to ASTM standards and further reduces first-degree burn risk.

**2.1.4 Bean Agitation**

IntelliRoast’s fan must lift and agitate approximately 120 grams of beans during roasting and eject them from the chamber after the roasting process is finished. 120 grams of coffee is enough for 12 6-ounce cups, or 1 pot, of coffee [4]. If the beans are not mixed and agitated during the roasting process, they will roast unevenly. The beans at the bottom of the chamber could char while others may not roast. In order to simplify the mechanical design, the beans will share a single entrance and exit from the chamber.

**2.1.5 Wireless Distance**

IntelliRoast must communicate wirelessly between the device and the user’s smartphone at a distance of 3 meters or less. In 2009, the National Kitchen and Bathroom Association defined the average kitchen area as approximately a 10 by 10-foot root with an area of 100 square feet [5]. Our 3-meter radial requirement allows continuous connectivity throughout the entire average kitchen space, ensuring no disconnection or data loss while the user tends to other tasks within the kitchen.

**2.2 Practical Design Constraints**

The product must also adhere to the five practical constraints listed in Table 2.2

**Table 2.2 Practical Design Constraints**

|  |  |  |
| --- | --- | --- |
| **Type** | **Name** | **Description** |
| Environmental | Water Resistance | IntelliRoast must comply with IP53 standards [6]. |
| Economic | Cost | In order to compete on the open market, IntelliRoast should cost roughly less than $500 due to part costs and retail markup. |
| Sustainability | Hands-Free Usage | IntelliRoast should operate without user intervention. |
| Social | App-Enabled | IntelliRoast must provide additional features through a companion smartphone app. |
| Safety | Chaff Collection | IntelliRoast must have the ability to collect chaff to avoid potential fire hazards. |

**2.2.1 Environmental**

IntelliRoast must comply with IP53 ingress standards. The main operating environment will contain hazards such as foreign objects and liquids. According to the International Protection Marking (IP), IP standards call for “protection of persons against access to hazardous parts, and protection of equipment against ingress of solid foreign objects” and “protection of equipment against harmful ingress of water” [6]. IntelliRoast’s IP53 rating will protect the equipment from the entry of dust and water sprays approaching from 60 degrees.

**2.2.2 Economic**

IntelliRoast must cost less than $500 for consumers. IntelliRoast is competing against home coffee roasters costing upwards of $1600 [7]. This significant cost difference makes IntelliRoast a viable competitor in the current coffee roasting market. Even though the production cost of IntelliRoast is lower than its competitors, the price is set primarily through the electronics and necessary heating element.

**2.2.3 Sustainability**

IntelliRoast’s roasting process must be fully automated. The preparation of the roast is designed to be an intimate and customizable user experience, and after initiating the roast, the process is entirely hands-off. Internally, IntelliRoast must heat up its heating coil, monitor bean temperature, and adjust the airflow and chamber temperature based on the roasting profile without user influence or any outside assistance. The automation of these key steps will ensure the exact roast profile is easily and quickly repeatable.

**2.2.4 Social**

IntelliRoast’s companion phone app must allow the user to select and customize their roast profiles, start the roasting process, and view other important information about the roast. The app must have an easy-to-use interface requiring no prior training.

**2.2.5 Safety**

IntelliRoast must collect the chaff in a container for disposal. Chaff, a paper-like substance, flakes off coffee beans during the roasting process. If not properly collected and disposed of, chaff can create a fire hazard. IntelliRoast will keep all chaff away from heating elements in order to eliminate a risk of combustion. Even with this potential fire hazard, IntelliRoast will not have any openings for the chaff to go near the heating element.

**2.3 Appropriate Engineering Standards**

Table 2.3 contains engineering standards used by IntelliRoast.

**Table 2.3. Appropriate Engineering Standards**

|  |  |  |
| --- | --- | --- |
| **Specific Standard** | **Standard Document** | **Specification/ application** |
| ASTM C1055 | Standard Guide for Heated System Surface Conditions that Produce Contact Burn Injuries | The surface temperature must be below 70°C. |
| IEC-60529 | Degrees of protection provided by enclosures (IP Code) | The device must abide by IP ratings to protect against the intrusion of solid objects and water. |

**2.3.1 ASTM C1055**

IntelliRoast must comply with ASTM standards to determine acceptable operating conditions for heated systems. ASTM C1055 recommends the maximum injury level is causing first degree burns on the average subject [1], and this is caused by temporary exposure to a surface temperature of 70°C. The maximum surface temperature of 60°C ensures IntelliRoast abides by ASTM C1055 standards and further reduces first-degree burn risk.

**2.3.2 IEC-60529**

IEC-60529 standards define the device’s protection against external objects and liquids as the IP Code [6]. IntelliRoast’s adherence to IP53 standards will allow for protection against dust and water sprays approaching from 60 degrees.

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