IMPERIAL COLLEGE LONDON

DEPARTMENT OF MATERIALS

MATE50003 ENGINEERING PRACTICE

Final Report

16 June 2025

STUDIO G

Project Manager: Dr S Humphrey-Baker

Mary Ma

Alexandra Vasilev

Vladimir Jurien De La Graviere

Ezekiel Oluwatosin

Harshvardhan Jhala

Jiahe Li

Luca Gerza

Luna J Lu

Marlon McCreight

Meghna Jeypal

Muizz M A Zaidi

Petal Chiam Tze-Shuen P Chiam

Samuel Wang

Temin Luangtana-ana

William Diffey

Executive Summary

Studio G has developed a high-end slow cooker that balances high performance, user-friendliness, and sustainability. The design features an optimised capacity of approximately 3.5–4 L, a safe mullite–quartz ceramic cooking pot with a durable enamel coating, and intuitive controls suited for convenient family cooking. To support long-term use, we offer an online platform with recipes, troubleshooting advice, and the option to purchase replacement pots — eliminating the need to buy an entirely new slow cooker if the original pot is damaged. Key materials and manufacturing processes were selected using the Longevity Loop Index (LLI) to ensure durability, recyclability, and minimal environmental impact. The design combines a ceramic cooking pot for safe, even heating; a resistive heating element embedded in a phlogopite mica ring for energy efficiency; a recycled aluminium inner pot for effective heat transfer; and a vacuum-insulated stainless steel outer casing for superior thermal retention and structural strength. Our cost model targets affordability for families without compromising quality: with mass production, the estimated unit production cost remains competitive, with a recommended retail price of around £75. Responsible sourcing and licensing ensure compliance with existing patents and support Studio G's commitment to sustainable and ethical manufacturing. By combining carefully engineered materials, practical usability, and strong sustainability principles, Studio G aims to deliver a reliable, environmentally responsible product and build a trusted brand in the growing slow cooker market.

1 Introduction

1.1 Market Research

Slow cookers have increased in popularity in the past 10 years,[1] with a few brands reimagining the 1970s design into something more modern. The increase in popularity can be attributed to consumers increasingly seeking convenient ways to prepare home-cooked meals with little user intervention. Following this renewed interest in slow cookers, a range of brands including the well-established CrockPot, have entered the market at various price points, offering diverse features and capacities.

Low-end (< £25): Designed for small households (1-4 portions). These models typically include ceramic bowls and basic controls — three heat settings, and a keep-warm mode — but lack advanced features like timers.

Mid-range (£25 - £40): Within this range, the models offer larger capacities (3-6 portions) and additional functionalities such as timers, LED indicators and occasionally digital controls, making them more convenient to use.

High-end (> £40): These models include all mid-range features with better material choices to enhance slow cooking performance and may have various unique features to maximise adjustability of the slow cooker's settings.

StudioG aims to enter the market with a high-end slow cooker that prioritizes sustainability, durability and ease of use. A variety of additional features sets StudioG's slow cooker apart from other slow cookers in this price range: a non-toxic coating, a recyclable aluminium pot, an efficient resistive heating ring and ergonomic handles. The slow cooker also includes a selection of control options for greater flexibility and convenience. With these features in mind, the carefully selected materials in StudioG's slow cooker satisfy durability, food safety, and environmental responsibility, while offering justified value for the performance delivered.

1.2 Recommendations

Testing the 4.7L Crock-Pot, 1.8L Crock-Pot, and the Morphy Richards Evoke slow cookers revealed that all three models utilise a similar resistive mica heating ring wrapped around an aluminium pot, which was later found to be common in slow cookers. However, the higher priced Morphy Richards Evoke utilises an aluminium cooking pot rather than the ceramic pot seen in the Crock-Pot models. The 4.7L Crock-pot, which is more expensive than the 1.8L, justifies its higher price through the large capacity and the inclusion of a timer function.

Based on the results from testing, several recommendations were made to enhance longevity, sustainability, and product performance. It was suggested that a ceramic cooking pot should be used instead of aluminium to improve heat retention with quartz-mullite ceramic being the preferred material due to its reduced quartz content, which reduces the effects of thermal shock. The use of an induction cooker was recommended to improve efficiency, though if the studio decided to remain with a resistive heater, the use of a thinner aluminium pot was suggested to increase sensitivity to temperature changes from the heating element.

Functionality could further be improved through the application of a non-stick coating to the cooking pot, though alternatives to Teflon should be used due to its toxicity at high temperatures. Additionally, it was suggested to increase the maximum timer setting to 20 hours. To improve the sustainability of the outer casing, it was suggested to use recycled PET and a thin aluminium coating to reflect heat and improve energy efficiency.

2 Design Proposal

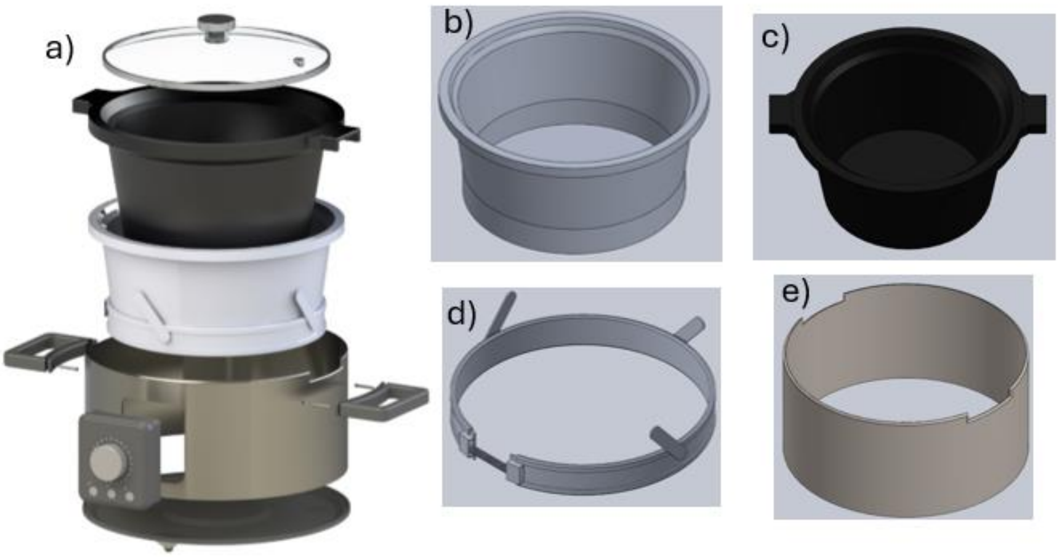

Figure 1: a) Exploded view of the slow cooker showing all components. b) Aluminium cooking pot. c) ceramic cooking pot. d) Mica heating ring. e) outer casing

2.1 Rationale

This 3.5L slow cooker is designed for modern families, combining energy efficiency, ease of use, durability and sustainability. Built for long-term reliability, the product provides the flexibility to prepare nutritious meals with minimal effort, while supporting eco-conscious living and circular design principles.

The slow cooker features a removable mullite-quartz ceramic pot coated with frit-based enamel, that is long lasting and easily replaceable. It uses a low cost but efficient heating ring, and a reflective metal outer casing that minimises energy loss. The design also features two sets of ergonomic handles.

Ease of use is central to this design. It features two sets of ergonomic handles: one set attached to the main outer-body allowing for portability, and a second set attached to the removable ceramic pot to reduce the risk of spills or dropping during handling. This makes it well-suited for family environments. To further improve usability, the front of the slow cooker has a dial for timer control up to 20 hours and buttons with 3 temperature options: low, medium and high, allowing for easy setting personalisation. It also includes an automatic keep warm setting, ensuring food is kept at a safe temperature and LED lights are used to indicate which mode is active.

A ceramic cooking pot with a frit-based enamel coating was chosen over an aluminium pot with a non-stick coating. Several studies have found non-stick coatings, such as Teflon, to degrade at high temperatures and release harmful substances, while the frit-based enamel coating does not.[2] Ceramic pots also ensure food is evenly and gently cooked, allowing soft textures to be achieved providing delicious meals for the whole family.

An induction heating approach was considered; however, it is expensive, complex to design, and requires the use of a ferrous pot — all of which increase the weight and cost of the slow cooker.[3] A resistive mica heating ring, which is more commonly used in slow cookers, was chosen instead. It reduces the overall weight and avoids a shift towards the separate induction hob market.

To maximise efficiency while keeping costs low, a 30mm wide mica heating ring was chosen as it is able to provide even heating and high efficiency at low cost. The aluminium heating pot is designed to be 4mm thick to ensure structural integrity and efficient heating. For a further reduction in heat loss, a vacuum-insulated stainless steel outer casing is used, efficiently trapping excess heat and providing a polished finish.

Sustainability is at the heart of this design, with materials selected to improve overall energy efficiency and durability while reducing environmental impact. Recycled aluminium is used in the heating pot to reduce resource extraction. The ceramic cooking pot retains heat more effectively than aluminium which lowers overall energy consumption and the vacuum insulation in the outer casing further reduces heat loss. While only the ceramic pot is removable, all components are designed to last, using materials selected for long-term thermal and mechanical stability, minimising the need for servicing or disposal. The ceramic pot is designed to be shock resistant and replacement pots are available to allow prolonged slow cooker usage in the event of the pot breaking.

To further support customers, StudioG plans to develop a website offering cooking recipes that include temperature and timer settings guidance, the option to purchase replacement pots, customisable colour options, as well as troubleshooting advice.[4]This will provide a cost-effective support system, helping customers get the most out of their product experience.

All structural materials are selected for long term thermal and mechanical stability, minimising the need for servicing or disposal. The materials selected are detailed below.

2.2 Material Selection

2.2.1 Material Selection Index

To evaluate materials for sustainability and performance in our slow cooker design, we used the Loop Longevity Index (LLI)[5] defined by the formula:

$$LLI = R \times L$$

Where: R represents the material's recircularity (recyclability, biodegradability, renewability) and L represents the material's longevity (mechanical resistance, environmental resistance, thermal stability). See Appendix A.1 for detailed scoring.

2.2.2 Ceramic Cooking Pot

The inner cooking pot plays an essential role in heat distribution, food safety, and durability. Having decided to use a ceramic cooking pot, multiple ceramic composites were investigated. Based on this, we selected Mullite–Quartz Ceramic for the cooking pot due to its strong combination of heat retention, chemical inertness, and mechanical durability (LLI = 10.08).

Mullite as the major phase in the selected ceramic, it is chemically resistant and has a maximum working temperature of 1800°C, far exceeding all cooking conditions.[6,7]Quartz has a low thermal expansion coefficient (CTE) of 0.59×10^{-6}/K and a high softening temperature around 1665°C.[8] The combination of both phases results in a CTE of 5.5×10^{-6}/K, enabling the material to resist cracking under rapid temperature changes.

The mullite-quartz ceramic is produced by a solid-state reaction sintering process, where alumina and quartz powders are mixed and heated at 1400-1600°C.[10] Both alumina and quartz are abundant, non-toxic and recyclable materials, and also be sourced from industrial by-products such as bauxite residue or silicate-rich mining waste, supporting a more sustainable raw material supply.[11]

Overall, the mullite–quartz ceramic has superior thermal shock resistance, with low thermal expansion, and is chemically inert making it suitable for use in our slow cooker.

2.2.3 Ceramic Coating of Cooking Pot

A two-layer frit-based enamel coating system was selected to optimise the thermal compatibility, durability, (LLI=10) and surface performance of the mullite–quartz ceramic pot (coefficient of thermal expansion ≈ 5.5 × 10^{-6}/K).[12]

The bonding layer utilises Ferro Frit CC263, a lead-free borosilicate frit with a thermal expansion coefficient (CTE) of 5.77 × 10^{-6}/K, which provides close compatibility with the ceramic substrate, preventing cracks and ensuring strong adhesion.[13,14] The glaze layer employs Ferro Frit 3195, with a slightly higher CTE of 6.7 × 10^{-6}/K, adding a smooth, protective surface that remains stable under heating.[13]Both frits are applied as aqueous slurries of pre-melted glass powders, then fired at 800–900 °C to produce a 180-360μm non-toxic coating layer that withstands repeated heating up to 650°C.[15,16] In typical household use, the coating remains stable for up to 10 years, significantly reducing the need for replacement and contributing to long-term sustainability.[17] The fired enamel surface is scratch-resistant and dishwasher safe, thanks to its high surface hardness (Moh's hardness ≈ 5-6). [17,18]

This two-layer design balances strong bonding with a smooth, scratch-resistant surface. As a result, the coating stays intact over time, resists daily wear and ensures safe and reliable performance in household cooking.

2.2.4 Mica Heating Ring

The mica heating ring is engineered with a five-layer structure to ensure high thermal efficiency, electrical insulation, and long-term durability. Layer 1 uses a 0.4 mm thick aluminium sheet (thermal conductivity ≈ 237 W/m·K),[19] which rapidly and evenly transfers heat to the cooking pot. Layers 2 to 4 use flexible phlogopite mica (LLI = 11.70), capable of withstanding up to 850 °C of continuous heating.[20] Its good dielectric strength (18-23 kV/mm)[21] and resistance to thermal shock makes it ideal for repeated heating cycles. Layer 3 also incorporates a 0.3 mm diameter $OCr_{25}Al_5$ (FeCrAl) heating wire, with the highest LLI overall (12.60), resistivity ≈ 1.42 μΩ·m and a total length of 0.88 m.[22] The wire is wound in a sawtooth pattern to maintain spacing, prevent crossing of wires, and improve safety and performance, with a calculated resistance of 17.68 Ω and the heater outputs approximately 2994 W of power at 230V. Heat spread is modelled using a Gaussian distribution indicating a symmetric thermal profile that improves energy uniformity. The outer shell (Layer 5) is made from ALCOT (aluminium-coated steel) (LLI = 10.08), capable of withstanding up to 600 °C and forming a stable Al_2O_3 layer for corrosion protection.[23] ALCOT is 90% aluminium and 10% silicon, offering thermal reflectivity, durability, and recyclability.[24] The mica layers are die-cut with precision notches, stacked, and clamped, while the outer shell is shaped through stamping and bending to enclose the heating elements securely.[25] Altogether, this layered configuration delivers efficient thermal transfer, safety, and longevity, making the design robust and aligned with both engineering and sustainability goals.

2.2.5 Aluminium Pot

The aluminium pot plays a critical role in transferring heat evenly from the heating ring to the ceramic cooking pot and providing structural support to the ceramic pot. Recycled aluminium (LLI = 7.56) has a thermal conductivity of approximately 150–180 W/m·K,[26] which is sufficient for the heat transfer demands of the aluminium pot. Its cost is lower and more stable than that of primary aluminium, as it is tied to scrap markets rather than global indices.[27] The aluminium pot has a wall thickness of 4mm, which provides sufficient structural support during normal use, even though recycled aluminium is mechanically weaker than pure aluminium or aluminium alloys.[28] Die casting is selected as the manufacturing method, as it improves strength by producing denser and more precise components, resulting in parts made from recycled aluminium to have a tensile strength of 172.25 N/mm² and a hardness of 26.7 RB.[29] In this process, molten recycled aluminium is injected into a steel mould at high pressure(100–150 MPa) and rapidly cooled to solidify the shape.[30] This method is especially effective for forming cylindrical pot structures with uniform wall thickness and smooth internal surfaces. Die casting offers significantly better surface finish and dimensional accuracy compared to sand casting.[30] Recycled aluminium is also very attractive as it is highly sustainable, mainly due to its low energy requirements in production and excellent recyclability.

2.2.6 Outer Casing

The outer casing holds the slow cooker together, prevents heat loss, and provides a polished finish to the product. Vacuum-insulated stainless steel (LLI = 10.08) was selected due to its excellent thermal insulation properties (thermal conductivity of 0.004-0.008 W/m·K)[31], corrosion resistance, high strength, and durability.[32] Furthermore, stainless steel (SS) has a clean modern look that appeals to most customers.

In manufacturing, 304 or 316 SS are typically used.[33] SS sheets are cut and deep drawn,[34] and then the inner vessel is placed concentrically inside the outer vessel and the edges are welded together via TIG (Tungsten Inert Gas) welding. The vacuum layer is then created by air evacuation via a small hole in the side and then the hole is sealed. 304 and 316 SS can both be produced from green steel process as recycling stainless steel produces high-quality material while consuming significantly less energy than virgin production, [35] reducing the overall CO_2 emissions.

3 Sustainability

StudioG's slow cooker design fully integrates sustainability at every stage, covering up-front carbon emissions, per-use energy, recyclability, durability, and material alternatives — all guided by a quantified material index.

Slow cookers are widely recognised for their low energy use, typically requiring about 1.32 kWh for a 10-hour cooking session on low heat (average ~132 W), and about 0.65 kWh for a 4–5 hour cook on high heat(average ~163 W), translating to approximately 277 g CO_2 per meal.[36] This design builds on this efficiency by incorporating a mullite–quartz-based ceramic pot, an optimised mica heating ring, and a vacuum-insulated stainless-steel casing for improved thermal performance.

The Loop Longevity Index was used to select materials for recyclability, durability, and low environmental impact. The mullite–quartz ceramic pot delivers higher thermal shock resistance and a lifespan of 100-120 heating cycles and releases no harmful emissions during production. The frit-based enamel coating's strong adhesion to the ceramic body ensures durability even under repeated thermal cycling. Within the mica heating ring, the FeCrAl wire performs reliably for thousands of hours; NASA tests confirm >2,300 hours at 900 °C with minimal damage.[37] A 90% aluminium and 10% silicon coating forms a stable Al_2O_3 layer on ALCOT that resists corrosion and scaling, maintains high thermal reflectivity, and ensures durability in dry and humid conditions.[38] Combined with the vacuum-insulated stainless-steel casing, these choices ensure a long service life and minimal replacements. Moreover, the stainless-steel casing maintains structural integrity for over 40 years under normal use, with high resistance to corrosion and stress cracking. [39]

Many components of this slow cooker incorporate the use of aluminium. Its global recycling efficiency rate is ~76%, and its high thermal reflectivity improves operational energy efficiency and durability, extending service life and reducing waste and, in use, it does not emit toxins when overheated.[40] We aim to use recycled aluminium for all relevant components, which will save up to 95% of the energy, leading to over 16 tonnes of CO_2 saved per tonne of recycled aluminium, significantly lowering emissions and energy requirements.[40] Aluminium provides high thermal conductivity (237 W/mK), service temperature ~400 °C, and lightweight strength at a lower environmental cost.[19,41]

At end-of-life, aluminium, FeCrAl, ALCOT, and stainless steel are fully recyclable through established recovery systems, minimising landfill waste and supporting a circular economy. The double layer frit-based coating itself is lead-free and non-toxic, but once fired onto the ceramic surface, it becomes fused with the ceramic pot body, preventing separation and making the entire ceramic component non-recyclable, though it remains inert and safe for disposal.[42,43] The design allows easy replacement of the ceramic insert extending the product's useful life by additional years. Our packaging uses only recyclable kraft cardboard and paper-based inserts, protecting the product during transit while enabling easy household recycling.[44]

Overall, by combining a data-driven material index, verified carbon data, realistic durability targets, clear alternative choices, and proven recycling routes, this slow cooker achieves comprehensive sustainability in manufacture, daily use, and end-of-life.

4 Cost Estimate

The initial capital expenditure required to launch the slow cooker involves essential manufacturing equipment. Based on listings from suppliers (see Appendix), the estimated capital investment for equipment is around £45,660. Assuming a lifetime of 15 years, no residual value and that the equipment will produce 17,300 units per year, depreciation per unit is estimated to be £0.18 per unit.[45] Per-unit manufacturing costs have been calculated including raw materials only (see Appendix). The resulting cost per unit is approximately £10.06-13.37. By using mass manufacturing processes, the cost per unit could potentially be lowered by around 20-30% giving a unit cost of £7-10.[46]

The total number of unit sales in the medium size segment of slow cookers was calculated based on the US slow cooker market share of $604.2M, with medium models comprising 46% and an average unit price of $80 (based on brands such as Ninja and CrockPot). From this data, the number of units sold annually was estimated (details of calculation in the Appendix).[47–49] This product aims to capture 0.5% of this segment in the first year, which is consistent with typical startup growth rates.[50] This translates to approximately 17,300 units. Based on these target production sales, the total costs in the first year are around £212,000 – £283,145 including overhead costs (~£47000). With transportation and marketing costs, total expenses could increase by around 30%.[51] The unit cost of mid-high end slow cookers is typically in the range of $9-11 (£6.64-8). Compared to this, the retail price will be around £50-80 which is around 10 times higher. Based on this, the Recommended Retail Price (RRP) will be around £75. Profits in the first year will amount to around £280,000 as around 50% of revenue will go to retail (details of calculation in the Appendix).[51]

To drive initial sales and build brand awareness, strategies such as an introductory offer could be implemented while aiming to capture 0.5% of the market ensures production volumes are manageable.

5 IP

To ensure that StudioG's slow cooker design does not infringe on any existing patents, detailed research into the existing IP landscape was done. "Heating Element for a slow cooker" (US6498323B1)[52] details a design very similar to StudioG's and includes details regarding the materials being used. "Slow cooker" (US79747928B2)[53] is a similar patent which includes a lid and housing rim that are not defined in the previous patent. Both these patents have expired, so there is no issue with using a similar design.

"Electric band heaters" (US3829657A)[54] describes the mica heating ring that is utilised in the slow cooker, and as this patent expired in 1991, it is permissible to include it in the design. However, "Mica heating ring" (CN212785903)[55], filed in 2020, builds on the previous patent's design with some added functionality allowing for adjustment in size. To avoid IP infringement from the patent holder, we will source the component directly from the company that holds the patent and pay the required licensing fees.

StudioG's slow cooker includes a novel outer casing made from vacuum insulated stainless steel, and two sets of ergonomic handles. This design can be protected by a patent; however, the overall patent application process can cost approximately £3000,[56] spread over 3 to 4 years. This price and the process length is costly; however, in order to protect potential profits, it is necessary.

A Appendix

A.1 GenAI Declaration

We acknowledge the use of GenAI in the capacities detailed below.

ChatGPT-4, published by OpenAI (https://openai.com/chatgpt/overview/) was used in the Executive summary, introduction, design rationale, materials selection index, mica heating ring, outercasing, IP sections and sustainability of this report for paraphrasing and checking grammar and correct usage of punctuation. It was also used to give advice on structuring text and sentences. ChatGPT was used as a guide and to provide suggestions that were then worked into the existing text. All the ideas are from the respective writers and no ideas were altered or generated by the tool.

Grammarly (https://www.grammarly.com/) was used in the Ceramic Coating of cooking pot to check for grammar and spelling errors during final work. ChatGPT-4, published by OpenAI (https://openai.com/chatgpt/overview/) was used for a grammar check of the initial version. No content, structure or ideas were generated or altered by the tool.

ChatGPT-4, published by OpenAI (https://openai.com/chatgpt/overview/) was used in the aluminium pot section to generate references. Each reference was checked for validity and the most relevant references were utilised. ChatGPT was also used to check for grammar and spelling issues, but all ideas were from the writer.

ChatGPT-4, published by OpenAI (https://openai.com/chatgpt/overview/) was used in the Cost estimate section. It was used to verify logic behind calculations and advise on manufacturing costs. All ideas were from the writer.

ChatGPT-o3, published by OpenAI (https://openai.com/chatgpt/overview/) was used in the Ceramic cooking pot section for paraphrasing, grammar checking, and structural guidance; all conceptual content is my own. Its deep-research feature was also employed to investigate the manufacturing process since reliable details were difficult to find by a simple Google search and then those findings were verified against multiple reputable websites.

A.2 Author Contributions

Executive Summary: Mary, Ezekiel
Introduction: Alex
Design Proposal: Alex, Ezekiel
Materials Selection: William, Muizz, Jessie, Mary, Luna, Petal, Meghna
Sustainability: Mary, William, Muizz, Jessie, Luna
Cost Estimate: Meghna, William, Jessie, Mary, Petal, Alex
IP: Alex
Technical Drawings: Luca, Harsh, Samuel, Marlon
Website: Vlad
Edited by: Samuel, Alex, Luna, Mary

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A.4 Appendix From Report

A.4.1 Material Selection LLI Definition

$$LLI = R \times L$$

Where:

$R = \sqrt[3]{C1 \times C2 \times C3}$ represents the material's recircularity (recyclability, biodegradability, renewability).

$L = \sqrt[3]{C4 \times C5 \times C6}$ represents the material's longevity (mechanical resistance, environmental resistance, thermal stability).

A.4.2 Material Selection Index Table

Component	Material	C1	C2	C3	C4	C5	C6	R	L	LLI
Cooking Pot	Mullite–Quartz Ceramic	4	1	4	4	4	4	2.519842	4	10.07937
	Stoneware	2	2	2	2	2	2	2	2	4
	Aluminium (with coating)	3	1	2	3	3	2	1.817121	2.620741	4.762203
Mica sheet	Phlogopite Mica	4	1	5	4	4	5	2.714418	4.308869	11.69607
	Muscovite Mica	3	1	3	3	3	4	2.080084	3.301927	6.868285
Heating wire	OCr25Al5	4	1	5	5	4	5	2.714418	4.641589	12.59921
	Ni80Cr20	4	1	3	4	3	4	2.289428	3.634241	8.320335
Outer layer (mica ring)	ALCOT	4	1	4	4	4	4	2.519842	4	10.07937
	SECC	2	1	2	2	2	2	1.587401	2	3.174802
Aluminium pot	Pure Aluminium	3	1	3	3	3	3	2.080084	3	6.240251
	Recycled Aluminium	4	1	4	3	3	3	2.519842	3	7.559526
	Al-Si Alloy	3	1	3	4	4	4	2.080084	4	8.320335
	6061 Aluminium Alloy	3	1	4	4	4	4	2.289428	4	9.157714
Outer casing	Vacuum-insulated Stainless Steel	4	1	4	4	4	4	2.519842	4	10.07937
	Thermally Insulating Polymer	3	2	3	3	3	3	2.620741	3	7.862224
Coating cooking pot	Vitreous Enamel Coating	2	1	4	5	5	5	2	5	10
	PTFE Coating	2	1	2	2	3	2	1.587401	2.289428	3.634241

Table 1 Loop Longevity Index (LLI) scoring of candidate materials for each slow cooker component. Scoring is based on six criteria (C_1–C_6): recyclability, biodegradability, renewability, mechanical resistance, environmental resistance, and thermal stability. Values of R (circularity), L (longevity), and their product LLI (Loop Longevity Index) are calculated for each material. Selected materials (highlighted in red) demonstrate the highest balance of sustainability and performance for their respective components.

A.4.3 Mica Heating Ring— Energy efficiency and Heat distribution calculations

Energy efficiency: Resistance $R = \frac{\rho L}{A}$, $P = \frac{V^2}{R}$ (at V = 230 V),

Heat distribution: Gaussian distribution $T(x) = \exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right)$ where x is the position across the band, μ = 15 mm is the centre of the mica band (½ of the 30 mm band width), and σ ≈ 7.5 mm (¼ of the 30 mm band width)

A.4.4 Aluminium pot material choice comparison

Material Type	Thermal Conductivity(W/m·K)	Strength (Yield)	Approx. Price(USD/kg)	Used by	Notes
Pure Aluminium (1100)	~237	Very Low (~35 MPa)	~$2.0–2.5	G20	High conductivity, low strength, assumed for G20 based on material analysis
Recycled Aluminium	**~210–230 (estimated)**	Low	**~$1.5–2.0**	G19	**Cost-effective and sustainable**, lower consistency and strength
Al–Si Alloy (e.g. A356)	~160–170	Medium–High (~200 MPa)	~$2.5–3.0	G21	Castable, stronger, used in mid/high-end cookware
6061 Aluminium Alloy	151–202	High (~240 MPa)	~$3.0–3.5	—	Strong, reliable, widely used in structural applications

Table 2. Comparison of thermal conductivity, strength, and cost of selected aluminium materials for Aluminium Pot.

A.4.5 Ceramic material choice comparison

Property	Mullite–Quartz Ceramic (60–65% mullite, 35–40% quartz)	Stoneware	Aluminium (with coating)
Thermal Shock Resistance	Excellent (ΔT > 250°C)	Moderate ($\Delta T \approx$ 100–150°C)	Poor (ΔT < 70°C) – distorts under sudden temperature changes
Thermal Conductivity	Moderate (1.7–2.5 W/m·K) – ideal for gentle, even heat	Low–moderate – uneven heating without thermal mass	Very high (≈205 W/m·K) – heats rapidly, prone to hot spots
Heat Retention	High – retains heat after cooking, reduces energy needs	High – good for stews/soups	Low – cools quickly once heat is off
Fracture Toughness	2.5–3.0 $MPa \cdot m^{1/2}$ – resists cracking from use, minor knocks	1.5–2.0 $MPa \cdot m^{1/2}$ – more brittle, higher porosity	Ductile – no fracture but dents/deforms easily
Strength	170–190 MPa	70–100 MPa	150–250 MPa
Food Safety	Inert, non-reactive, no leaching	Safe if glaze is food-grade; risk if poorly applied	Requires coating; uncoated Al can leach into acidic foods
Durability	100–120 thermal cycles before failure	60–80 cycles	40–60 cycles
Manufacturing Complexity	Moderate – needs precise control over phases and cooling	Low – natural clays, variable composition	Low – fast, scalable mass production
Unit Production Cost	\$3.50–4.00	\$2.50–3.00	\$2.00–2.50 (including coating)
Visual Appeal	High – premium, heavy, solid	Rustic feel	Low – utilitarian look, unless coated or anodised

Table 3. Comparison of ceramic material options based on thermal, mechanical, food safety, cost and manufacturing criteria.

A.4.6 Comparison of coating system candidates for ceramic coating

Property/Material	Frit-based enamel	Sol-gel	PTFE
Thermal stability (°C)	Up to 650 °C (no degradation)	~400–600 °C (depends on type)	Max 260 °C (degrades/toxic)
Scratch Resistance	Mohs hardness 5–6	Moderate (3–4), weaker over time	Very good initially
Dishwasher Safe	Yes	Generally yes	Risk of degradation
Environmental Sustainability	Energy-intensive but long life	Low-temp, low energy	Non-biodegradable, non-recyclable
Adhesion to Ceramic Substrate	Strong (via bonding layer)	Moderate to good	Poor, often delaminates
Process Temperature(°C)	800°C-900°C	250°C-430°C	360°C-400°C
Durability in Household Use	Up to 10 years (long life, stable quality)	Shorter life (~2–5 years)	Surface damage after months
Toxicity / Food Safety	Inert, food-safe	Inert (if processed correctly)	Toxic fumes when overheated
Coefficient thermal expansion	Customize	Customize	$70\text{-}150 \times 10^{-6}$/K
Cost/m²	\$3-\$7	\$1.5-\$4	\$0.5-\$2

Table 4. Comparison of ceramic coating based on different performance criteria.

A.4.7 Oxide Composition Ranges of Ferro Frit CC263 and 3195 (wt%)

Oxide	Ferro Frit CC263	Ferro Frit 3195
SiO_2	25–50%	25–50%
B_2O_3	25–50%	25–50%
Al_2O_3	5–15%	5–15%
CaO	5–15%	5–15%
MgO	<5%	Not present
SrO	<5%	Not present
ZrO_2	<5%	Not present
Alkalis(Na_2O/K_2O)	5–15%	5–15%

Table 5. Oxide composition range (wt%) of Ferro Frit CC263 and Ferro Frit 3195

A.4.8 Heating Wire selection

Property	OCr25Al5 (FeCrAl)	Ni80Cr20 (Nichrome)
Max Operating Temp	1250 °C	1100°C
Resistivity	~1.42 µΩ·m	~1.09 µΩ·m
Density	~7.1 g/cm³	~8.4 g/cm³
Oxidation Resistance	Excellent (forms Al_2O_3)	Good (forms Cr_2O_3)
Ductility/Forming	Low (brittle)	High (ductile, easy to form)
Cost	Low (no nickel)	High (80% nickel)
Recyclability	High	High
Environmental Impact	Low	High (nickel mining impact)

Table 6 Material selection of heating wire based on varies properties.

A.5 Cost Estimate

Table 7. Capital expenses

Type of production	**Equipment**	**Subtotal/£**	**Listings**
Metal forming	hydraulic press, polishing machine	9285	[1] [2]
Ceramic	ball mill, spray booth, kiln, drying oven	25,719	[3] [4] [5] [6]
Safety	reusable PPE, ventilation	486	[7] [8]
Total		35,490	

Table 8. Raw materials

Component	**Materials**	**Unit Price/ £**	**Sources**
Outer housing	stainless steel	3.20-6.40	[1] [2] [3] [4]
Ceramic coating	SiO_2, B_2O_3, Al_2O_3, CaO, MgO, SrO, ZrO_2	0.53-0.64	[6] [7] [8] [9] [10] [11] [12] [13]
Ceramic Cooking pot	calcined alumina (Al_2O_3), kaolin, SiO_2 powder (quartz)	2.01	[14] [15] [16]
Heating element	mica ring	1.07	[17] [18]
Aluminium pot	recycled aluminium	2.80	[19]
Glass lid		0.45	[20]
Total		10.06-13.37	

Table 9. Production-Level Overhead Costs

	Description	Cost	Sources
Labour costs	For different stages of manufacturing and quality checks	3.50 (unit)	[1]
Packaging	cardboard box, foam packaging	1.34 (unit)	[2] [3]
Safety	disposable PPE	£0.3-£1.00 (per worker)	[4]

Unit sales estimate

$$Total\ units\ sold = \frac{Total\ Revenue}{Average\ Revenue\ per\ unit}$$

Where the “Total Revenue” is the estimated revenue for the medium size segment of slow cookers.

Profit

$$Profit = Revenue - Cost = (75 \times 17300 \times 0.5) - (283145 * 1.3)$$

This includes 30% increase in costs from reasons mentioned in the estimate