

MistiFry

Technical Report

Ultrasonic Mist Infusion Air Fryer - Design & Manufacture

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1. Introduction & Project Overview

MistiFry is a premium, mid-size domestic air fryer engineered around a core proposition that goes beyond the conventions of its product category. Competing air fryers compete primarily on cooking performance and capacity whereas MistiFry introduces a pulsed ultrasonic mist system integrated directly into the cooking cavity - a feature that fundamentally changes what an air fryer can do.

This report documents the full design and development of MistiFry: a 5-7 litre family-sized air fryer intended for permanent worktop placement in a domestic kitchen, targeting health-conscious home cooks and families who value both cooking quality and low-effort maintenance.

1.1 The Design Opportunity - Starting With the Brief

The brief established two clear non-negotiables: ease of cleaning and safety. Initial research in TP2 approached these as the primary design problems to solve. The findings confirmed they are genuine issues in the current air fryer market. Observational research and task analysis conducted (See TP1 Logbook) with users across a range of existing air fryer products identified three consistent pain points.

1. Grease and food residue accumulate in areas that are physically inaccessible during cleaning - particularly the cavity ceiling, the underside of the heating element and the area around the fan housing. Users improvised with brushes and soaking with inconsistent results.
2. The heating element itself - fixed in place across every product analysed, from budget supermarket brands through to premium models including Philips, Ninja and Tefal. This was identified as the single hardest component to clean safely. Its position, its proximity to electrical connections and fragility make thorough cleaning impractical for most users.
3. The difficulty of cleaning meant that users actively avoided or delayed the task, leading to hygiene concerns and a degraded cooking performance as built-up grease affected air circulation and heat distribution.

These findings established a clear design direction: the product needed to make cleaning dramatically easier, and the heating element needed to be accessible. Both requirements are met in the MistiFry design - but they are not the key feature the product leads with.

1.2 Reframing the Proposition - Surprise and Delight

A critical decision in the MistiFry design process was recognising that 'easier to clean' is a rational benefit, but not an emotionally compelling one. A product positioned primarily around cleaning is, at its core, positioned around a chore. TP2 research and concept development (See TP2 Logbook) led to a reframing of the product proposition: rather than leading with what MistiFry solves, the product leads with what MistiFry enables.

The integrated mist system - originally a mechanism for the self-cleaning cycle - was identified as having a far more exciting primary application: food. By pulsing a fine water or aqueous flavoured solution mist into the cooking cavity during the cook cycle, MistiFry can moisten food during air frying. This prevents the dryness that is one of the most common criticisms of air frying, particularly for chicken, fish and reheated foods.

The tank can be filled with flavoured water, diluted stocks or infused liquids enabling users to introduce flavour into food through mist during cooking - a technique previously associated only with professional kitchen equipment.

This repositions MistiFry from a 'cleaner air fryer' to an 'air fryer that can infuse and moisten food' - a novel cooking capability presented as the hero feature. The product's three modes reflect this hierarchy: Cook (standard air frying), Infuse (air frying with pulsed mist - the primary differentiator) and Clean (mist and fan cycle for cavity cleaning - the secondary surprise). Users who purchase MistiFry for its cooking capability discover that it is one of the easiest air fryers they have ever had to clean. That sequence - capability first, convenience second - is the surprise and delight design intent.

1.3 Key Research Findings from TP2

Market penetration and usage context. Air fryer ownership in the UK has grown substantially - 61% of UK households now own an air fryer, with the majority using it to cook for two [10]. The global air fryer market is projected to continue growing through 2030 [11], reflecting sustained consumer adoption.

Safety concerns as a validated design problem. Safety issues within the category are well documented. A 2025 survey found that nearly one in five UK adults had encountered potential or actual fire hazards in their homes due to air fryers [9]. Formal product recalls have been issued for air fryer models including Tower, citing overheating and fire risk [3], and safety experts have issued public warnings about air fryer use in domestic settings [2] [7].

Product lifespan and landfill contribution. Small appliances including air fryers frequently end up in landfill due to poor repairability and difficult-to-clean components that accelerate product deterioration [1]. Grease coating degradation and non-cleanable heating elements are identified as the primary reasons users replace their air fryers prematurely [8] - a problem MistiFry's removable element and self-clean system directly addresses by extending usable product life.

Accessibility and user diversity. Approximately 400,000 people in the UK live with rheumatoid arthritis [4], a condition that significantly affects hand function and grip strength [5]. This represents a meaningful portion of the target user population for whom conventional air fryer interactions - sustained grip, reaching into a hot cavity, and manual scrubbing - present genuine difficulties. MistiFry's single-encoder interface and automated cleaning cycle reduce the physical demands of both use and maintenance.

Academic evidence for the cleaning mechanism. The fat hydrolysis principle underpinning the MistiFry self-clean cycle is supported by peer-reviewed research confirming that water contact promotes the breakdown of polymerised cooking fats [6], validating the scientific basis of the mist-based cleaning approach.

The closest cleaning innovation identified in the competitor analysis was the use of dishwasher-safe removable baskets and trays, which address only the lower cavity and leave the heating element and cavity ceiling entirely unaddressed. Research into products in professional catering, steam ovens and microwave technology confirmed that controlled humidity during cooking is a well-established technique for improving food texture and enabling flavour transfer.

No domestic air fryer product currently brings this capability to market. This gap, identified through both market research and technical investigation in TP2, defines MistiFry's commercial opportunity as clearly as it defines its design brief.

1.4 Target Users & Context of Use

MistiFry has been designed for two primary user groups whose needs are complementary.

1. Health-conscious home cooks are the core audience - adults who have adopted air frying as part of a low-oil cooking routine and who are interested in cooking quality, ingredient integrity, and the long-term hygiene of their kitchen equipment. For this group, the mist infusion capability is a genuine cooking upgrade, and the stainless steel, PTFE-free cavity addresses a growing awareness of chemical coatings in cookware.
2. Families are the secondary audience, for whom ease of use and low maintenance effort are the priority - a product that cooks well and practically cleans itself is a compelling proposition for a busy household.

The product is designed for permanent worktop placement in a domestic kitchen - not stored away between uses. This decision is both a design constraint and a brand statement: MistiFry is intended to be a considered, desirable object on the worktop, not an appliance that gets hidden in a cupboard. The 5-7 litre capacity serves family-sized portions whilst maintaining a footprint compatible with standard UK kitchen worktop dimensions. The single rotary encoder interface, developed and validated through prototype electronics, is designed to be operable with one hand in a busy cooking environment.

2. Updated Product Design Specification (PDS)

2.1 PDS Table

Requirement	Specification	Justification / Source
Function - Cooking Performance	Must air-fry food effectively using a high-speed convection fan and heating element operating between 80°C and 220°C. Temperature accuracy $\pm 5^\circ\text{C}$. Timer range 1-60 minutes. Must achieve equivalent crispness to leading competitors (Philips, Ninja) at equivalent settings.	Core function must not be compromised by the addition of mist system.
Function - Mist Infusion (Primary Feature)	Integrated ultrasonic mist module must deliver a controlled fine mist into the cooking cavity during the cook cycle when 'Infuse' mode is selected. Mist must be food-safe and distributed evenly across the cavity. Mist and heat operate simultaneously in this mode.	Primary feature of MistiFry - moistens and infuses food during cooking, improving texture and enabling flavour infusion. Identified as a surprise-and-delight feature through concept development.
Function - Self-Clean Cycle (Secondary Feature)	A dedicated 'Clean' mode activates mist and fan simultaneously (no heat) to loosen grease and food residue from cavity surfaces. Clean cycle duration: 5 minutes. Water tank must hold sufficient volume for a full clean cycle. Post-mist, fan continues to aid drying.	Secondary surprise-and-delight feature. TP2 research showed users avoid cleaning - this must require minimal user effort. No detergents required; water mist + airflow sufficient.
Removable Heating Element	Heating element must be removable by the user without tools. Mechanism: lift and pull with spade electrical connections (like electric hob hotplate removal). Element must seat positively and lock securely during use. Electrical connection must be rated for the full operating current of the element. Safety interlock must prevent operation if element is not correctly seated.	Key usability and hygiene requirement identified in TP2 task analysis. Spade connectors are a proven, low-cost, high-reliability connection method used in comparable appliances.
Water Tank	Removable side-mounted water tank with lid for top-fill access. Tank capacity: 500ml - sufficient for a full clean cycle plus 40-50 minutes of infuse-mode cooking. Food-safe material (PP or PETG). Tank must be dishwasher safe. Clear or translucent to allow water level visibility. Drip-free removal when tank is lifted out.	Side-mounted removable tank identified as most ergonomically accessible fill method in TP2 user observation. Translucency required so user can check water level without removing the tank.
User Interface	Rotary encoder with integrated push-to-select function. OLED or equivalent display showing selected mode (Cook / Infuse / Clean), set temperature (Cook and Infuse modes only, range 80-220°C in 1°C increments) and timer. Mode selection made by rotating encoder. Temperature and timer adjusted in settings sub-menu. Single confirm press to start cycle.	Prototype electronics validated this UI approach. Rotary encoder provides tactile, single-hand operation suitable for users with wet or greasy hands during cooking. Minimal button count reduces complexity for family users.
Capacity	5-7 litre internal cooking cavity. Must accommodate a whole chicken (approx. 1.5kg) or equivalent family-sized portion. Basket and tray must be dishwasher safe.	Target user group (health-conscious home cooks and families). 5-7L is the dominant family-size category in the UK market.
Materials - Housing	Outer housing: Polypropylene (PP) preferred over ABS for recyclability. Housing must be heat-resistant to at least 80°C surface temperature. Matte surface finish to minimise visible fingerprints on worktop appliance.	PP selected over ABS due to recyclability TP2 sustainability research supports material choice.

Requirement	Specification	Justification / Source
Materials - Cooking Cavity	Stainless steel for all internal cavity surfaces in contact with food or mist. No PTFE or non-stick coatings - consistent with health-focused product positioning and eliminates coating degradation risk. Brushed or electropolished internal finish for cleanability.	Stainless steel 304 is food-safe, corrosion-resistant, steam-compatible, and consistent with health-conscious values. PTFE-free aligns with growing consumer concern over PFAS chemicals in cookware. TP2 user research confirmed this was a priority for the target user group.
Safety	Electrical safety: compliance with IEC 60335-1 (household appliances) and IEC 60335-2-9 (toasters/grills - applicable part). Heating element interlock: appliance must not energise element if not correctly seated. Thermal cut-out at 230+°C. Water ingress protection: control electronics must be physically separated and sealed from water tank and mist module area. Mains fusing: 13 A. Earth bonding on all metal parts. Child safety: no exposed heating surfaces accessible during operation.	Mains heating element and water system in proximity represents the primary safety design challenge. IEC 60335 compliance required for CE/UKCA marking and UK retail sale.
Sustainability	Housing in recyclable PP. Stainless steel cavity is fully recyclable. Self-clean cycle reduces reliance on chemical cleaning products. Target product lifespan: 10 years minimum. Packaging: recyclable cardboard, no single-use plastic. Energy consumption: 1000-1800W typical - to be benchmarked against Philips and Ninja equivalents.	Sustainability credentials are a purchasing driver for the health-conscious target user. PP housing and steel cavity both have established recycling pathways.
Manufacturing Cost Target	Target manufacturing cost: £30-£45 per unit at volume (10,000+ units). Target retail price: £100-£150. Gross margin target: approximately 65-70% at retail, consistent with premium small appliance category norms. Key cost drivers: stainless steel cavity, ultrasonic mist module, OLED display and rotary encoder assembly.	Premium £100-£150 retail positioning confirmed through TP2 competitor pricing analysis. Philips premium air fryers retail at £80-£130; MistiFry's mist infusion feature justifies a price premium over standard models.
Ergonomics & Dimensions	Footprint: maximum 310mm W × 270mm D for worktop compatibility. Height: maximum 350mm. Tank removal: single-hand operation. Rotary encoder height and position: accessible from standing adult height without bending. Total product weight: 5-7 kg when empty.	Permanent worktop placement context (from TP2) requires a considered, compact footprint. Ergonomic requirements derived from TP2 observational research with target users.

The specification prioritises food safety and health-conscious brand values throughout. The PDS aims target a £100-£150 retail price point for a premium product.

2.2 PDS Calculations

These calculations were completed to prove rationale in the PDS

Calculation 1 - Water Tank Capacity

	Calculation 1 - Water Tank Capacity
Purpose	Determine minimum tank capacity to support a full Infuse cook cycle and a full clean cycle without refilling.
Given	Infuse pulse pattern: 30s ON / 90s OFF Max cook cycle: 60 min clean cycle: 5 min continuous Target tank: 500ml
Step 1 - Infuse active mist time	Pulse period = 30 + 90 = 120s → Pulses in 60 min = $3,600 \div 120 = 30$ pulses → Active mist time = $30 \times 30s = 900s = 15$ minutes
Step 2 - Total active mist time (worst case)	Infuse (60 min cook) = 15 min active + Clean (5 min continuous) = 5 min → Total = 20 minutes active mist per full fill
Step 3 - Max allowable flow rate	Max flow rate = $500ml \div 20 \text{ min} = 25ml/min = 1500ml/hr$ Typical 20mm 113kHz modules: 300-500ml/hr
Step 4 - Clean cycles per fill	Water per 5-min clean $500ml/hr = 500 \times (5/60) = 41.7ml$ → $500ml \div 41.7ml = 12$ clean cycles minimum per fill (approx. 2-3 weeks of daily cleaning)
Result	Water tank capacity = 500ml Max module flow rate $\leq 1500ml/hr$ clean cycles per fill ≥ 12

The above calculation is to calculate the water tank capacity based on the flow rate of the atomiser module.

Calculation 2 - Heating Element Current Draw & Fuse Rating

	Calculation 2 - Heating Element Current & Fuse Rating
Purpose	Derive operating current and confirm correct UK plug fuse rating for a 1000W element.
Given	Element power: $P = 1000W$ UK mains voltage: $V = 230V$ AC nominal (BS 7671)
Step 1 - Operating current	$I = P \div V = 1000 \div 230 = 4.35A$
Step 2 - Fuse selection	BS 1362 fuse ratings available: 3A and 13A $4.35A > 3A$ rating - 3A insufficient Next standard rating = 13A - selected Standard for all UK appliances rated 700W-3000W
Result	Operating current = 4.35A Fuse = 13A (BS 1362) Element = 1000W 230V AC

Although the prototype will not be using mains power, for DFMA purposes a calculation for the operating current is needed.

Summary of All Derived Specification Values

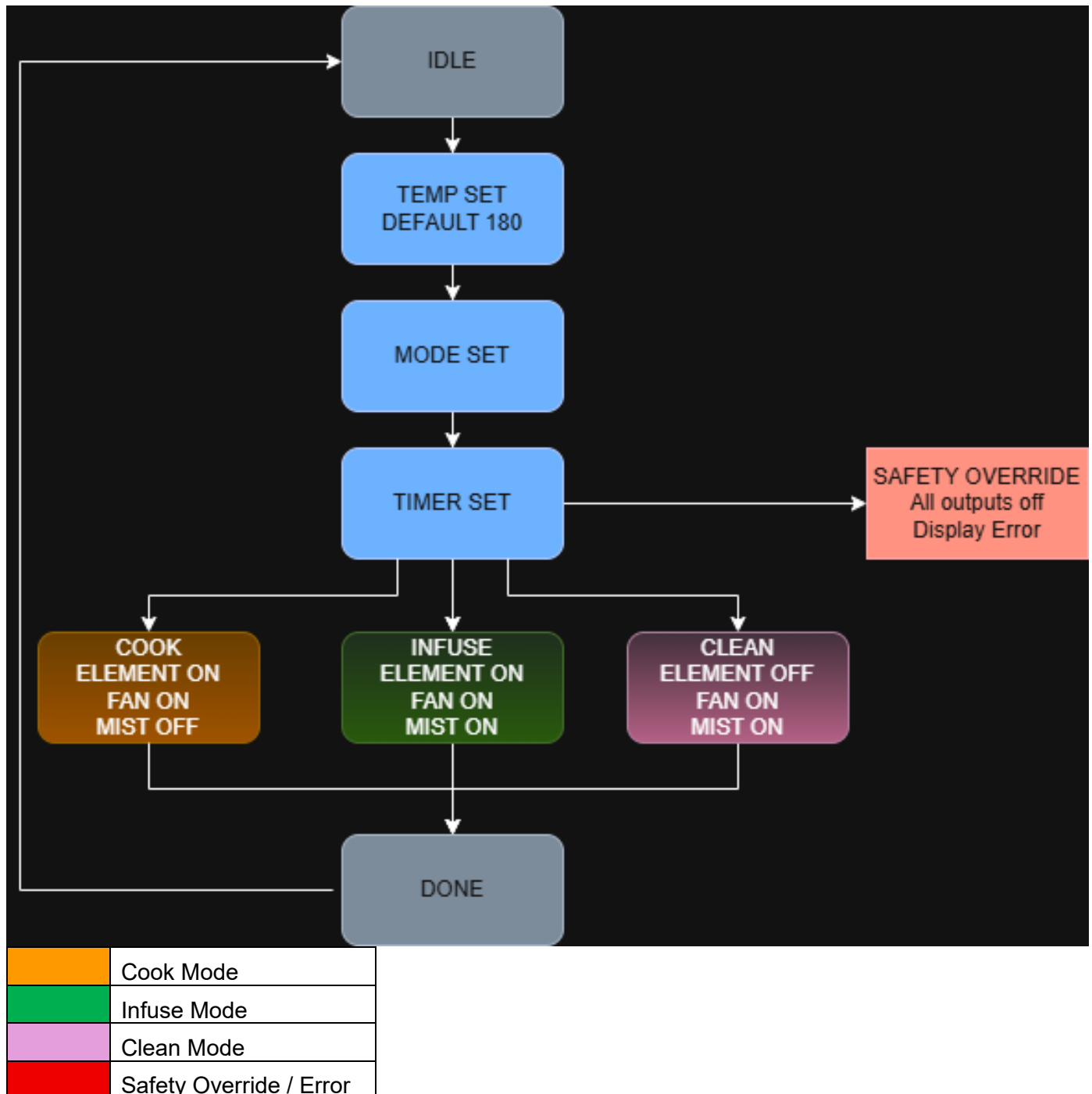
Specification	Derived Value	Calculation Basis
Water tank capacity	500ml	Calc 1: supports ≥ 12 clean cycles and worst-case 60-min Infuse per fill
Mist module max flow rate	$\leq 1500ml/hr$	Calc 1: $500ml \div 20 \text{ min}$ worst-case active mist time
Clean cycles per fill (500ml)	≥ 12 cycles	Calc 1: $500ml \div 41.7ml$ per cycle 500ml/hr
Heating element rating	1000W	Design decision - standard UK domestic air fryer rating
Operating current (element)	4.35A	Calc 2: $I = P \div V = 1000 \div 230$
Mains plug fuse	13A (BS 1362)	Calc 2: 4.35A exceeds 3A rating - 13A is next BS 1362 standard
Clean cycle duration	5 minutes	Design decision - validated by Calc 1 tank capacity

3. User Interaction & Context of Use

This section documents how a user interacts with the MistiFry across its three operating modes: Cook, Infuse, and Clean.

3.1 Interface Overview

All three modes are accessed through a single rotary encoder with an integrated push-to-select function and an OLED display. This interface was developed and tested on the MistiFry scale prototype. The interaction logic is consistent across all modes: rotate to select or adjust a value, press to confirm and press again to start. This single-control approach was chosen deliberately to keep the interface learnable, minimal and usable in a kitchen context where the user may be distracted, holding food or managing multiple cooking tasks simultaneously.

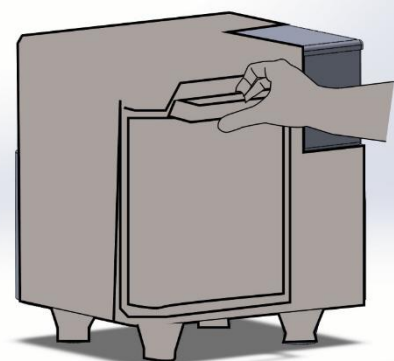
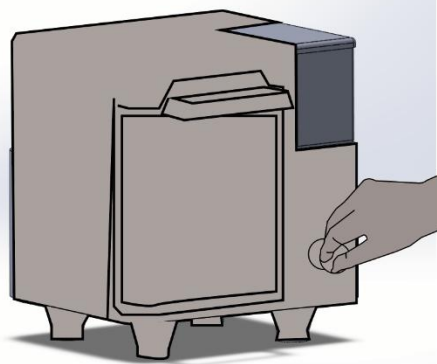
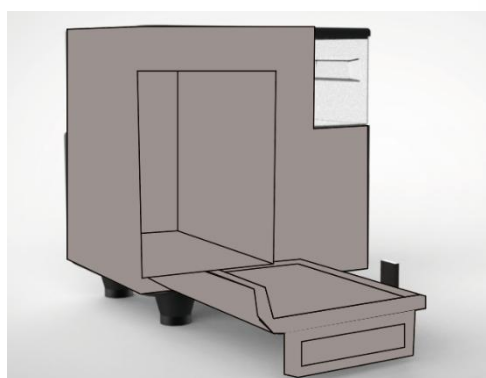


3.2 User Journey

1. Cook mode operates the heating element and convection fan only - no mist.
2. Infuse mode is the primary differentiating feature of MistiFry. The mist module pulses on a 30-seconds-on, 90-seconds-off cycle during cooking. This pulsed approach was chosen for two reasons: to conserve water tank volume across a full cook cycle and to prevent over-saturation of food, which can compromise crispness in air-fried dishes.
3. Clean mode is the secondary surprise-and-delight feature of MistiFry. It uses the mist module and convection fan without heat to loosen grease and food residue from the internal cavity walls. This removes the need for manual scrubbing of the cavity interior. The user's primary cleaning task is reduced to a simple wipe-down after the cycle is completed and the separate hand-washing of the removable heating element.

The fan-circulated mist reaches all internal surfaces including the cavity ceiling and walls where grease accumulates during cooking.

Step	Cook Mode	Infuse Mode	Clean Mode
1	Place food into basket. Slide basket or tray into cavity	Check water tank level and fill if required	Allow appliance to cool fully. Remove basket + trays
2	Rotate encoder to select 'COOK' mode.	Rotate encoder to select INFUSE. Adjust temperature	Rotate encoder to select CLEAN. Press to confirm. Set timer (recommended 5 minutes)
4	Press to confirm temperature. Rotate to set timer (1-60 min). Press to start	Press to confirm temperature. Rotate to set timer. Press to start	Press to start
5	Element energises. Fan starts. Countdown begins. Door can be opened, heating pauses and resumes on close	Element energises. Fan starts. Mist pulses 30s on / 90s off. If tank empties mid-cycle cooking continues without mist	Fan starts at full speed. Mist runs continuously. No heat. Mist loosens grease from all cavity surfaces
6	Timer elapses. Beep × 3. Element and fan off	Timer elapses. Beep × 3. All systems off	Timer elapses. Beep × 3. Fan continues 60s post-cycle to aid drying. Wipe cavity with cloth





^ Keyshot Render using Vizcom



^ CAD Image using Vizcom

3.3 Context of Use

MistiFry is designed for permanent worktop placement in a domestic kitchen. MistiFry's considered form factor and premium finish are intended to make it a desirable worktop presence - similar to a high-end kettle or coffee machine. The footprint must be compatible with standard UK kitchen worktop depths, the control interface must be accessible from standing height without requiring the user to move the appliance and the side-mounted water tank must be fillable and removable without clearing surrounding worktop items.

The two primary user groups, health-conscious home cooks and families interact with the product in different but compatible ways.

Health-conscious users are likely to engage with Infuse mode regularly, experimenting with flavoured mist infusions and using the product as a centrepiece of their cooking routine.

Family users are more likely to use Cook mode for everyday meals and value Clean mode as the feature that makes owning an air fryer low effort to maintain. Both groups benefit from the simplified single-encoder interface and the intuitive three-mode structure.



^ Keyshot Render in Situ using Vizcom

4. Final Design & Technical Details

This section documents the final design of MistiFry, the technical rationale behind its key sub-systems and the manufacturing and sourcing strategy for commercial production.

4.1 Final Design Description

Form Factor & Architecture

MistiFry is a front-loading air fryer. The cooking cavity is accessed via a hinged glass-fronted door on the front face of the appliance, rather than the pull-out basket drawer used by the majority of competitors.

1. It allows the user to see into the cooking cavity during operation without interrupting the cook cycle - an improvement in usability over drawer-style products where checking food requires fully removing the basket.
2. The oven-like form factor accommodates a more versatile internal cooking arrangement: a rack, perforated trays and a drip tray, all on runners built into the cavity side walls - rather than the single basket constraint of most air fryers.
3. The separation of the door from the cavity makes the self-cleaning cycle more effective: with the door closed, mist and fan-circulated airflow is fully contained within the cavity maximising cleaning coverage.

The fan is located on the side of the cavity, circulating air across and under the food in a circular convection. The water tank is mounted on the top right-hand side panel of the appliance, accessible via a top-fill lid. The tank can be fully removed by lifting it out of its aperture.

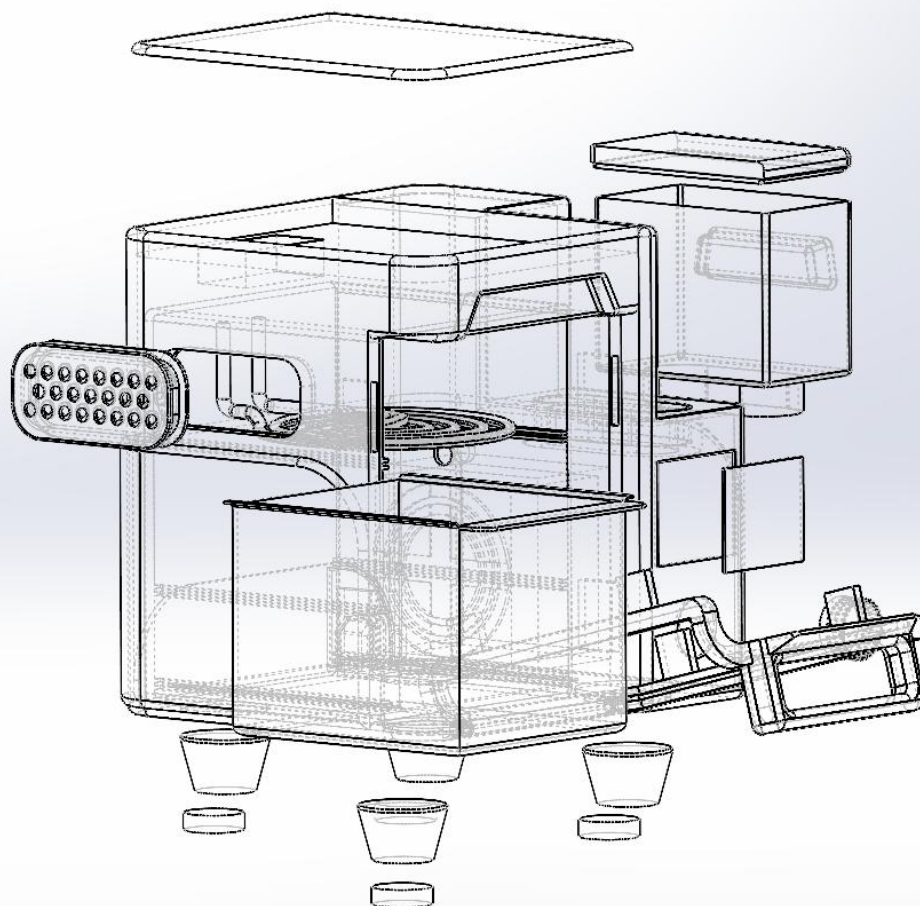
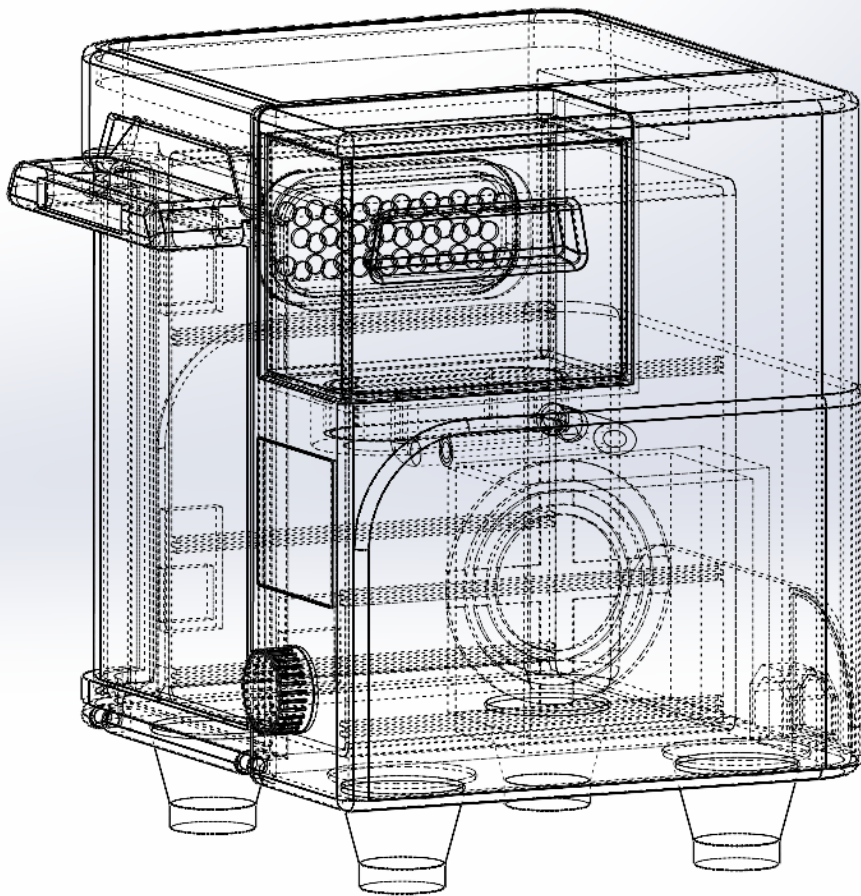
The ultrasonic mist module is seated in the side of the tank, with the mist output ducted through the right-hand side cavity wall to deliver mist into the cooking space.

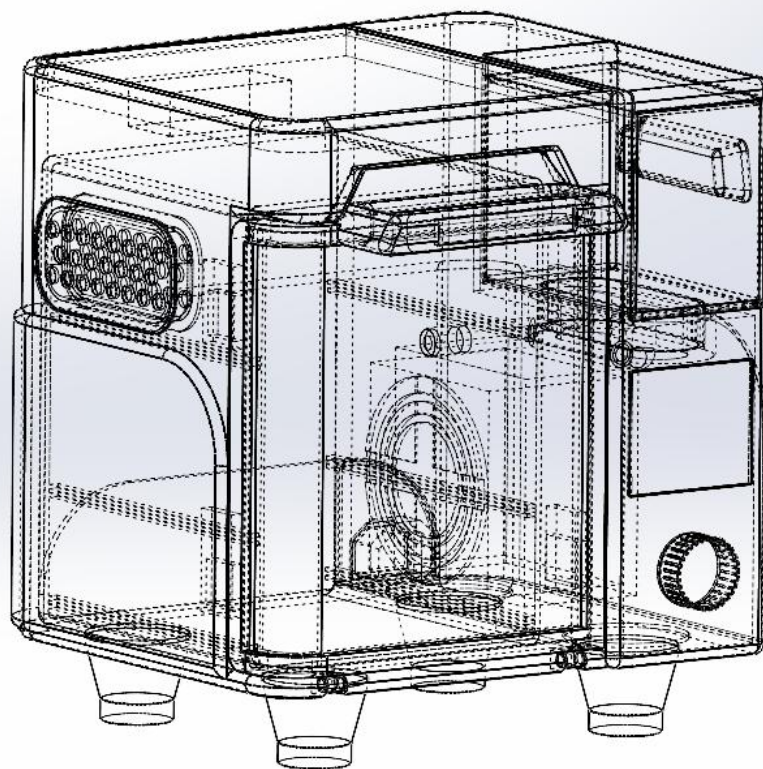
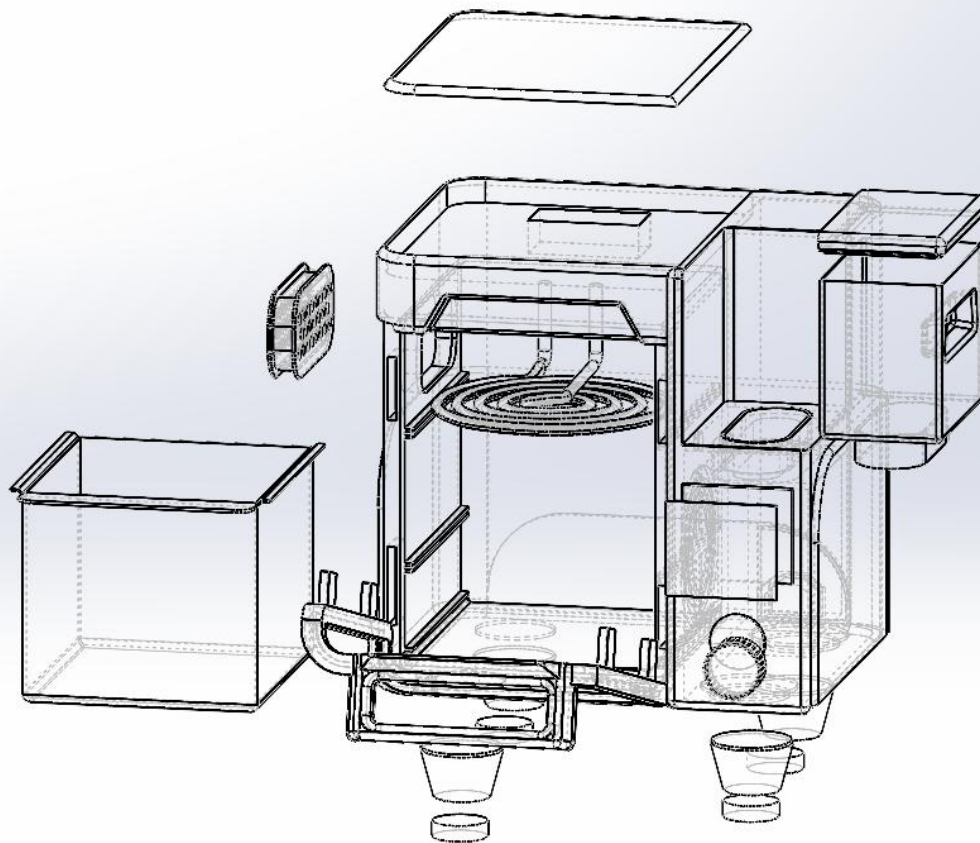
The control interface, a single rotary encoder with OLED display is mounted on the bottom-right of the front face, to the side of the door. This position is accessible from standing height without requiring the user to lean over or move the appliance, consistent with its permanent worktop placement context.





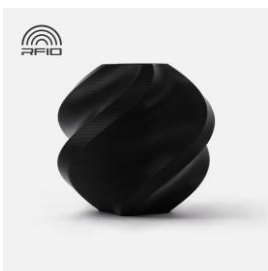
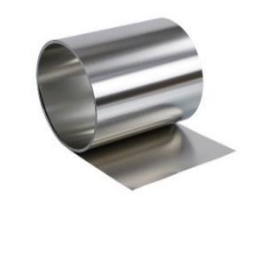
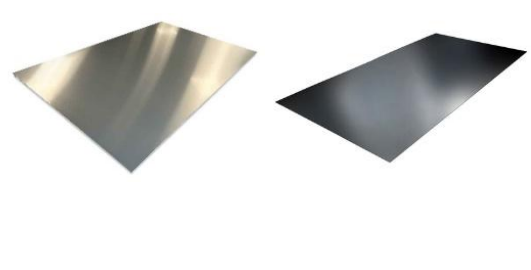
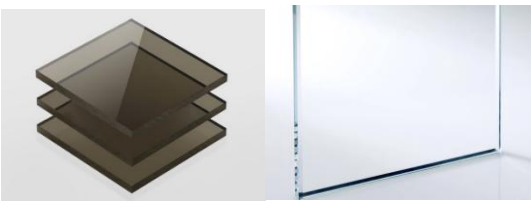






4.1.1 CMF Justification

Colour, material, and finish decisions were made to support MistiFry's functional requirements and sustainability objectives.

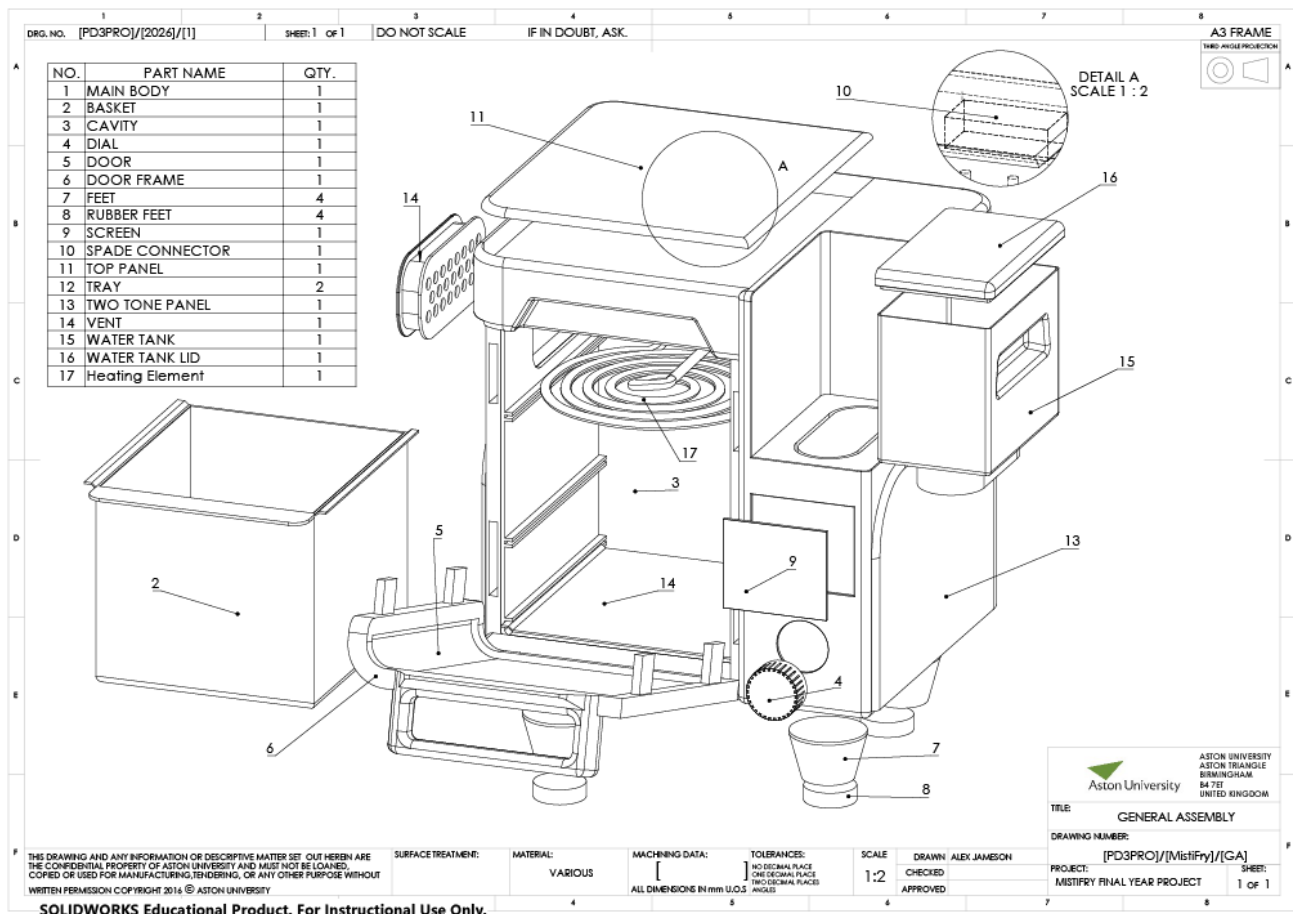
Component	Selected Material	Alternative(s) Considered	Justification for Selection
Outer housing panels		 	Black was selected as dark finishes are strongly associated with high-end products. Black minimises the visual impact of minor surface scratches and conceals fingerprints effectively on a permanent worktop appliance.
Top housing panels		 	Grey introduces a subtle two-tone contrast with the black side and front panels, adding visual interest. The lighter tone reduces the visibility of any heat-related discolouration on the top surface.
Water tank		 	Clear PETG allows the user to see the water level at a glance without removing the tank. This provides immediate visual confirmation before starting an Infuse or Clean cycle.
Cooking cavity & trays			Stainless steel 304 is food-safe, corrosion-resistant and fully compatible with sustained moisture exposure during mist cycles. The brushed finish communicates quality and hygiene to the user.
Front door glass			Borosilicate glass was selected for its thermal shock resistance, with a coefficient of thermal expansion approximately one third that of standard soda-lime glass.

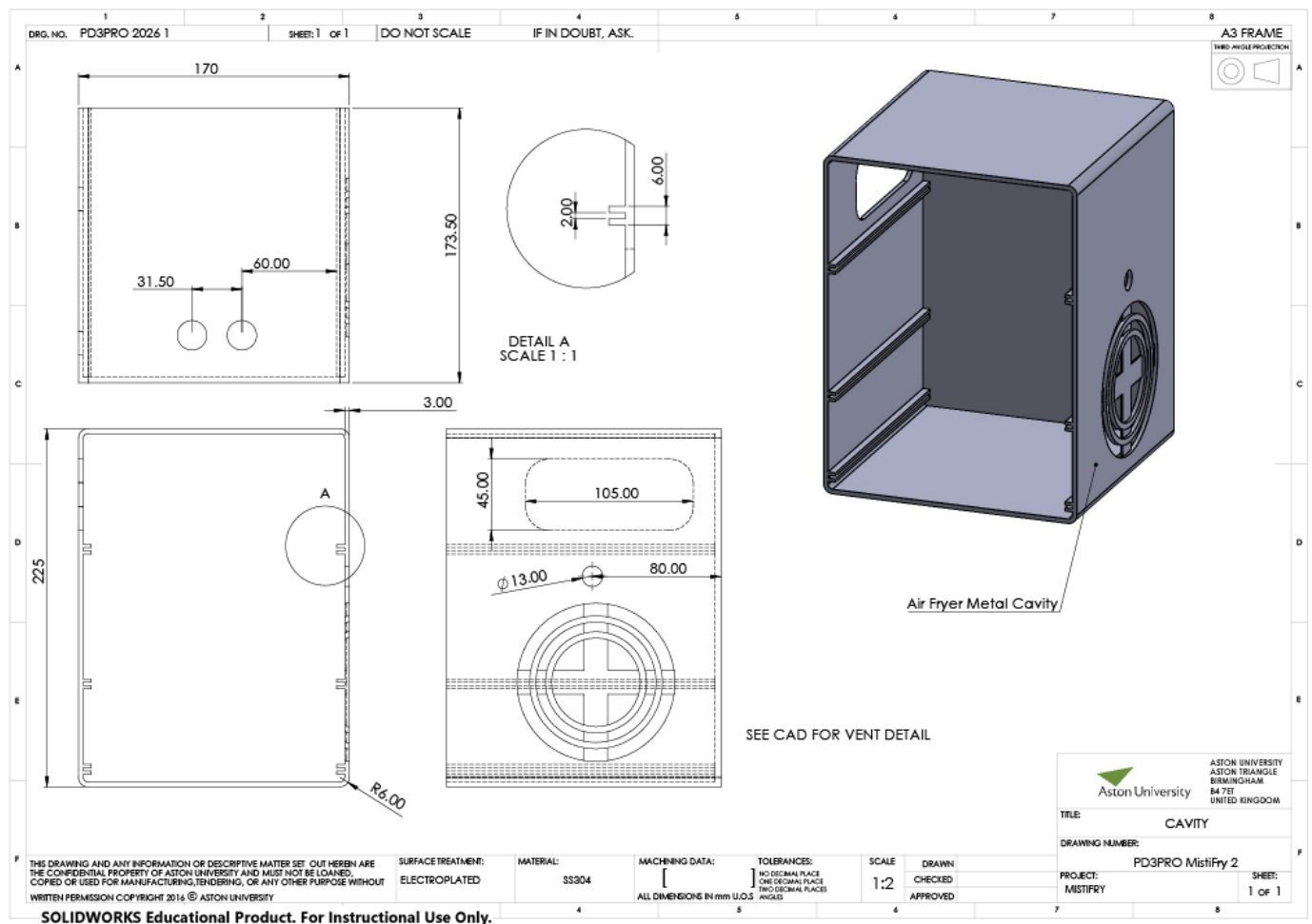
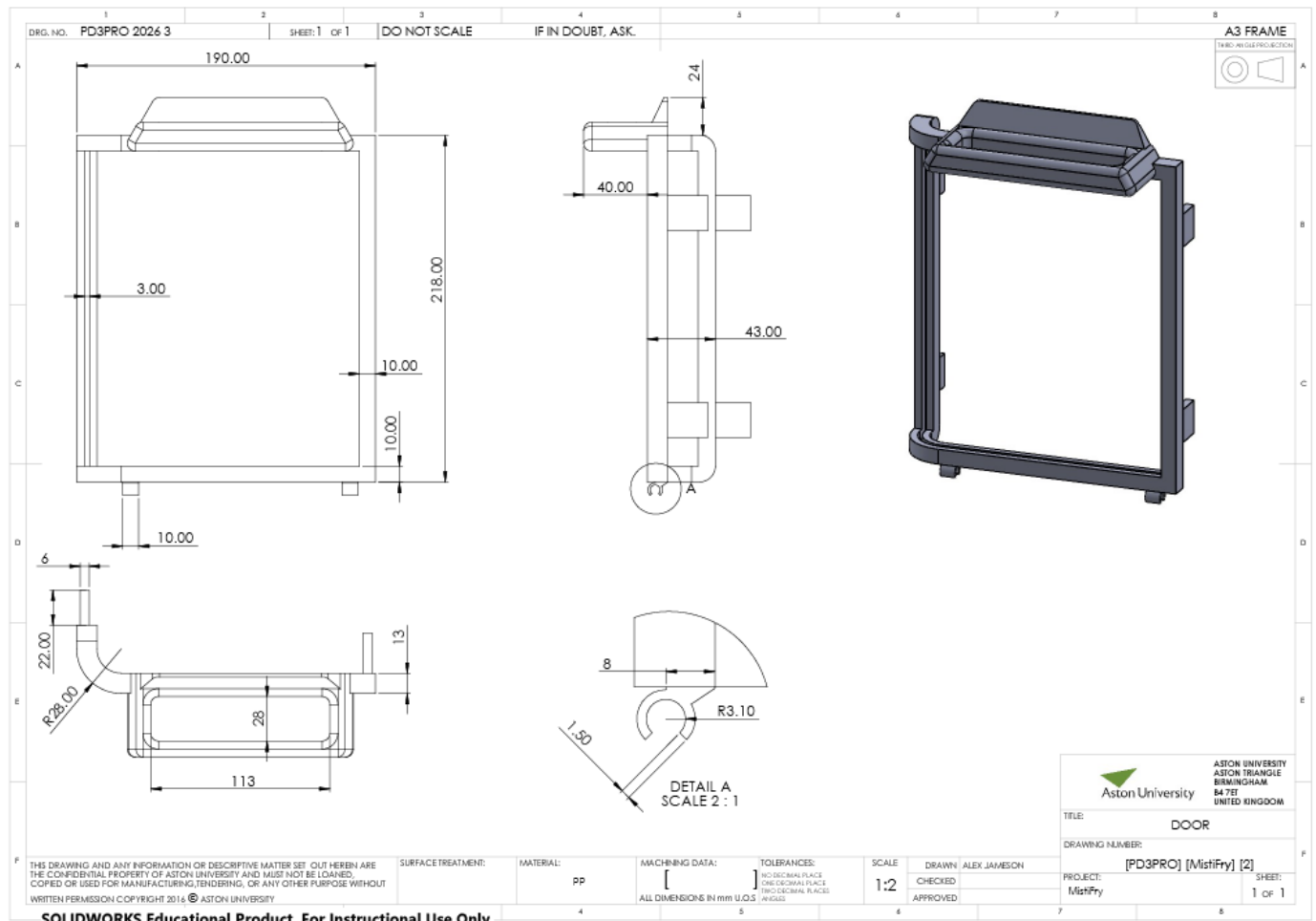
Key Sub-Systems Summary

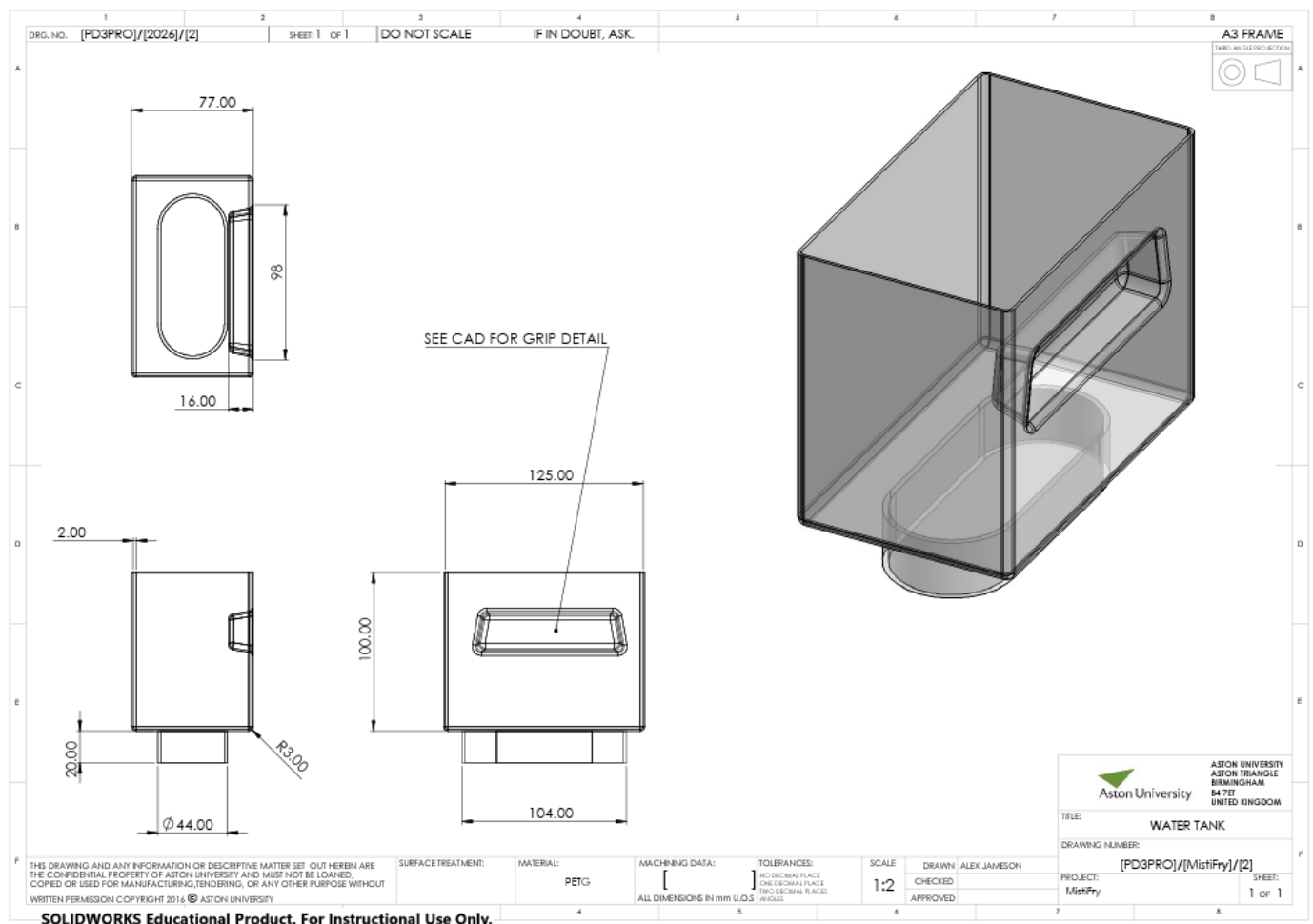
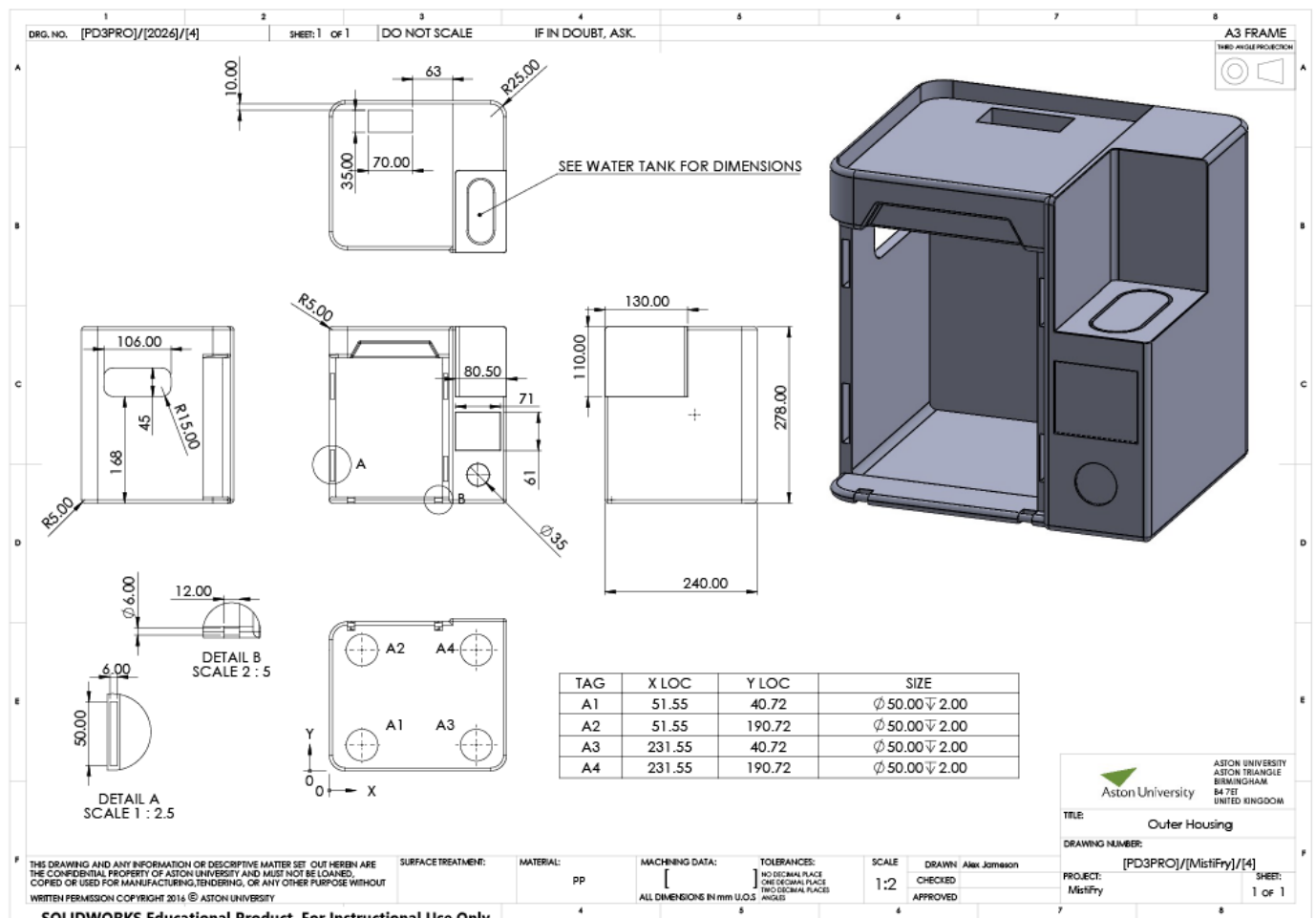
Sub-System	Description	Key Design Decision
Cooking cavity	Front-loading, SS304 fabricated box with door aperture, tray runners and fan/element mount at top	Oven-style form factor over drawer - improves usability, cleaning coverage and cooking versatility
Heating element	Nichrome coil, 1000W, removable via spade connectors on SS mounting bracket	Lift-and-pull removal without tools - core PDS requirement, proven mechanism from electric hob analogies
Convection fan	Axial fan, brushless DC motor, rear-mounted in cavity top	Purchased sub-assembly - custom manufacture not cost-effective at target volume
Mist system	Ultrasonic piezo module in water tank base, mist ducted into cavity via PP tube and grommet	Pulsed operation in Infuse mode (30s on / 90s off), continuous in Clean mode
Water tank	Side-mounted, removable, translucent PP or PETG, top-fill lid, 500ml capacity	Removable for easy filling and rinsing, translucent for visual level check
Door	PP frame with borosilicate glass insert, hinge, silicone perimeter seal	Borosilicate for thermal shock resistance, glass allows in-cycle food monitoring
Cooking inserts	SS304 perforated trays, wire rack, drip tray - all on cavity side-wall runners	Multiple cooking positions, all items dishwasher safe, drip tray collects moisture from mist cycle
Control interface	Rotary encoder + OLED display, top-right of front face	Single-control operation for use with wet or greasy hands

4.2 Engineering Drawings

Engineering drawings for all bespoke manufactured components and key assemblies are included below. Drawings include the general assembly, cooking cavity, door assembly and water tank.







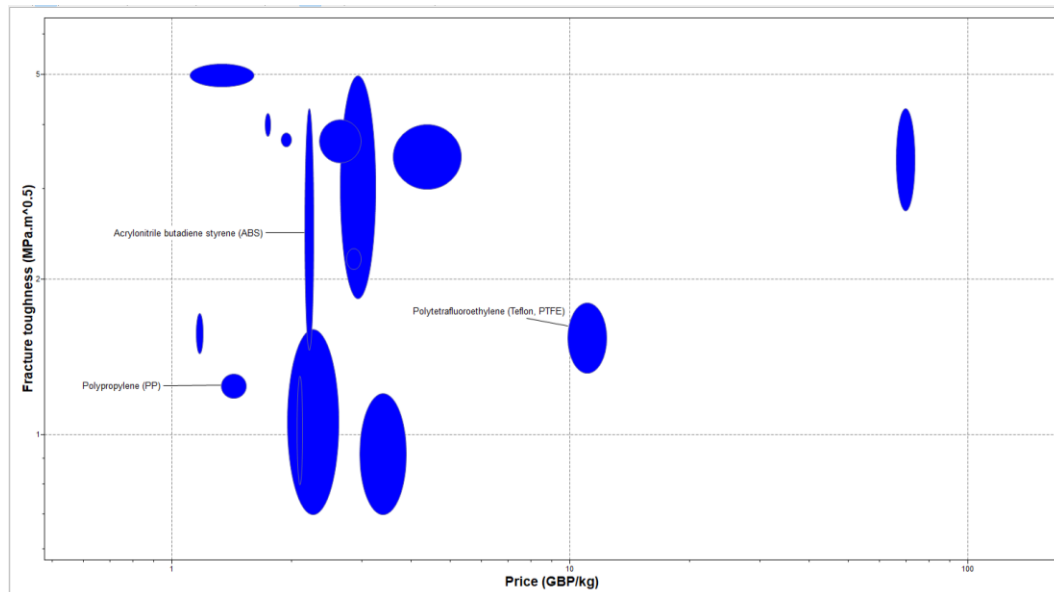
4.3 Materials Selection for DFMA

Material selection for MistiFry has been driven by four priorities: food safety, thermal performance, sustainability and a health-conscious positioning. Material properties have been referenced against Granta data.

Component	Selected Material	Alternative Considered	Justification for Selection
Outer housing panels	Polypropylene (PP)	ABS	PP selected over ABS on recyclability grounds, PP has adequate heat resistance (~100°C) for a worktop appliance where surface temperatures remain below. ABS considered for surface finish but rejected as inconsistent with sustainability positioning.
Cooking cavity & trays	Stainless Steel 304	Aluminium alloy	SS304 is food-safe, corrosion-resistant and fully compatible with sustained moisture exposure during mist cycles. PTFE coating rejected - aligns with PTFE/PFAS-free health positioning and eliminates coating degradation risk. Aluminium not chosen due to inferior corrosion resistance in a mist environment and difficulty of achieving food-safe weld quality.
Front door glass	Borosilicate glass	Soda-lime glass polycarbonate	Borosilicate has a coefficient of thermal expansion approximately one-third that of soda-lime glass, providing superior resistance to thermal shock when the door is opened during or immediately after a cook cycle.
Water tank	PETG (clear)	Polycarbonate (PC)	PP preferred for recyclability. PETG considered for superior optical clarity. PC rejected due to BPA concerns - directly contrary to the product's health-focused positioning. PETG was confirmed for better moulding feasibility and optical performance of translucent PP grade.
Door seal & mist tube grommet	Silicone rubber	EPDM rubber	Silicone selected for operating temperature range (-60°C to +230°C), food-safety certification and flexibility retention after repeated thermal cycling. EPDM has inferior upper temperature limit.
Control panel bezel	ABS	PP	ABS selected for the control panel - the display aperture and encoder require tighter dimensional tolerances and a higher-quality surface finish than PP readily delivers in thin-walled mouldings. ABS's use is limited to this single component to minimise impact on overall housing recyclability.
Heating element wire	Nichrome (NiCr 80/20)	Kanthal (FeCrAl)	Nichrome 80/20 is the standard resistance heating alloy for domestic appliances - well-characterised, widely sourced, and proven in comparable products. Kanthal has higher maximum operating temperature (1400°C vs 1200°C) but is more expensive and offers no performance benefit at the temperatures required for air frying (max 220°C operating, max ~700°C element surface temperature).
Spade connectors (element)	Copper alloy, tin-plated, 6.3mm	Magnetic connectors	6.3mm quick-disconnect spade connectors are the proven standard for high-current disconnectable connections in domestic heating appliances. Magnetic connectors - cost, current rating uncertainty, and risk of inadvertent disconnection during operation.

4.3.1 Granta Edu Pack Data

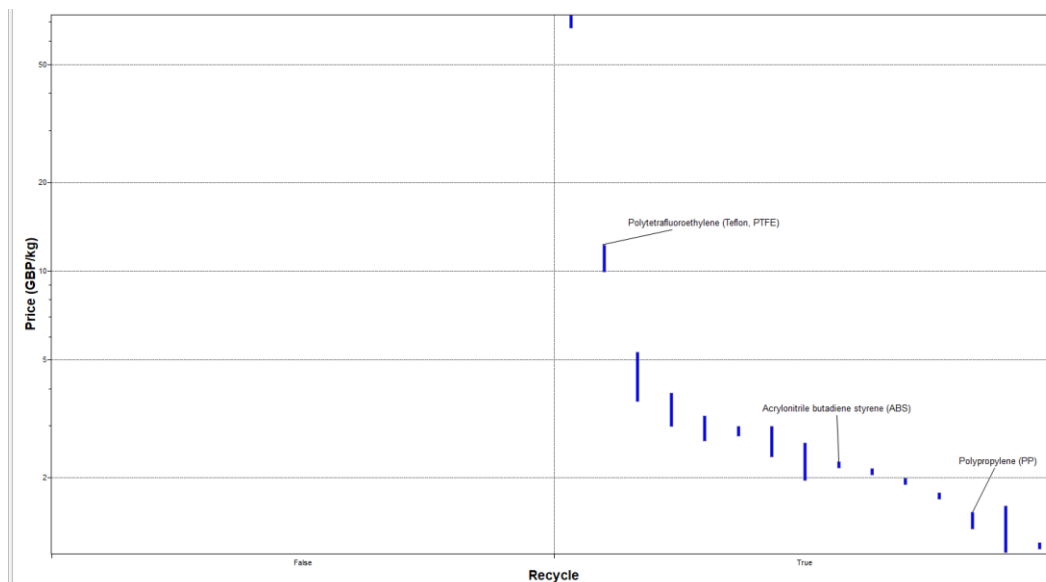
The following graphs document key comparisons for factors in material selection.



Fracture Toughness vs Price

PP sits in a favourable region, having medium impact resistance for a domestic appliance housing at lower cost than tougher alternatives.

ABS offers no meaningful toughness advantage over PP to justify its higher cost or poorer recyclability.



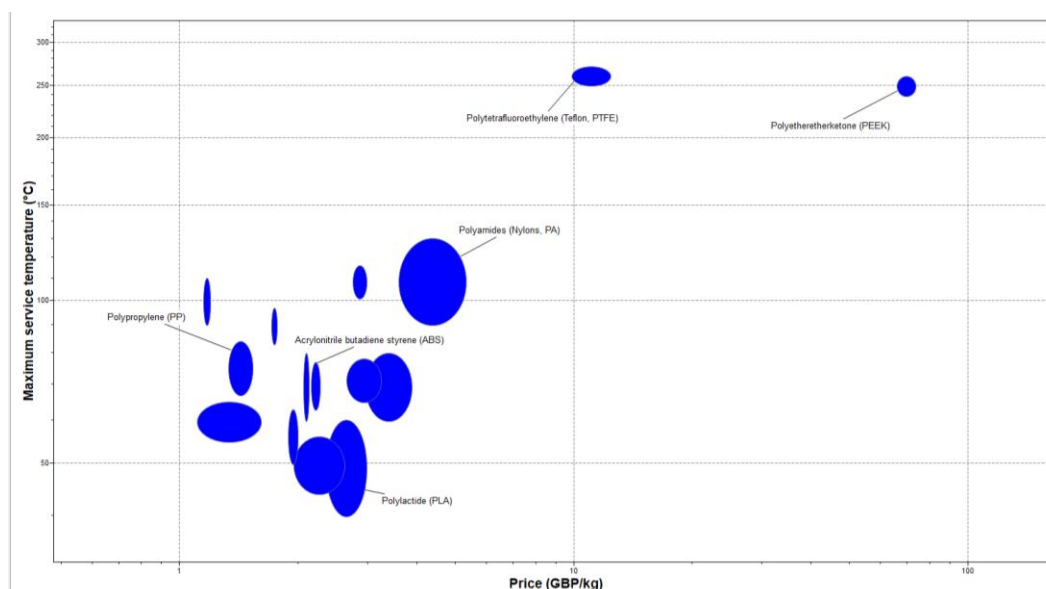
Price vs Recyclability

Both PP and ABS are recyclable, however PP scores higher on the recyclability index.

ABS recycling is less established.

Both materials occupy a similar price band.

PP delivers a better recyclability profile at no meaningful cost penalty.



Maximum Service Temperature vs Price

PP's service temperature of approximately 100°C is sufficient for the housing application.

The SS304 cavity acts as the structure and thermal barrier, meaning housing surface temps remain below this threshold.

Higher-temp polymers offer no benefit here and carry a significant price premium.

4.4 Manufacturing Process

The following table documents the selected manufacturing process for each key component, the process parameters and the justification. Process selection has been guided by the principles of Design for Manufacture and Assembly (DfMA): minimising part count, designing for ease of assembly and selecting processes appropriate to the target production volume of 10,000+ units per annum.

Component	Process	Material	Key Parameters & Justification
Outer Housing - Front, Rear, Top, Base Panels	Injection Moulding (PP)	PP (Polypropylene)	High-volume production efficiency, PP flows well for large thin-walled parts. Wall thickness: 2.5-3mm. Draft angles: min 1.5°. Surface finish: textured to minimise visible fingerprints on permanent worktop appliance.
Cooking Cavity - Inner Box	Sheet Metal Fabrication - Pressing & Folding	Stainless Steel 304	Cavity formed from flat-blanked, pressed and folded SS304 sheet. Seams welded and ground flush. Electropolished internal finish for cleanability and mist resistance. Tolerances: $\pm 0.5\text{mm}$ on folded dimensions.
Front Door - Framed Glass Panel	Injection Moulded PP Frame + Toughened Glass Insert	PP frame, borosilicate glass	Door frame injection moulded in PP with integrated hinge bosses and seal groove. Borosilicate glass inserts bonded and retained by PP frame ridge. Glass must withstand sustained temperatures up to 230°C without distortion. Hinge: integrated to door, rated for 3000 open/close cycles.
Removable Heating Element Assembly	Purchased Sub-Assembly + Custom Mounting Bracket	Nichrome resistance wire, stainless steel housing, copper spade terminals	Nichrome coil element wound to 1000W rating, housed in stainless steel support frame. Spade connectors (6.3mm quick-disconnect, rated 13A) are the user-facing connection interface.
Convection Fan & Motor Assembly	Purchased Sub-Assembly	Brushless DC motor, PP or PA fan blade	Axial fan mounted at rear of cavity. Fan blade diameter: 100 mm. Motor rated for continuous operation at cavity temperatures up to 230°C. Fan housing integrated into rear cavity wall pressing.
Water Tank	Injection Moulding (PP or PETG)	Food-grade translucent PP or PETG	Side-mounted removable tank. Injection moulded. Hinged top-fill lid with silicone seal. Capacity: 500ml. Translucent natural PP or clear PETG to allow water level visibility. Tank locates into side aperture.
Mist Module	Purchased Component	Ultrasonic piezoelectric transducer assembly	20mm ultrasonic mist module, operating at 113kHz. Drive voltage: 5V DC. Mist output: 1500 ml/hr. Module seated in tank base with silicone seal. Mist ducted into cavity via PP tube routed through cavity wall grommet.
Cooking Trays, Wire Rack & Drip Tray	Sheet Metal Fabrication - Stamping & Wire Forming	Stainless Steel 304	Flat perforated trays stamped from SS304 sheet. Wire rack formed from SS304 wire, spot-welded at intersections. Drip tray: pressed SS304 with upturned lips. All dishwasher safe. Tray runners: integral pressed features on cavity side walls.
Control Panel Bezel & Encoder Surround	Injection Moulding (ABS) + Soft touch over mould	ABS, TPE over mould on encoder grip	Control panel bezel injection moulded in ABS - ABS selected here (rather than PP used for main housing) for superior surface finish quality and dimensional stability for display aperture. Rotary encoder grip over moulded in TPE for tactile feedback. OLED display window: polycarbonate lens, 1.5mm.

4.5 Manufacturing Costs & Sourcing Commercial Costing

The table below provides the bill of materials (BOM) for MistiFry at target production volume (10,000+ units per annum). The target manufacturing cost is £30-£45 per unit at volume, supporting a retail price of £100-£150 and a margin consistent with the premium small appliance category.

Component / Part	Material	Supplier / Source	Est. Unit Cost	Notes
Outer housing - injection moulded PP (all panels)	PP	Rutland Plastics (UK) Tooling est. £10,000-£25,000 per panel tool.	£3.50-£6.00	Per-part cost at 10,000+ units.
Cooking cavity - SS304 sheet fabrication	SS304	Fractory (fractory.com) services for sheet metal.	£4.00-£7.00	Cost depends on cavity geometry complexity.
Front door - PP frame + borosilicate glass	PP / Borosilicate	PP frame: same moulder as housing. Borosilicate glass: specialist glass supplier	£2.50-£4.50	PP frame injection moulded. Glass bonded with high-temp silicone adhesive.
Removable heating element assembly	Nichrome	Speciality element supplier Spade connectors (6.3mm): RS Components	£3.00-£5.50	Nichrome coil, SS304 support frame, 2× spade connectors, heat-resistant grip.
Convection fan & motor assembly	Purchased sub-assembly	Small appliance fan/motor suppliers: Sunon or Nidec all supply UK market.	£2.50-£4.00	Purchased sub-assembly custom manufacture not cost-effective at target volume.
Water tank - injection moulded PP/PETG	PP or PETG	Same injection moulder as housing panels. PP preferred for recyclability.	£1.50-£2.50	1 mould. Hinged lid with silicone seal moulded separately.
Ultrasonic mist module	Purchased component	RS Components or Farnell	£1.50-£3.00	Off-the-shelf piezo module.
Trays, wire rack & drip tray - SS304	SS304	Same sheet metal fabricator as cavity. Trays lower cost due to simpler geometry.	£1.50-£2.50	Trays stamped, wire rack spot-welded, drip tray pressed. All dishwasher safe.
Control panel bezel + OLED display	ABS / PC / TPE	ABS bezel: injection moulded, same moulder. OLED: RS Components	£2.00-£3.50	ABS moulded with display. PC bonded over OLED.
Rotary encoder	Purchased component	Farnell UK	£1.80-£2.50	Push-to-select rated to 60 RPM.
Gaskets, seals, grommets (silicone)	Silicone	Custom-cut silicone for all seals from supplier	£0.80-£1.50	Food-grade silicone rated to 230°C.
Fasteners	Various	Screws, clips, standoffs	£0.80-£1.20	Screws, PCB standoffs, snap clips.
PCB & electronics (excl. display/encoder)	Various	JLCPCB or PCBWay - UK small appliance production.	£2.50-£4.00	Includes circuit components See Section 5.
Packaging - recyclable cardboard	Cardboard	Kite Packaging. Printed box moulded to product shape. No single-use plastic.	£1.00-£1.80	Sustainable packaging consistent with brand values.
Assembly labour (estimated at [X] min/unit)	-	UK contract manufacturer or own assembly line	£4.00-£7.00	25-35 min estimated at UK manufacturing rate (approx. £15-£20/hr).
TOTAL MANUFACTURING COST (per unit at 10,000+ volume)	-	-	£33-£55	Target: £30-£45. Upper end reflects UK assembly labour.

4.6 Injection Moulding Viability

To validate the manufacturability of the MistiFry housing panels, two independent automated DFM analyses were conducted using industry-standard quoting platforms.

Manufacturing Analysis [Return to Quote 2554-603](#) [Configure Part](#)

BODY for Proto.SLDPRT

● Your part exceeds our limitations for Injection Moulding.

Your part is deeper than our process currently accommodates. Please refer to our [Injection Moulding Design Guidelines](#) for current size limitations.

What we need from you:

- ⚠ Upload revision or remove part from quote
- 📄 Download Manufacturing Analysis
- Contact us or [schedule a call](#) for free design assistance

1 Additional Note Required Change

We'd like you to know

⚠ This is a required change

Part is too deep for Factory.

[Next](#)

Transparency: ☐ On ☒ Off

Highlight Issues: ☐ Off ☒ On

D Distance

10 in

The model was assessed using the Protolabs automated DFM tool. The analysis confirmed the housing as manufacturable. However, it flagged the cooking cavity depth as exceeding their capability.

This is a limitation of the service rather than a fundamental design flaw as cavity depth restrictions vary between moulding suppliers.

DFM Feedback
6 checks passed | 0 failed

- ✓ Confined Hollow
- ✓ Floating Parts Check
- ✓ Large Part for Material
- ✓ Large Part for Process
- ✓ Model Fidelity
- ✓ Part Volume

278.000mm × 240.000mm × 194.228mm | 10.945in × 9.449in × 7.647in | 254.482 in³

CAD was uploaded to Xometry's instant DFM tool with PP selected as the material. The analysis returned a fully viable result across all checked parameters - wall thickness, draft angles and feature geometry were all within acceptable tolerances for injection moulding at the target wall thickness of 2.5-3mm. No design changes were flagged as required.

4.7 Design Verification - DFMEA

Design Failure Mode and Effects Analysis (DFMEA) is a structured risk assessment tool used in product development to identify potential failure modes within a design, assess their severity and define preventative measures before the product reaches production.

Each failure mode is scored across three criteria:

1. Severity (S) - the impact of failure on the user or product
2. Occurrence (O) - the likelihood of failure happening
3. Detection (D) - the ease with which failure can be identified before it causes harm

These three scores are multiplied together to produce a Risk Priority Number (RPN) - the higher the RPN, the greater the priority for design intervention.

For MistiFry, DFMEA was applied to validate the safety and durability of the design.

All scores are rated on a scale of 1-10.

Score	Severity	Occurrence	Detection
1-3	Minor inconvenience	Unlikely	Easily Detected
4-6	Moderate - affects function	Occasional	May go undetected
7-9	Serious - injury or major failure	Likely	Difficult to detect
10	Catastrophic / safety issue	Almost certain	Undetectable

Function	Potential Failure / Effects	S	Potential Cause(s)	O	Prevention / Detection Controls	D	RPN
Heat cooking cavity to set temperature during Cook and Infuse modes	Uncontrolled heating - fire risk, damage to appliance and surrounding kitchen surfaces, user injury	9	Fan failure causing heat to build without circulation, firmware temperature control loop failure	2	NTC thermistor firmware detection test	2	36
Door close verification to initiate heating	Heating initiates without door close verification, user injury	8	Door mechanism engagement blocked or broken	4	Door engagement mechanism test. Logic dependencies check.	2	64
Mist applied during Infuse and Clean modes	System unable to clean, no water provided	6	Module failure, Piezo plate not in contact with water	2	Clean function test	2	24
Water tank sealed and retained during operation	Tank leaks during cycle, water contacts electrical components, appliance failure	8	Tank retention disengages due to vibration from mist module/fan, seal degradation over time	3	Tank retention and seal integrity test	2	48

The DFMEA process has been a valuable tool in identifying and mitigating design risks before the MistiFry reaches prototype validation or production. The RPN score is relatively low due to identification of appropriate test method being identified. Above is an example of some functional issues that could arise.

4.8 Sustainability Considerations

Sustainability was considered throughout the MistiFry design process, from material selection and manufacturing decisions through to end-of-life disposal. As a product targeting health-conscious consumers, environmental responsibility is consistent with the brand's values and the expectations of its target user group. The following table summarises the key sustainability considerations and the design decisions made in response to each.

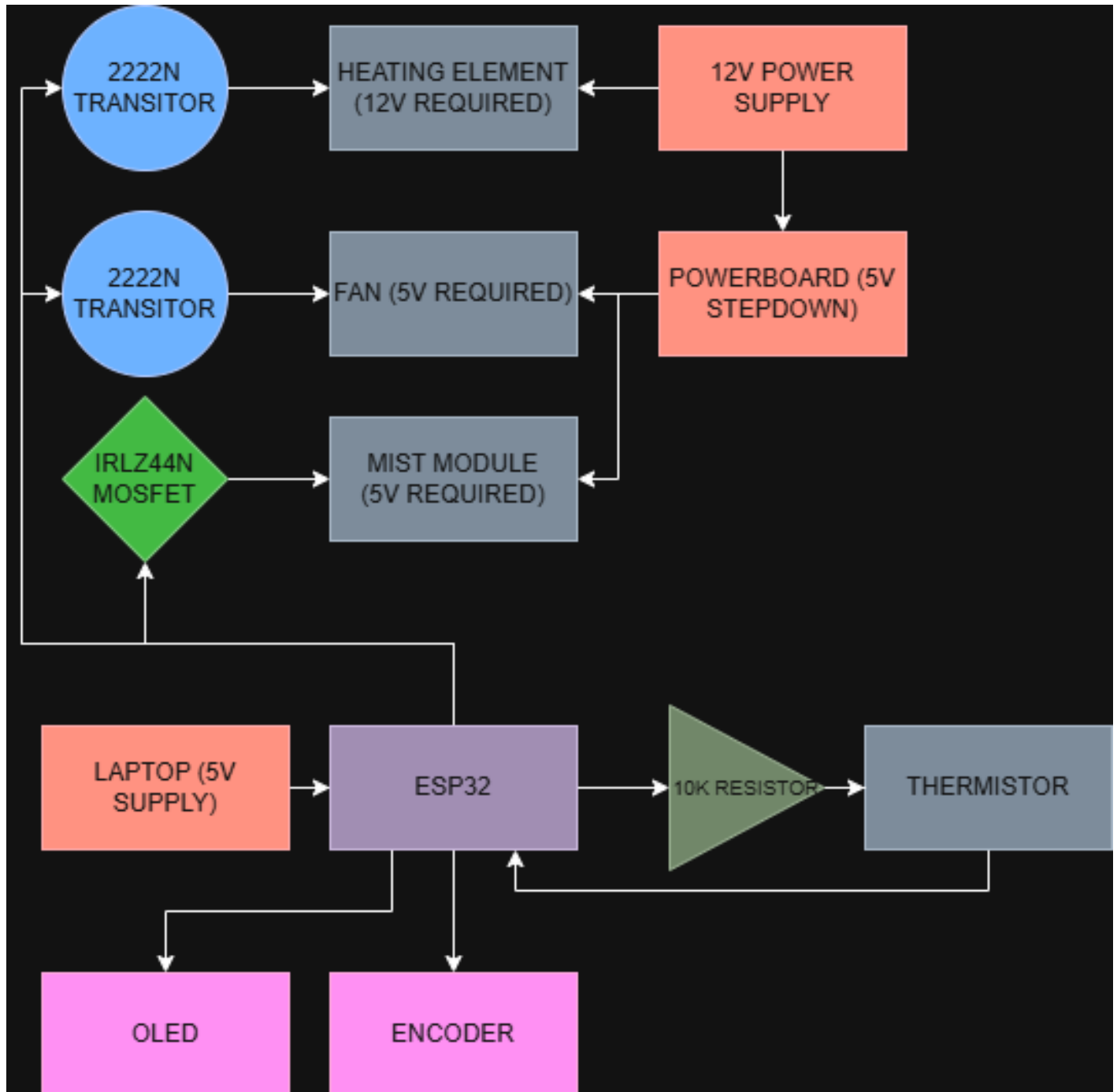
Considerations	Detail	Decision / Justification
Housing material recyclability	PP is widely accepted in UK kerbside recycling streams, unlike ABS which has no established kerbside collection	PP selected over ABS for all outer housing panels - material choice directly reduces end-of-life landfill contribution
Cooking cavity & trays	Stainless steel 304 is 100% recyclable and has an established recycling infrastructure globally	SS304 specified throughout internal cavity - no coating degradation, no PTFE waste, fully recyclable at end of life
PTFE-free design	PTFE coatings degrade at high temperatures and are not recyclable	MistiFry cavity is PTFE-free - eliminates coating degradation risk and associated health and environmental concerns
Product lifespan extension	Removable heating element allows the most wear-prone component to be replaced independently	Designed for component-level repairability - extends product lifespan and reduces frequency of full appliance disposal
Self-clean water consumption	Mist-based clean cycle uses approximately 25–42ml of water per 5-minute cycle	Significantly lower water consumption than manual washing under a running tap - estimated saving of 3–5 litres per clean cycle
Energy consumption	Clean mode draws only ~55W compared to ~1,060W during cooking	Low-energy clean cycle reduces total appliance energy footprint over product lifetime
Packaging	Recyclable cardboard outer carton with card inserts	No single-use plastic in line with UK single-use plastics regulations
Mist infusion - reduced cooking oils	Mist infusion reduces the need for added cooking oils	Indirectly reduces consumption of single-use oil packaging and supports health-conscious cooking positioning
Electronic components	ESP32 and passive components contain rare earth materials	Product to carry WEEE symbol - user guidance to direct to appropriate recycling at end of life
Carbon footprint	Housing and sheet metal fabrication targeted at UK or EU suppliers	Reduces logistics carbon footprint versus full Asian manufacture and shipping

5. Electronics & Control System

A working scale prototype was built using an ESP32 microcontroller on a breadboard.

5.1 System Architecture

The MistiFry control system is organised around three functional layers: power management, load switching, and user interface.



The MistiFry control system operates across three voltage domains from a 12V DC supply and a 5V supply. The heating element is switched directly at 12V via a 2N2222 transistor. The mist module operates at 5V via a the 5V power board and is switched by an IRLZ44N MOSFET to handle its 1A current.

The ESP32 microcontroller, OLED display, rotary encoder and NTC thermistor all run from a laptop supply 5V. The ESP32 was powered independently via USB-C during prototype development.

5.2 Prototype Electronics - Components & Decisions

The following table documents every component used in the working scale prototype.

Component	Part Used	Key Specification	Rationale & Development Notes
Microcontroller	ESP32 (38-pin DevKit)	3.3V Wi-Fi capable	Powered via USB-C from laptop during prototype development.
Rotary Encoder	Incremental rotary encoder	Detents/revolution, integrated push switch	Used with ESP32 encoder library for smooth detent-by-detent interrupts. Handles mode selection, temperature adjustment and timer setting via single control.
Display	0.96" OLED (SSD1306)	128×64 px, 3.3V	Displays mode (COOK / INFUSE / CLEAN), temperature setpoint.
Heating Element (prototype)	12V DC nichrome element, rated 80°C max surface temperature	12V supply, switched via 2N2222 NPN transistor.	Scale model element not mains voltage. Maximum surface temperature 80°C at 12V input. 2N2222 collector driven from ESP32 GPIO.
Heating Element & Fan Switch (prototype)	2N2222 NPN bipolar transistor ×2	V: 40V I(max): 600mA	Two 2N2222 transistors used in the prototype - one switching the heating element, one switching the convection fan. Both loads operate within the 2N2222's 600mA collector current rating at prototype scale voltages (12V element, low-voltage fan).
Mist Module	USB ultrasonic mist module (5V, ~1A)	5V ~1A current draw ultrasonic piezoelectric transducer	USB cable cut and wired directly into breadboard 5V rail. Driven via IRLZ44N N-channel MOSFET.
Mist Module MOSFET	IRLZ44N MOSFET	V): 1-2V, I(max): 47A,	Used exclusively for the mist module in the prototype - the only load that required a MOSFET due to its ~1A current draw
NTC Thermistor	10kΩ NTC thermistor (B-value ~3950K)	Resistance at 25°C: 10kΩ. Used in voltage divider with 10kΩ fixed resistor.	Analogue output read via ESP32 ADC. Steinhart-Hart equation (or simplified Beta equation) used in firmware to convert reading to temperature in °C. Thermistor positioned in prototype cavity airflow to sense cooking temperature.
Power Supply - 12V rail	12V DC barrel jack supply (mains-to-DC adaptor)	12V, 1A output. Stepped down to 5V and 3.3V via power board.	12V feeds heating element directly via 222N. On-board power module steps 12V down to 5V for mist module and Fan.

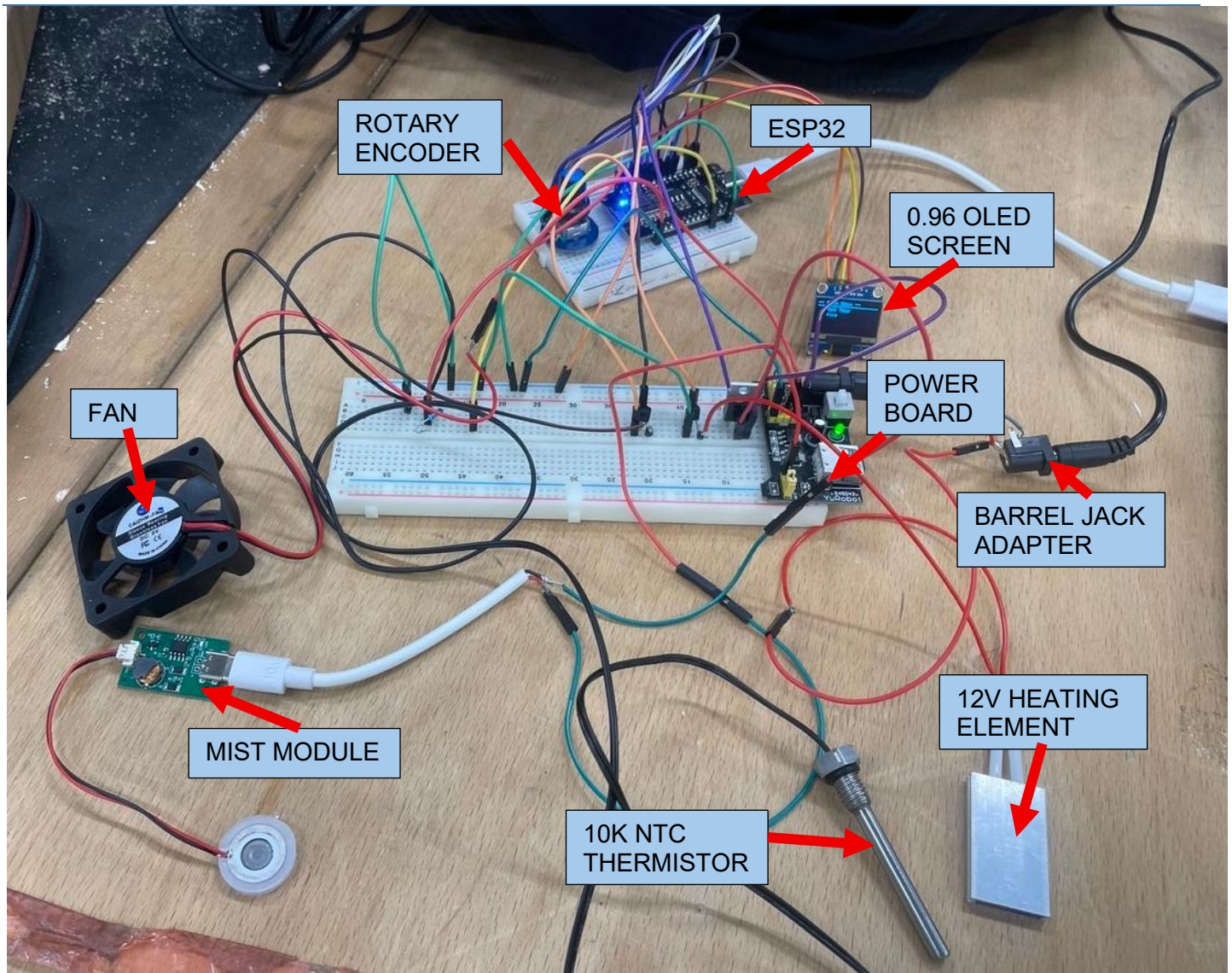
5.3 Key Engineering Decisions from Prototype Development

5.3.1 Transistor to MOSFET Upgrade - Mist Module

During initial prototype assembly, a 2N2222 NPN bipolar transistor was used to switch the mist module. The 2N2222 has a maximum collector current rating of 600mA.

The ultrasonic mist module was measured to draw approximately 1A at 5V during operation - exceeding the transistor's rating.

The 2N2222 was replaced with an IRLZ44N N-channel MOSFET, which has a maximum drain current of 47A and an on-resistance of 22mΩ - providing a comfortable margin above the 1A mist module load with negligible switching losses.



Above are 3 images demonstrating the UI on the 0.96 screen (image 1 and 2 distorted due to screen latency with camera). Image 1 is the menu screen where the user can freely select the modes, image 2 demonstrates clean mode and indicates what components are in use and the 3rd image demonstrates cook mode where it shows the current temperature (measured by NTC thermistor).

6. Critical Evaluation

This section evaluates the MistiFry design and prototype against the Product Design Specification (PDS).

Two physical prototypes were produced. The electronics prototype is a working low-voltage breadboard circuit with all three operating modes implemented and tested in firmware.

The aesthetic prototype is a full-scale 3D printed model demonstrating the form factor, door mechanism, tray rails and water tank placement. It is not electrically functional but physically validates the key interaction and mechanical features. Together they address different aspects of the PDS.

6.1 Evaluation Against the PDS

The following table evaluates the final design against each key PDS requirement, with evidence from prototype testing and an honest assessment of what remains to be verified.

PDS Requirement	Status	Evidence	Outstanding / Comment
Function - air frying performance	✓ Met (scale)	Scale prototype heating element reached 80°C max at 12V - proportional to full-size operation.	Full-size mains performance not yet verified. Requires testing at 220°C with real food loads against competitor benchmarks.
Mist infusion - pulsed delivery during cooking	✓ Met	Ultrasonic mist module operated successfully in prototype. Pulse logic (30s on / 90s off) implemented in firmware via Millis () timer and verified in testing.	Mist consistency varied slightly under extended operation
Self-clean cycle - mist + fan, no heat	✓ Partially met	Mist and fan operated together in clean mode successfully. Real-world grease testing not conducted on scale model.	Cannot fully verify cleaning effectiveness at scale without a full-size cavity and real cooking residue. This is acknowledged as a prototype limitation.
Removable heating element - tool-free, spade connectors	✓ Partially met	3D printed aesthetic model demonstrates lift-and-pull mechanism with physical tray rails and door functioning correctly. Spade connector mechanism modelled.	Electrical spade connection tested in electronics prototype separately. Integration of mechanism with live element not yet physically combined.
User interface - rotary encoder, three modes	✓ Met	Working encoder UI with OLED display tested on electronics prototype. All three modes (Cook, Infuse, Clean) selectable. Temperature and timer setting functional.	Touchscreen identified as a preferred alternative by users familiar with conventional air fryers.
Water tank - removable, translucent, side-mounted	✓ Met (3D model)	Aesthetic model demonstrates side-mounted removable tank with lid. Tank form factor and proportions validated physically. Translucency incorporated in design intent.	Actual water containment and mist module seating not tested in 3D printed model.
Materials - PLA housing, SS304 cavity, PTFE-free	✓ Partially met	Material selection documented and justified in PDS (Section 2) and Materials table (Section 4.3). PP recyclability advantage over ABS confirmed through Granta datasheet review.	Physical material testing not taken place as product has not been commercially manufactured.
Target retail price - £100-£150	✓ Partially met	BOM developed in Section 4.5. Manufacturing cost target £30-£45 per unit at volume.	Cost target is credible based on real supplier quotations. Issue with metal and plastic fabrication as for a singular unit quote it is £1000.

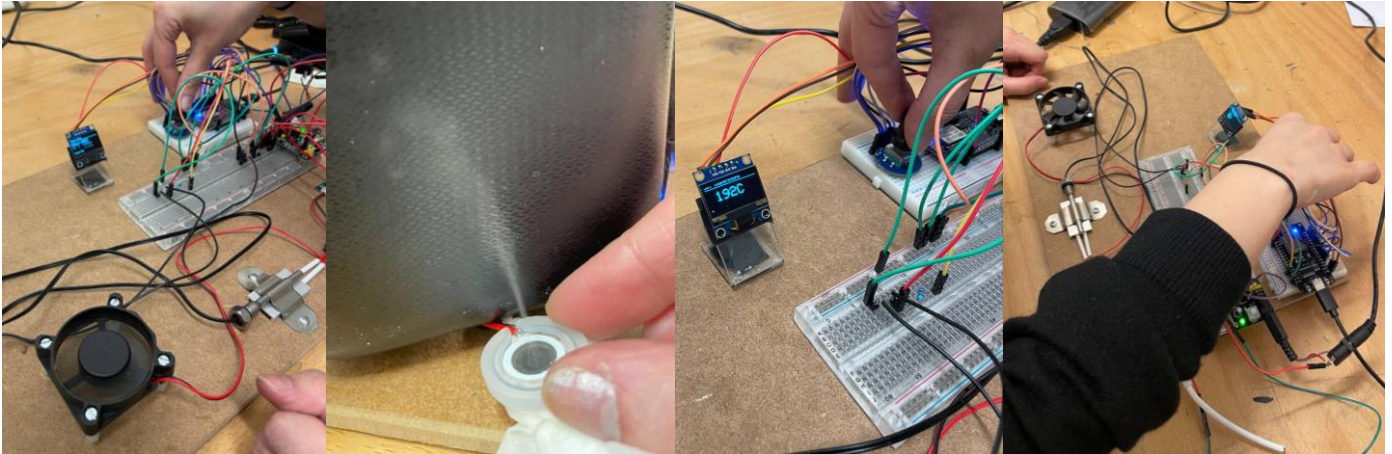
6.2 Prototype Testing - Findings & Insights

6.2.1 Electronics Prototype

The electronics prototype demonstrated functionality on a scale level. All three modes Cook, Infuse and Clean were implemented and worked through the rotary encoder interface.

The OLED display communicated mode, temperature and timer clearly. The mist module activated reliably under MOSFET switching, the pulsed Infuse logic operated as specified. Temperature sensing via the NTC thermistor returned consistent readings within the scale model's operating range.

One area identified for improvement during electronics testing was mist consistency. Under extended operation in Infuse mode, the ultrasonic mist module's output varied slightly - observed as occasional reduction in visible mist density.



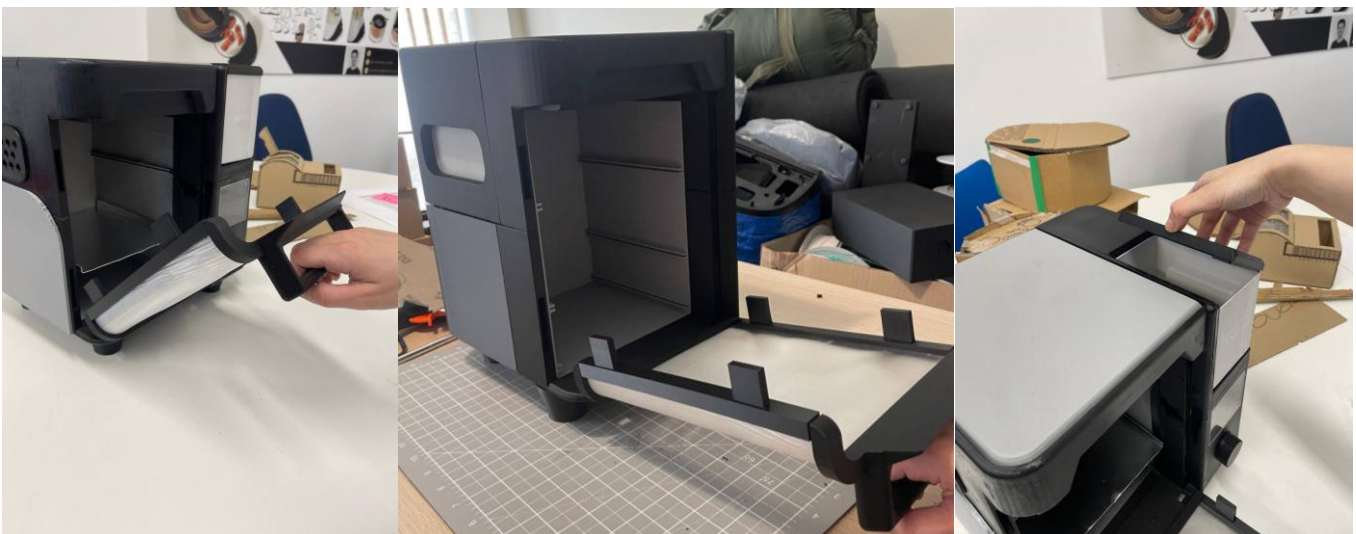
6.2.2 Aesthetic / Physical Prototype

The full-scale 3D printed model was assessed through physical handling by the designer and evaluation with others who interacted with the prototype.

The front-loading door mechanism operated smoothly, and the side-mounted water tank form factor was well received - described as logical and easy to access. The overall proportions and worktop footprint were confirmed as appropriate for a family-sized appliance.

The rotary encoder interface (demonstrated on the electronics prototype) was evaluated as smooth and intuitive, with users able to navigate between modes and settings without instruction after a single demonstration.

However, one consistent piece of feedback was that a touchscreen interface would feel more familiar, as this is the dominant control paradigm in the current premium air fryer market.



6.2.3 Self-Clean Mechanism - Research Basis

The self-cleaning function could not be fully validated at prototype scale - the 3D printed aesthetic model cannot be exposed to cooking grease, and the scale electronics prototype operates at temperatures too low to generate real cooking residue.

However, the cleaning mechanism is grounded in established chemistry. Research into the behaviour of cooking fats and oils under humid conditions indicates that water mist in contact with polymerised cooking grease promotes fat hydrolysis - the chemical breakdown of triglycerides into fatty acids and glycerol.

The expected outcome is that the mist cycle loosens grease sufficiently to be removed with a single wipe, rather than eliminating the need for any manual action entirely.

6.3 Areas for Improvement

The following areas have been identified as limitations of the current design.

Mist distribution

The position of the mist relative to the fan and heating element will affect how evenly mist is distributed. In the current design, mist enters through a port in the cavity wall and relies on fan circulation to distribute it. There is a risk that mist is concentrated near the entry point and does not reach all surfaces.

Element connector durability

Assuming a user removes and reattaches the element once per week for cleaning, this represents approximately 500 cycles over the product life. Standard spade connectors are typically rated for 100-150 mating cycles - adding a custom positive-locking mechanism could reduce wear.

6.4 MoSCoW Prioritisation

The MoSCoW framework (Must have / Should have / Could have / Won't have) is used here to prioritise MistiFry's features across the current design phase and future development.

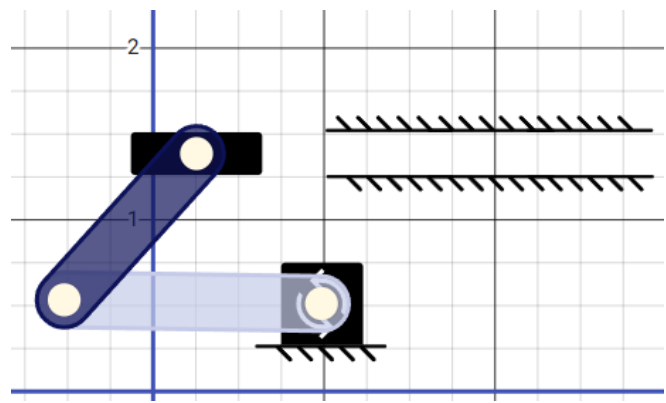
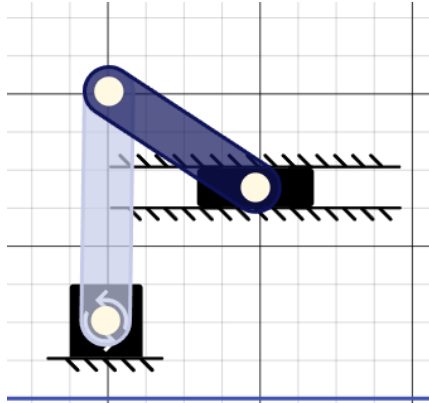
Priority	Feature	Rationale
Must have	Effective air frying function	Core product function - without this MistiFry is not an air fryer
Must have	Pulsed mist infusion	Primary differentiating feature - defines the product proposition
Must have	Removable heating element	Core PDS requirement
Must have	Self-clean cycle (mist + fan)	Secondary surprise-and-delight feature
Must have	Safety interlocks	Mandatory for CE/UKCA certification and legal UK retail sale
Must have	UI with OLED display	Validated in prototype - minimum viable control interface
Must have	Removable water tank	Required for mist system function - core to both Infuse and Clean
Should have	Digital water level readout	Adds usability, translucent tank provides backup visual
Should have	Dishwasher-safe trays and rack	Strong user expectation in this category - improves cleaning
Should have	Borosilicate glass door	Significant usability advantage over opaque door
Could have	Touchscreen control interface	Users familiar with conventional air fryers preferred touchscreen.
Could have	Wi-Fi connectivity / app control	ESP32 has native Wi-Fi capability - app-based mode selection and remote monitoring is achievable without hardware change.
Could have	Flavour infusion cartridge system	Replaceable flavoured water cartridges for mist tank - commercial opportunity for recurring revenue.
Won't have	Voice control integration	Adds significant firmware and cloud infrastructure complexity
Won't have	Automatic food recognition / AI cooking presets	Technically complex, out of scope for this design

6.5 Future Development

In a product iteration, the touchscreen interface identified as a Could Have in the MoSCoW analysis would be the primary UI development target.

The ESP32's native Wi-Fi capability positions the product well for app connectivity without hardware change, enabling remote mode selection and cook monitoring as a V2 software feature.

Additional considerations were made for the door mechanism to have a linkage built in to allow tray movement without user interaction.



The 2 above images are of a 2-d linkage system where the door (light blue) would be connected to the edge of the tray (dark blue) and would allow the tray to come out fully (guided by the rail (marked with hatches)). This is an additional feature that adds complexity to the design and benefits the user with easier access. However, this is at the cost of additional cleaning and potential for the linkage system to be a critical fail point.

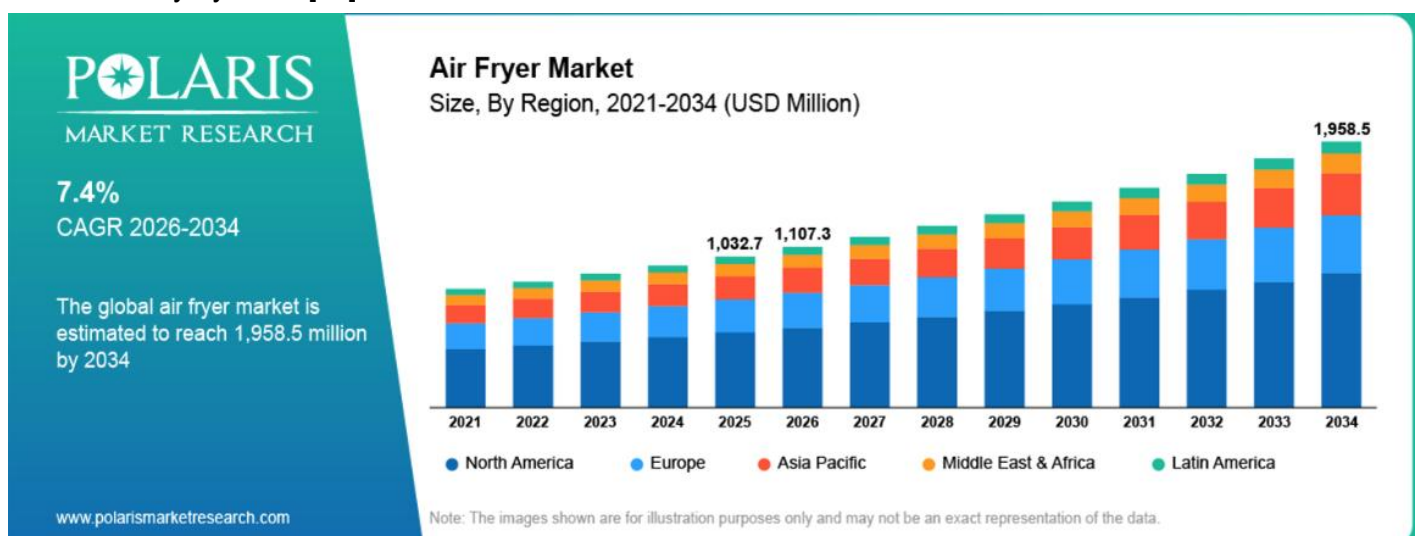
7. Commercial Applications & Intellectual Property

This section assesses the commercial opportunity for MistiFry, documents the intellectual property landscape identified through patent searching and outlines potential routes to market.

7.1 Market Context

7.1.1 UK Air Fryer Market

The UK air fryer market represents a significant commercial opportunity. The market was valued at approximately USD 279 million in 2024 and is projected to reach USD 438 million by 2030, growing at an annual growth rate of 7.8% [11]. Forecasts project the market reaching USD 478 million by 2034 [12]. Market data indicates it is expected to grow by 10.4% between 2024 and 2029, reaching a volume of 2.04 million units annually by 2029 [13].



[15]

7.1.2 Competitive Landscape

The following table maps MistiFry's position against the full competitive landscape, across all price tiers analysed in TP2 research.

Product	Price (RRP)	Capacity	Form	Controls	Cleaning	Mist / Steam	Notes
Philips 3000 Series XL	£89-£120	6.2L	Drawer	Digital touchscreen	Dishwasher-safe basket only	No	Market leader - strong brand, proven performance. No mist, no removable element, fixed PTFE-free basket.
Ninja Foodi MAX AF160	£129-£160	7.6L	Drawer	Digital display	Dishwasher-safe basket only	No	Premium positioning, dual-zone variant available. No steam or mist function. Touchscreen control.
Tefal Easy Fry Compact	£49-£69	4.2L	Drawer	Dial / digital	Dishwasher-safe	No	Entry-level. Smaller capacity, basic controls. No premium features.
Supermarket own-label (e.g. Asda, Tesco)	£25-£40	3-4L	Drawer	Dial / basic digital	Basket only	No	Budget tier. Minimal features. Price-driven purchase.
Our Place Wonder Oven	£145-£175	Countertop oven	Door / oven-style	Digital	Dishwasher-safe trays	Yes - steam infusion (thermal)	Closest competitor to MistiFry's steam concept. Uses thermal steam, not ultrasonic mist. No removable element. US-focused brand, limited UK availability.
MistiFry (proposed)	£100-£150	5-7L	Door / oven-style	Rotary encoder + OLED	Dishwasher-safe trays, rack, drip tray	Yes - ultrasonic mist (cold), pulsed	Only product combining ultrasonic mist infusion, removable heating element, self-clean cycle and PTFE-free SS304 cavity in a front-loading form factor.

No product in the UK market combines ultrasonic mist infusion, a removable heating element, an automated self-clean cycle, and a PTFE-free stainless steel cavity. This combination represents MistiFry's core competitive differentiation.

As of 2022, approximately 30% of UK households owned an air fryer [10]. Research indicates that the majority of UK consumers spend around £110 on an air fryer, with medium-sized models being the most popular choice this is directly aligned with MistiFry's 5-7L capacity and £100-£150 price point.

Nearly 63% of buyers cited lower running costs compared to conventional ovens as their primary purchase motivation, whilst health-conscious cooking trends continue to drive adoption among millennials and younger households [10].

7.2 Intellectual Property

7.2.1 Patent Search - Methodology

A patent search was conducted using Google Patents and the USPTO public search database to identify existing patents relevant to MistiFry's two primary novel features:

1. Ultrasonic mist infusion into an air fryer cooking cavity during cooking
2. A tool-free removable heating element with spade electrical connectors.

Search terms used included: 'air fryer mist steam infusion', 'air fryer removable heating element', 'air fryer steam patent' and 'steam type air fryer'.

The following patents were identified as the most relevant and are assessed for their implications for MistiFry.

7.2.2 Patent Search Findings

Patent No.	Title	Year	Key Claim	Relevance to MistiFry	Source
US20180035698A1	Air Frying Systems and Methods	2018	Steam supply and circulation system integrated into an air fryer. Covers steam-based moisture addition during or around the cook cycle.	This patent covers thermal steam generation. MistiFry uses ultrasonic cold mist rather than heated steam generation. Ultrasonic mist is produced by vibrating water, not by boiling. This distinction is significant for freedom to operate.	Google Patents
US11974692B2	Steam-type air fryer	2024	Integrated steam generator, water inlet, drainage structure and cavity sealing.	This patent covers a door-type air fryer with steam. MistiFry shares the water system concept. However, this patent covers a steam generator (thermal) system, not ultrasonic mist.	USPTO / Google Patents
US20220175186A1	Air fryer with removable heating coil for cleaning	2022	An air fryer design featuring a removable heating coil specifically to facilitate cleaning. The coil is designed to be detachable from the cooking pan assembly.	This is the most directly relevant patent to MistiFry's removable element feature. The patent covers a removable heating coil in the context of cleaning. MistiFry's spade-connector lift-and-pull mechanism may overlap.	Google Patents
US4817509A	Air Fryer	1989	Early air fryer design with a powered heater.	Expired patent - no IP constraint.	Google Patents
BR112018008687B1	Air-based fryer with fluid inlet (Philips)	2018	An air fryer with a fluid inlet that can introduce steam, smoke, cold mist (specifically mentions ultrasonic transducer), saline solutions, and flavoured liquids into the hot air stream during cooking.	The patent describes introducing cold mist into a hot circulating air during cooking. MistiFry's Infuse mode shares the principle of mist delivery into a circulating air cavity. However, technical distinction exists in MistiFry's Clean mode: it operates with no heating element present whatsoever. The patent is directed at a combined cooking and misting system with heating. MistiFry's element-free self-clean cycle represents a sufficiently distinct configuration that does not directly infringe.	Google Patents

7.2.3 IP Assessment & Recommended Strategy

Thermal steam integration into air fryers is well-covered by existing patents, primarily from Chinese manufacturers and Philips. The most significant finding is the Philips patent BR112018008687B1, which explicitly mentions ultrasonic cold mist as a fluid type that can be introduced into the air stream during cooking - this directly overlaps with MistiFry's Infuse mode concept.

For the removable heating element, patent US20220175186A1 covers a removable heating coil specifically for cleaning purposes, which overlaps with MistiFry's element removal feature. The earlier US4817509A (1989, now expired) establishes removable heater concepts as prior art, which narrows the scope of any new patent claim in this area.

Despite these constraints, MistiFry's IP opportunity lies in the specific combination of features - no identified patent covers the combination of:

1. ultrasonic cold mist infusion as a primary cooking feature,
2. a tool-free spade-connector removable heating element
3. a dual-mode mist system serving both cooking infusion and self-cleaning functions

A patent application for this combination, framed around the novel system integration and the dual-mode mist application, may be viable subject to professional IP advice.

7.3 Routes to Market

Three commercially viable routes to market have been identified for MistiFry. Each carries different risk, capital requirements, and strategic implications. A definitive route has not been selected at this stage - the choice will depend on the outcome of IP clearance and prototype validation.

Route	Description	Advantages	Challenges
Retail - John Lewis, Currys, Amazon	Manufacture MistiFry under own brand and supply to premium UK retailers. Target John Lewis and Currys for presence Amazon for online volume. Standard wholesale margin structure (typically 40-50% retailer margin).	High visibility in premium retail environment consistent with £100-£150 price point. John Lewis buyer relationship signals quality to consumers. Amazon provides scale and discoverability.	Requires substantial upfront investment in tooling, stock, and marketing. Retailer payment terms (60-90 days) create cash flow pressure. Strong competition from established brands on shelf.
Direct-to-consumer (DTC) via own website	Sell MistiFry exclusively through a branded website, using social media and content marketing to drive traffic. Higher margin per unit retained - no retailer cut. Model used successfully by Our Place (Wonder Oven) in the US.	Full margin retention. Direct customer relationship enables data collection and feedback loop. Lower barrier to market entry - no retail buyer approval required. Consistent with premium lifestyle brand positioning.	Requires significant investment in digital marketing, fulfilment, and customer service. Lower initial visibility than retail. Returns handling is operationally complex for a large kitchen appliance.
Licence the technology to an existing manufacturer	License the mist infusion system, removable element mechanism, and associated IP to an established air fryer manufacturer (Philips, Ninja, Tefal, or equivalent) in exchange for a royalty per unit sold.	Lowest capital risk - no manufacturing investment required. Leverages existing manufacturer's supply chain, retail relationships, and brand. Fastest route to market at scale.	Requires robust IP position before any licensing negotiation - the Philips prior art finding makes this complex. Royalty rate typically 2-8% of net sales - lower financial upside than own-brand. Loss of brand identity and design control.

7.4 Future Design Brief

Based on the evaluation in Section 6 and the commercial context established in this section, the following future design brief is proposed for the next phase of MistiFry development. This brief is deliberately specific - it identifies what must be resolved, rather than restating the original brief.

Area	Future Design Brief Statement
Integrated prototype	Design and build a single full-size, mains-powered functional prototype combining the validated electronics architecture with the full-scale SS304 cavity, PP housing and door mechanism. This prototype must cook real food at 220°C and demonstrate the Infuse and Clean modes with a full water tank.
Mist nozzle optimisation	Conduct mist distribution testing using a visual tracer method. Establish the optimal nozzle position and orientation to achieve even mist coverage across the full cavity interior including the ceiling zone. Update the design accordingly.
Spade connector specification	Source and specify a high-cycle-rated 6.3mm spade connector rated for minimum 500 mating cycles. Alternatively, design a positive-locking mechanism for the element connection that reduces wear whilst maintaining tool-free removal. Test to rated cycle count before production release.
IEC 60335 compliance	Engage a certified test laboratory (BSI) to assess the full-size mains-powered prototype against IEC 60335-1 and relevant Part 2 standards. Identify any design modifications required for compliance and incorporate into the production design.
IP clearance	Commission an opinion from a qualified patent attorney, addressing BR112018008687B1 (Philips ultrasonic mist claim) and US20220175186A1 (removable heating coil). Based on the outcome, determine whether to pursue a utility patent for the combined system or a registered design for the form factor.
User testing at scale	Conduct structured usability testing of the integrated prototype with a minimum of 10 participants drawn from both target user groups. Test all three modes, the element removal and reseating sequence and the water tank fill workflow. Specifically evaluate the Infuse mode cooking outcomes with different food types and mist tank contents.
Touchscreen UI (V2)	Evaluate touchscreen display options compatible with the ESP32 control architecture. Define a UI specification for a touchscreen variant that retains the three-mode Cook / Infuse / Clean structure, adds recipe preset functionality and enables Wi-Fi app connectivity via the ESP32's native Wi-Fi capability.

7.5 Conclusion

MistiFry represents a considered response to a problem in the domestic air fryer market.

MistiFry introduces ultrasonic mist infusion which changes what an air fryer can do and uses that same system to make the product almost effortless to maintain.

The design has been completed at prototype stage across two physical models:

1. a working low-voltage electronics prototype confirming the three-mode control architecture
2. a full-scale 3D printed model confirming the form factor, door mechanism, tray rail system and water tank interaction.

Materials selection, manufacturing process and commercial costing have been developed to production-intent level, with real supplier references and specification values. The IP has been assessed, primary competitors have been evaluated and three routes to market outlined.

MistiFry is a functionally viable and commercially differentiated product with a defined development pathway.

8. References

GENERATIVE AI STATEMENT

Generative AI tools were used solely for image generation purposes within this report, where explicitly stated. All written content, research, analysis, design decisions, calculations and prototype development were completed through independent human effort using academic and engineering methods. No AI tools were used to in the production of written content submitted as part of this report.

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Appendices

Appendix A - Ethics Forms: User Testing



Student Ethics Application Form for UG & PGT Student Projects/Dissertations

College/Department: School of Engineering & Technology

Project/Dissertation Module Code: PD3PRO Product Design Final Year Project

Project/Dissertation Title: Product Design Final Year Project

Supervisor Name and e-Mail: Ian Storer | i.storer@aston.ac.uk

Student Name, Number and e-Mail: 230161632

Section 0: Ethics Declaration Questions

If you are conducting a study for your supervisor where your supervisor already has ethical approval for the work to be conducted, please consult with your supervisor to ensure that (s)he has applied for an amendment to the existing ethical approval in order to permit your involvement. A letter from the College Research Ethics Committee confirming that permission will need included with your project report. You do not need to complete the remainder of this form.

Please answer the following questions honestly and carefully:

Will your project involve any of the following?	Delete as applicable
The NHS – either patients selected via the NHS or clinical staff working for the NHS	Not Permitted
Participants under the age of 18	Not Permitted
Vulnerable groups – individuals with physical disabilities, mental health disabilities, health, individuals with learning difficulties, prisoners/detained persons, people over 65 years of age, and/or pregnant women	Not Permitted
Any of the following: i) clinical procedures or ii) physical intervention (this excludes low-level physical activities or moderate exercise such as resistance training or cycling etc) or iii) penetration of the participant's body or iv) prescription of compounds additional to normal diet or other dietary manipulation/supplementation or v) collection of bodily secretions or vi) involve human tissue which comes within the Human Tissue Act (e.g., surgical operations, taking body samples including blood and DNA, exposure to ionising or other radiation (this excludes everyday electromagnetic waves exposure such as Wi-Fi, Bluetooth etc), extreme exposure to sound light or radio waves), psychophysiological procedures such as fMRI, MEG, TMS, extreme exercise testing procedures, administration of any chemical substances)	Not Permitted
Delving into topics that might be sensitive, embarrassing or upsetting or where it is possible that criminal or other disclosures requiring action could take place (e.g., during interviews) – including but not limited to projects focusing on mental health disorders	Not Permitted

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Human participants (including all types of interviews, questionnaires, focus groups, records relating to humans, use of online datasets or other secondary data, observations, usability testing, motion capture etc.)	Yes
Testing of apparatus for use with human participants (including where you have developed new apparatus and are testing it for accuracy, including on yourself. It could also include moderate exercise testing or collecting physiological data e.g. heart rate using proprietary equipment or off-the-shelf sensors)	Yes
Risk to you, including:	Yes
alone working during data collection	Yes
travel to areas where you may be at risk	No
risk of emotional distress	No
other: please outline	No
Any risk to the environment	No
Any conflict of interest	No
Work/research that could be considered controversial or be of reputational risk to Aston University	No
Social media data and/or data from internet sources that could be regarded as private	No
Any other ethical considerations (delete this row or contact the Research Ethics Office via your College Ethics inbox if there are any substantial ethical considerations you are aware of and would like to flag for the REC)	No

If you answer 'yes' to any of the questions above, you will need to continue to complete the rest of this form as well as any required participant-facing documentation (see ethics guidance provided). You and your supervisor will need to sign the declarations section at the end of this form before submitting it, along with all other paperwork, for ethical approval. No data collection and use (including recruitment of participants) may take place before ethical approval has been granted. All ethics paperwork, including evidence of ethical approval, should be included in your final report/dissertation submission.

If you answered 'no' to all of the questions above, you may skip to section 2. You and your supervisor will need to sign the declarations section at the end of this form. The form will need included in your final report submission.

Section 1: Study Details

Please provide the following information about your study. Be as detailed as possible. Where a question is not relevant, please indicate 'not applicable' but also explain why you believe that to be so.

Study Details
Project/Dissertation Objectives Please provide a brief outline of your overall project/dissertation objectives The project aims to develop product design solutions that are innovative, practical, socially responsible, and sustainable by applying appropriate research methods to investigate and address user needs within the chosen topic. Through effective self-management and project planning, students will take full ownership of their work, meeting deadlines and demonstrating professional practice. They will explore, evaluate, and refine ideas using research, analysis, and design development techniques while also considering ethical and client-focused perspectives. The project will culminate in the production and communication of a prototype, supported by artefacts such as posters, models or CAD images, allowing students to demonstrate their ability to

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translating research into impactful, well-communicated design outcomes. The project aims to redesign a household air fryer using safe, heat-resistant, and recyclable materials while integrating a moisture-spray feature to improve food texture and reduce dryness. The goal is to create a safer, more user-friendly and sustainable product design through material and usability research.	
Study Objectives Please explain how the study you are seeking ethical approval to conduct contributes to your overall project/dissertation objectives	This study supports the overall project objectives by generating first-hand insights to inform the design and development process. Through interviews, surveys or usability testing, students will explore user needs, challenges, and expectations as well as receive feedback related to their chosen topic. The findings will provide essential information to identify design opportunities, guide the creation of innovative and user-centred solutions and ensure that project outcomes are both relevant and impactful. In doing so, the study strengthens the research foundation of the project and ensures that the final outputs are grounded in robust and ethically collected data. This study focuses on evaluating design and material choices through classroom discussions and feedback sessions with peers and tutors. It does not involve external participants, personal data collection, or product testing with live heat or electrical operation.
Data Collection Method(s) to be Used Please outline your proposed data collection method(s) – e.g., questionnaires/survey, interviews, observational study, etc. Justify their use and explain how you will conduct the data collection in practice, including timeframe	Peer feedback within the classroom environment to gather meaningful insights during the development process, I will primarily use structured peer feedback sessions within the classroom environment. This method is appropriate because peers can provide immediate, relevant, and constructive responses based on their shared understanding of the project content. Peer feedback is particularly valuable at early development stages, as it allows for rapid iteration and refinement of concepts in a low-pressure setting. The data collection will involve presenting design ideas, early sketches, or prototype elements to classmates and asking targeted questions related to usability, clarity, and overall user experience. Responses will be recorded through short written forms and informal discussion notes. This approach is low-risk, non-intrusive, and ensures that participants feel comfortable sharing honest evaluations. 2. In-Person Usability Tests 1. General physical use of a decommissioned air fryer (no electrical hazard) Usability testing will include observing participants as they interact with a decommissioned air fryer to understand common user behaviours, difficulties, and expectations. Participants will be asked a series of product-related questions before and after the activity to gauge their familiarity and comfort with similar appliances. Because the item is non-functional, there is no electrical risk, and the physical actions required are minimal. No questions will be invasive or distressing, making this method low risk and suitable for a classroom environment.

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2. Physical interaction with a prototype – no electrical risk. Participants will also engage with a non-powered prototype to test the usability and ergonomics of the developing design. Observational notes will be taken, focusing on how users handle, interpret, and respond to the prototype's physical features. Short follow-up questions will collect direct feedback regarding potential improvements. Again, this activity presents no electrical hazards, involves only light physical effort, and avoids any sensitive or uncomfortable questioning. Both usability tests will take place during scheduled class sessions, with each test lasting approximately 10–15 minutes per participant. All observations and feedback will be stored anonymously and used solely to inform the iterative design process.	
Data to be Collected Please briefly outline the type of data to be collected	Design preferences and suggestions. User feedback + anonymous images of user interaction with the product / prototype.
Location of Data Collection Please briefly outline where you will be collecting the data – e.g., where you will be conducting your study	In-class discussions and tutorials at Aston University M5.146
Participant Recruitment Please outline how you will recruit participants to your study and how you will ensure that participants are not coerced to participate	Only classmates and tutors will provide informal feedback as part of standard coursework. No external recruitment or advertising will take place. Participation is voluntary and non-identifiable.
Data Storage Please outline where you will store your data (locally, on an encrypted server, USB drives are not permissible)	Written notes will be typed on notepad and stored on the student's OneDrive account, password-protected under Aston University's secure system. Physical copies will be shredded.
Data Deletion Please outline when you will erase the data you collected. For personally identifiable information, it should be deleted once an anonymised version is created, e.g., audio recordings should be deleted once the corresponding anonymised transcripts are created. For anonymised data, it should be kept until the final grade of the project/dissertation is released (if there is agreement from participants (via the consenting process) to retain and share data for health research purposes). Please provide justification if you have no plan to delete the collected data.	In-person or online usability test data Data generated from usability testing sessions may include recordings (audio, video, or screen-capture for online sessions on M5 Teams), researcher notes, and participant-generated materials (e.g., diaries, photographs or task outcomes). Any physical notes will be scanned and then securely destroyed once digitalised. Digital files will be anonymised, stored securely on OneDrive, and retained only until the final module grades are released and confirmed (end of September). At that point, all recordings and supplementary files will be permanently deleted.
Data Access Please indicate who will have access to the data you collected – e.g., your supervisor and any other members of the research team.	Only individual student (to which the single project belongs to) and supervisor will have access to data collected for the project. It will not be shared with anyone else.

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For Secondary Data/Dataset Use Only: Compliance with Terms & Conditions of Use <i>If you will be in receipt of secondary data that will be using an online, publicly available dataset, please provide evidence that you are observing any terms and conditions associated with its use and have permission to use it. Be mindful that just because data is available online does not mean that you are ethically entitled to use it for your study. <u>Consent</u> proven. If you are using data for, for example, a third party, you need to be sure that the individual has permission to share the data with you.</i>	N/A
Risk <i>Please outline any risks to either the participants in your study and/or yourself in the conduct of the study and what you have done to mitigate that risk</i>	• Risk of breach of personal information Students will provide participants with a Participant Information Sheet that clearly explains how their data will be anonymised, used, stored and deleted. All identifying details will be removed or coded in the interview notes, and only anonymised data will be included in the assignment. Secure digital storage (e.g., OneDrive with Multi-Factor Authentication) will be used and no data will be shared with unauthorised parties. • Risk of coercion or undue influence when inviting friends and family Students will make it explicit that participation is entirely voluntary and that declining will have no effect on their personal or professional relationship. Recruitment communications will focus on the purpose and scope of the study rather than the personal relationship. Potential participants will be given time to consider the invitation and will not be pressured to respond immediately. • Risk of psychological distress The supervisor and students will ensure interview questions are respectful, relevant to the study, and avoid unnecessary probing into sensitive areas. Participants will be reminded that they may skip any question or withdraw from the interview at any point, without having to provide a reason. If any unexpected distress arises, the interview will be paused or terminated, and the participant will be offered appropriate signposting to support resources if necessary. Low risk to participants or researcher. Feedback will occur in supervised classroom settings. Only foreseeable risk may be minor wrist strain in event of repeated usage of air fryer.

Section 2: Declarations

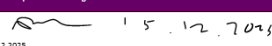
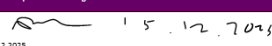
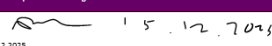
The following declaration should be signed by both you, the student, and your supervisor

Student:

I confirm the following:

- The above is an accurate representation of my study activities.
- That I shall not commence participant recruitment and/or data collection without ethical approval to do so (where applicable).

Page 5
REC ID: 230161632 Version 3 15.12.2025

• That I shall seek further ethical approval should I need to make any changes to my study after ethical approval has been granted (where applicable). • That I shall conduct my study with integrity and in accordance with the ethical approval granted (where applicable). • That, where necessary, I shall use existing or secondary data in accordance with terms and conditions of use or ethical approval, as <u>applicable</u>. • That I understand that if I breach the terms of the approval <u>granted</u> I may not be able to use the data collected in my project report and may face disciplinary procedures, and • That I shall respect my participants (where applicable) and the data I have collected and am using. Supervisor: I confirm the following: • That I have reviewed the content of this form and all associated paperwork and am happy with its standard and <u>accuracy</u>. • That I shall monitor the student's conduct of the study in accordance with the ethical approval granted (where applicable); and • That I shall report to the person(s) granting ethical approval any breaches of approval and ensure that no data is included in the student's work that has been collected in breach of approval. Both student and supervisor must sign* and date below: <table border="1"><tr><td>Signatures:  Supervisor: Ian Storer 15.12.2025</td><td>Date: 15.12.2025</td></tr></table> *All signatories must be acceptable	Signatures:  Supervisor: Ian Storer 15.12.2025	Date: 15.12.2025	Jean Kim Formatted: Highlight Jean Kim Formatted: Highlight Jean Kim Formatted: Highlight
Signatures:  Supervisor: Ian Storer 15.12.2025	Date: 15.12.2025		

Page 6
REC ID: 230161632 Version 3 15.12.2025

230161632 – Usability Protocol Ver 2 15.12.2025**Purpose of the Study**

The purpose of this usability testing is to gather formative feedback during the design development process. The study aims to identify usability issues, user expectations, and ergonomic considerations through peer feedback and in-person interaction with a decommissioned air fryer and a non-powered prototype. The findings will inform iterative improvements to the developing design.

Pre-Test Procedures**Participant Information Sheet**

- Each participant will be provided with a **Participant Information Sheet** prior to taking part in any testing activities.

Informed Consent

- After reviewing the Participant Information Sheet, participants will be asked to complete and sign a **Consent Form**.
- No testing will begin until written consent has been obtained.

Usability Testing Methods – applicable to test 1 and 2**Procedure**

- The researcher will present design ideas, early sketches, or prototype elements to participants.
- Participants will be asked a set of targeted questions focusing on:
 - Usability
 - Clarity of design
 - Overall user experience
- Feedback will be collected through:
 - Informal group discussion

In-Person Usability Test 1: Decommissioned Air Fryer**Procedure**

- Participants will be asked to physically interact with a decommissioned (non-functional) air fryer.
- Will observe how participants:
 - Handle the appliance
 - Interpret controls and physical features
 - Demonstrate expected usage behaviours

230161632 – Usability Protocol Ver 2 15.12.2025**In-Person Usability Test 2: Non-Powered Prototype Interaction****Procedure**

- Participants will interact with a non-powered physical prototype.
- The researcher will observe:
 - Grip, handling, and ergonomics
 - User interpretation of form and function
 - Areas of confusion or misuse

Follow-Up Questions – applicable to test 1 and 2

- Participants will be asked short, non-invasive questions regarding:
 - Comfort
 - Usability
 - Suggested improvements

Duration – applicable to test 1 and 2

- Each usability test will last approximately **20 minutes per participant**.
- All activities will take place within regular class time.

Debriefing – applicable to test 1 and 2

- At the conclusion of the session, participants will be thanked for their involvement.
- Participants will be reminded of how their feedback contributes to the design process.
- Any final comments or questions will be addressed.

Data Collection – applicable to test 1 and 2

- Written responses and discussion notes will be recorded.
- No identifying information will be collected.
- Feedback will be used to support early-stage design refinement.



Air Fryer Design Participant Information Sheet

Invitation

I would like to invite you to take part in a study forming part of my final year project for Product Design & Technology BSc.

Before you decide if you would like to participate, take time to read the following information carefully and, if you wish, discuss it with others such as your family, friends or colleagues.

Please ask me, my contact details can be found at the end of this information sheet, if there is anything that is not clear or if you would like more information before you make your decision.

What is the purpose of the study?

The purpose of this study is to thoroughly evaluate the usability, safety, and overall user experience of both existing air fryers and the developing redesigned concept. By examining how users interact with current products, the study aims to identify common difficulties, safety concerns, and limitations related to materials, handling, and general operation. These insights will directly support the development of a safer air fryer that incorporates improved materials, clearer functionality, and more intuitive design features.

This study also seeks to gather detailed feedback from potential users, peers, and experts to ensure that every stage of the redesign is informed by authentic user needs. Understanding user behaviours, expectations, and pain points will help highlight opportunities for enhancement, such as reducing physical risks, improving ergonomics, simplifying controls, or addressing issues that commonly cause confusion or misuse. By observing real interactions and collecting user-driven suggestions, the study will guide decisions that make the redesigned product more practical, accessible, and safer for everyday use.

Additionally, the study aims to assess how effectively the redesigned prototype communicates its purpose and functions through its form, materials, and layout. This includes evaluating whether users can interpret the product correctly without prompts, whether the chosen materials support safer use, and whether the design reduces or eliminates typical hazards associated with standard air fryers.

Overall, the purpose of this study is to generate meaningful, evidence-based insights that will refine and strengthen the redesign of the air fryer, ensuring the final solution is not only functional and user-friendly but also significantly safer and better aligned with modern expectations for responsible, sustainable product design.

REC ID: 230161632 Version PIS-OUT 3.0, 15.12.2025

Why have I been chosen?

You are being invited to take part in this study because I believe your knowledge, experience and perspectives are highly valuable in assessing the designed solutions. By participating, you will help identify usability challenges and opportunities for improvement, which can inform the development of more effective and user-centred solutions. You have been selected based on their alignment with the study's inclusion criteria, which may include:

- You are aged over 18.
- You have experience as a user of the relevant products
- Expertise within the sector, such as professional knowledge, technical skills, or involvement in related practices
- Willingness to provide feedback on the design solutions and suggest opportunities for improvement.

What will happen to me if I take part?

If you decide to participate, you will be invited to take part in a usability test of the system. You will be invited to a session at MB149 during which I will ask you to interact with an existing air fryer and a prototype. I will ask you to make comments on your interaction and any general notes you may have will be recorded. It is anticipated that the session should take approximately 20 minutes of your time.

Do I have to take part?

No. It is up to you to decide whether or not you wish to take part.

If you do decide to participate, you will be asked to sign and date a consent form. You can halt your participation at any time just by letting the student know and any data collected up to that point will not be used. You would still be free to withdraw from the study at any time up to 2 weeks from the date of your interview without giving a reason by emailing the student.

Will my taking part in this study be kept confidential?

Yes. A code will be attached to all the data you provide to maintain anonymity. Analysis of your data will be undertaken using coded data.

If we need to collect personal data (such as a name and contact details) we will only use this for the purposes outlined in this participant information sheet – e.g., to contact you to arrange the interview.

The data we collect will be stored in a secure document store (paper records if applicable) or electronically on a secure encrypted mobile device, password protected computer server or secure cloud storage device.

To ensure the quality of the research, Aston University may need to access your data to check that the data has been recorded accurately, e.g., for the purposes of audit. If this is required, your personal data will be treated as confidential by the individuals accessing your data.

How will the conversation during the session be recorded and the information I provide managed?

REC ID: 230161632 Version PIS-OUT 3.0, 15.12.2025

With your permission we will take notes in the interview session.

We will ensure that anything you have told us that is included in the reporting of the study will be anonymous.

You of course are free not to answer any questions that are asked without giving a reason.

What are the possible benefits of taking part?

While there are no direct benefits to you of taking part in this study, the data gained provide will help shape innovative products and services that address real consumer needs, drive innovation in the sector and contribute to business development. It will allow me to gain valuable feedback in order to improve my design.

What are the possible risks and burdens of taking part?

Given the topic of discussion, the fact that the processed data collected from you will be anonymous, and the original recordings will be destroyed once transcribed, we feel there is minimal risk to you in participating.

In terms of burden, the interview will require approximately 20 minutes of your time.

What will happen to the results of the study?

The results of this study will be published in the project/dissertation report of the student, wherein your identity will remain confidential.

The results of this study may be published in scientific journals and/or presented at conferences. If the results of the study are published, your identity will remain confidential.

Expenses and payments

There are no expenses or payments being provided for participation.

Who is funding the research?

The study is being funded by Aston University.

Who is organising this study and acting as data controller for the study?

Aston University is organising this study and acting as data controller for the study. Research data will be used only for the purposes of the study or related uses identified in this Information Sheet or Appendix A.

Who has reviewed the study?

This study was given a favorable ethical opinion by delegated authority by the Engineering & Physical Sciences Research Ethics Committee.

What if I have a concern about my participation in the study?

REC ID: 230161632 Version PIS-OUT 3.0, 15.12.2025

If you have any concerns about your participation in this study, please speak to the student and s(he) will do his/her best to answer your questions. Contact details can be found at the end of this information sheet.

If the student is unable to address your concerns or you wish to make a complaint about how the study is being conducted you should contact the Aston University Research Integrity Office at research_governance@aston.ac.uk or telephone 0121 204 3000.

Study Team Details

Alex Jameson, 230161632@aston.ac.uk, 01544 20881
Jon Storer, j.storer@aston.ac.uk, 0121 204 3000

Thank you for taking time to read this information sheet. If you have any questions regarding the study please don't hesitate to ask one of the study team.

REC ID: 230161632 Version PIS-OUT 3.0, 15.12.2025



Appendix A: Transparency Statement

Aston University takes its obligations under data and privacy law seriously and complies with the Data Protection Act 2018 ("DPA") and the General Data Protection Regulation (EU) 2016/679 as retained in UK law by the Data Protection, Privacy and Electronic Communications (Amendments etc) (EU Exit) Regulations 2019 ("the UK GDPR").

Aston University is the sponsor for this study based in the United Kingdom. We will be using information from you in order to undertake this study. Aston University will process your personal data in order to register you as a participant and to manage your participation in the study. It will process your personal data on the grounds that it is necessary for the performance of a task carried out in the public interest (GDPR Article 6(1)(e)). Aston University may process special categories of data about you which includes details about your health. Aston University will process this data on the grounds that it is necessary for statistical or research purposes (GDPR Article 9(2)(j)). Aston University will keep identifiable information about you for 6 years after the study has finished. Your rights to access, change or move your information are limited, as we need to manage your information in specific ways in order for the research to be reliable and accurate. If you withdraw from the study, we will keep the information about you that we have already obtained. To safeguard your rights, we will use the minimum personally identifiable information possible.

You can find out more about how we use your information at <https://www.aston.ac.uk/about/statutes-ordinances-regulations/publication-scheme/policies-regulations/data-protection> or by contacting our Data Protection Officer at dp_officer@aston.ac.uk.

If you wish to raise a complaint on how we have handled your personal data, you can contact our Data Protection Officer who will investigate the matter. If you are not satisfied with our response or believe we are processing your personal data in a way that is not lawful you can complain to the Information Commissioner's Office (ICO).

<retain the following two paragraphs (and delete this sentence) if you wish the data you collect to be shared otherwise delete this sentence and both paragraphs>

When you agree to take part in a research study, the information about you may be provided to researchers running other research studies in this organisation and in other organisations. These organisations may be universities, NHS organisations or companies involved in health and care research in this country or abroad.

This information will not identify you and will not be combined with other information in a way that could identify you. The information will only be used for the purpose of research, and cannot be used to contact you.

Risk Assessment Record

Description of Activity: Air Fryer and Prototype Interaction

Location of Activity: Mb 149

1. Hazards associated with the activity	2. Consequences of exposures to the hazards	3. Who or what at risk and numbers affected	4. What control measures are in place to prevent this from happening	5. With existing controls			6. Risk Category	7. Action required to reduce the risk to an acceptable level	8. Responsibility for action and timescales to complete	9. With additional controls		
				Initial Severity	Initial Likelihood	Initial Risk Rating				Revised Severity	Revised Likelihood	Revised Risk
Dropping Product	Minor injury	Participant	Testing will take place on a table with prototype secured	2	3	6	Acceptable	Ensure prototype is securely fixed before testing. Keep testing area clear of unnecessary items. Instruct Participant to handle product with both hands	Assessor to secure prototype and brief Participant To be completed prior to testing	2	1	2
Impingement of fingers in air fryer	Minor injury	Participant	Participant will be instructed to be careful and assessor will supervise	2	3	6	Acceptable	Provide clear verbal instructions before use Demonstrate correct hand positioning	Assessor to provide instruction and supervision To be completed before and during testing	2	1	2
Material allergy	Minor reaction	Participant	Considerations to be made beforehand. Participant will be informed what materials are in use	1	1	1	Acceptable	Confirm Participant has no known allergies prior to testing Provide material information in advance Stop testing immediately if irritation occurs	Assessor to check allergies and inform Participant To be completed prior to testing	1	1	1
Arm Strain	Arm Strain	Participant	Participant will not be required to repeat tasks to an excessive degree	2	2	4	Acceptable	Allow regular breaks during testing Limit duration of repetitive tasks Ensure working height and posture are comfortable	Assessor to monitor task duration and posture To be completed during testing	1	1	1
						0	Acceptable					0

10.

Assessor Name: Alex Jameson

Manager responsible for the assessment: Ian Storer

Peer Reviewer (where required):

Date: 15.12.2025

1-3 Insignificant

7-6 Low

7 - 10 Moderate

12-19 High

>20 Critical

Greater than 12 Action Needed

Risk Assessment = Level of Risk	1. Negligible				
	1. Rare	2. Unlikely	3. Possible	4. Likely	5. Almost Certain
1. Rare	1	2	3	4	5
2. Unlikely	2	4	6	8	10
3. Possible	3	6	9	12	15
4. Likely	4	8	12	16	20
5. Almost Certain	5	10	15	20	25

15/12/2025, 13:49

Final Year Project - In-person Usability Test Consent Form

Final Year Project - In-person Usability Test Consent Form

Ver 2 - Alex Jameson

* Required

1. I confirm that I have read and understand the Participant Information Sheet (Version PIS-OUT 3.0 and 15.12.2025 for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. *

☐ Yes

2. I understand that my participation is voluntary and that I am free to withdraw at any time up until the point I submit my responses, without giving any reason and without my legal rights being affected. *

☐ Yes

3. I understand that I am able to withdraw my data up to 14 days after taking part in the study by contacting the study team, after this time my data will be anonymised and I will no longer be able to withdraw. *

☐ Yes

4. I agree to my personal data and data relating to me collected during the study being processed as described above. *

☐ Yes

5. I agree to my anonymised data being used by research teams for future research. *

☐ Yes

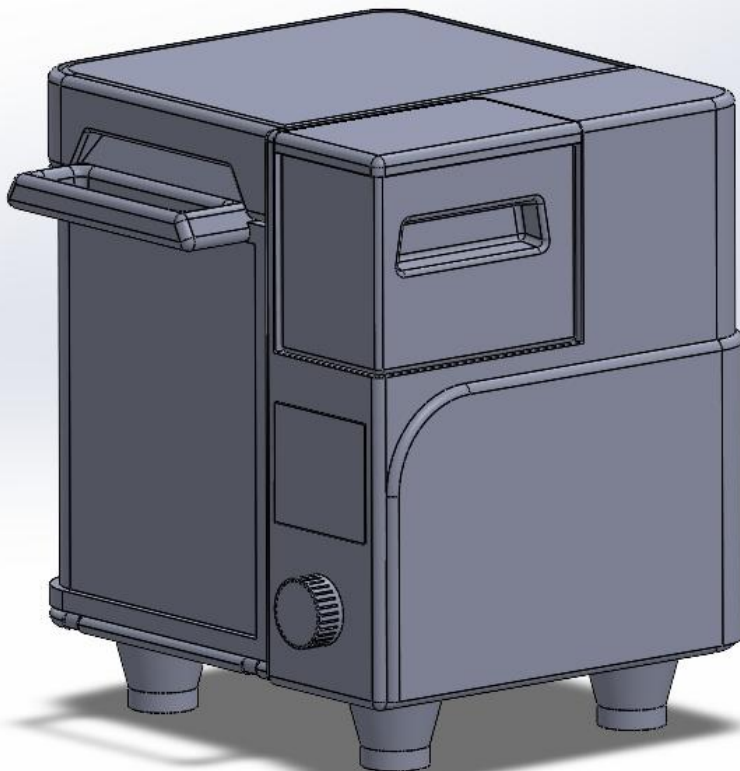
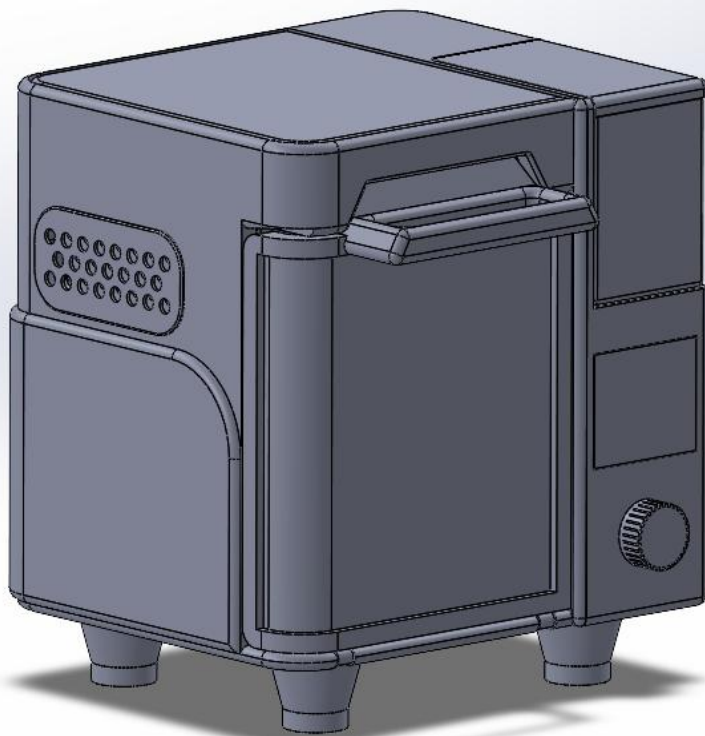
☐ No

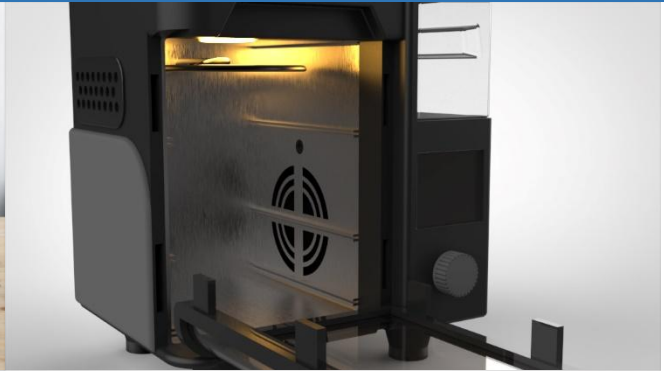
6. I consent to images being recorded of me during this session *

☐ Yes

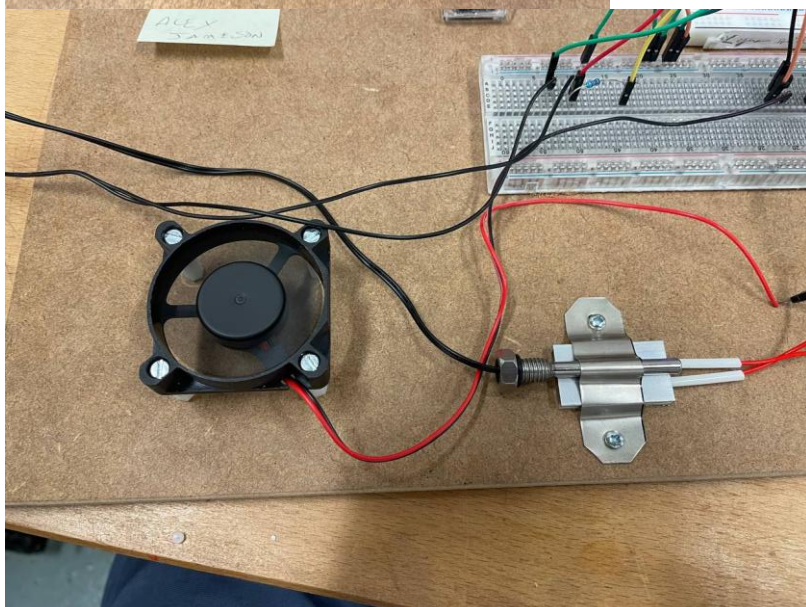
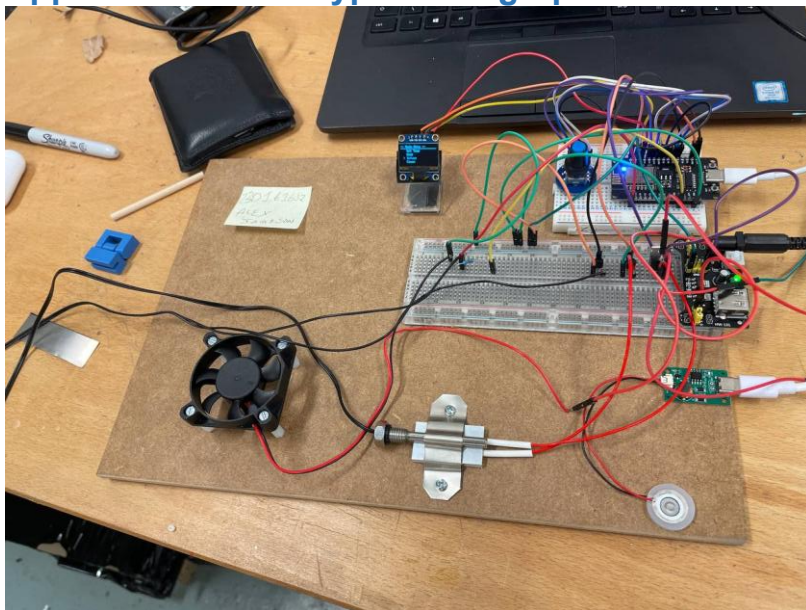
☐ No

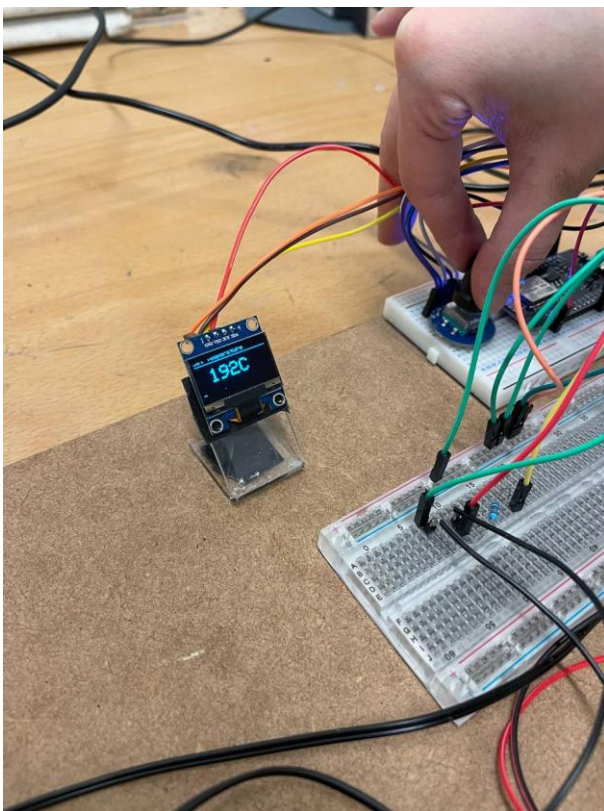
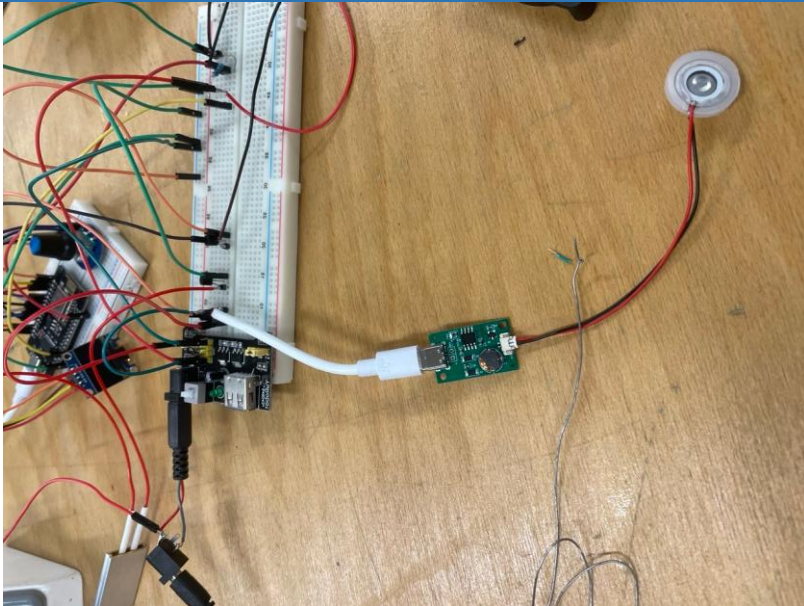
Appendix B - Additional CAD Views / Renders





Appendix C - Prototype Photographs







Appendix D - Supplier Quotes & Sourcing



Driver plate + atomizer plate + holder + cotton swab + individual packaging

Ultrasonic Atomization Maker 20mm 113KHz Mist Atomizer DIY Humidifier with PCB DC3-12V Mini USB Humidifier Module

★★★★★ 4.7 212 Reviews | 2,000+ sold

Welcome deal

£1.10 New shoppers save £0.01

Price includes VAT

£0.76 off over £13.67

Color: colorful Module



Product sellpoints

- Humidifier Module 12v|High-Quality Materials:Crafted from premium materials, this mist maker ensures durability and longevity.
- Adjustable Mist Volume:Customize your humidity levels with the mist maker's adjustable fog volume.
- Versatile Application:Ideal for DIY projects, plant care, and aquatic landscaping, this mist maker is a versatile tool.
- Efficient Performance:Experience stable, dynamic spray with the mist maker's efficient and reliable performance.
- Aesthetic Lighting:Enhance your space with seven-colour gradient or monochrome lighting

Bourns 24 ppr Pulse Incremental Mechanical Rotary Encoder with a 6 mm Knurl Shaft (Indexed), Through Hole

RS Stock No.: 789-9541 | Distrelec Article No.: 302-47-381 | Mfr. Part No.: PEC11R-4215K-N0024 | Brand: Bourns



3D

Bulk discount available

Subtotal (1 unit)*

£1.42 (exc. VAT)	£1.70 (inc. VAT)
---	---

Units
Select or type quantity

[Check delivery dates](#)

[Add to basket](#)

FREE delivery for orders over £60.00

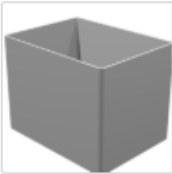
In Stock

- Plus 135 unit(s) shipping from 11 May 2026
- Plus 5 unit(s) shipping from 11 May 2026
- Plus 841 unit(s) shipping from 18 May 2026

Need more? Click 'Check delivery dates' to find extra stock and lead times.

☐  **CNC & Sheet Metal**

☐



10. Final-Metal Cavity Liner f... 

Qty:

Process: CNC Machining

Dimensions: 226.0mm × 172.5mm × 170.4mm

Material: Aluminium AW-6082 / 3.2315 / Al-Si1Mg

Finish: Standard

Threads and tapped holes: 0 locations

Surface Roughness

Requirements: Standard (3.2 um Ra), entire part

Tolerance: ISO 2768 - medium (mK), entire part

Manual quote required

Please proceed with a manual quote request. You can also split parts to different quotes for faster quoting.

Page 53 of 62

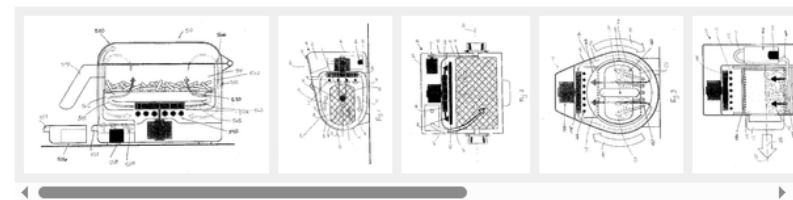
Appendix E - Patent Search Evidence

Air frying systems and methods

Abstract

An air frying system including a housing defining an inner chamber, a food container positioned in the inner chamber, an air heating and circulation system in communication with the food container, and a steam supply and circulation system in communication with the food container, wherein the air heating and circulation system and the steam supply and circulation system are independently controllable for cooking a food product in the food container.

Images (9)



Classifications

A47J37/0641

Small-size cooking ovens, i.e. defining an at least partially closed cooking cavity with electric heating elements with forced air circulation, e.g. air fryers

View 5 more classifications

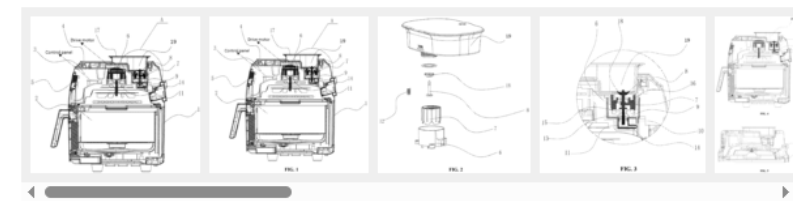
Landscapes

Steam-type air fryer

Abstract

A drain structure of an air fryer having a steaming function is provided. The air fryer includes a shell, a cooking cavity located at a lower side of the interior of the shell and a control cavity located at an upper side of the interior of the shell. The control cavity is provided therein with a control panel and a drive motor. The upper side of the shell is provided with a vent in communication with the control cavity. A top portion of the shell is provided with a water tank. The shell is provided therein with a steam generator in communication with the water tank. The steam generator is configured to input steam into the cooking cavity. The water tank is in a structure that is opened at bottom and closed at top, and the water tank is detachably mounted on the shell.

Images (14)



Classifications

A47J27/004

Cooking-vessels with integral electrical heating means

View 4 more classifications

US20180035698A1

United States

Download PDF

Find Prior Art

Similar

Inventor:

Gerald Joseph McNerney, Casey Aaron Klock, Boopalan Sampath, Jacob Daniel Smith

Current Assignee :

Spectrum Brands Inc

Worldwide applications

2017 • [WG](#) [GA](#) [US](#) [CN](#) [US](#) [CA](#) [WG](#) [CN](#)

Application US15/667,068 events ⓘ

2017-08-02 • Application filed by Spectrum Brands Inc

2017-08-02 • Priority to US15/667,068

2017-09-26 • Assigned to SPECTRUM BRANDS, INC. ⓘ

2018-02-08 • Publication of US20180035698A1

2020-07-31 • Assigned to ROYAL BANK OF CANADA ⓘ

2024-04-23 • Assigned to ROYAL BANK OF CANADA ⓘ

Status

• Abandoned

US11974692B2

United States

Download PDF

Find Prior Art

Similar

Inventor:

Yichi ZHANG

Current Assignee :

Ningbo Careline Electric Appliance Co Ltd

Worldwide applications

2020 • [EP](#) [AU](#) [US](#) [CA](#) 2021 • [KR](#)

Application US17/105,626 events ⓘ

2020-11-26 • Application filed by Ningbo Careline Electric Appliance Co Ltd

2021-09-30 • Publication of US20210298512A1

2024-05-07 • Publication of US11974692B2

2024-05-07 • Application granted

Status

• Active

2042-09-24 • Adjusted expiration

Show all events ▾

Page 54 of 62

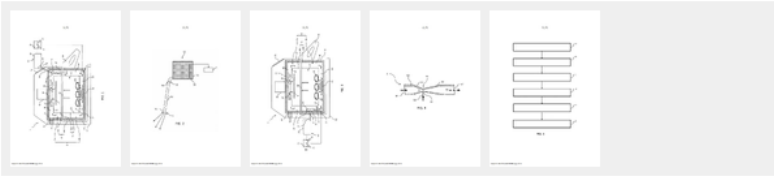
AIR-BASED FRYER AND METHOD OF PREPARING FOOD INGREDIENTS IN AN AIR-BASED FRYER

Abstract

translated from Portuguese

AIR-BASED FRYER, AND METHOD OF PREPARING FOOD INGREDIENTS IN AN AIR-BASED FRYER. The present application relates to an air-based fryer (1) for the preparation of food ingredients. The air fryer comprises a food preparation chamber (2), an air heater (3) for heating the air in the food preparation chamber (2) and a fan (4) for circulating an air flow. hot in the food preparation chamber (2). The air fryer (1) additionally comprises a fluid inlet (5) for introducing a fluid directly into the circulating flow of hot air. This solution allows the increased humidity of the hot air flow to result in food of superior quality in terms of taste, texture and aesthetics and increases the versatility of the air fryer.

Images (5)



Classifications

A47J37/0641

Small-size cooking ovens, i.e. defining an at least partially closed cooking cavity with electric heating elements with forced air circulation, e.g. air fryers

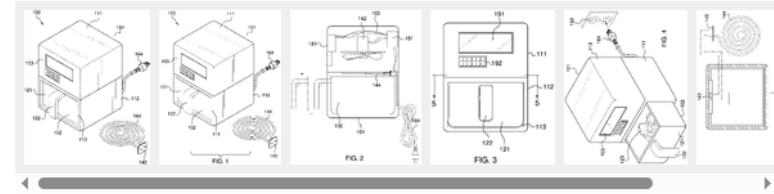
View 2 more classifications

Air fryer with removable heating coil for cleaning

Abstract

The air fryer with removable heating coil for cleaning is an appliance. The air fryer with removable heating coil for cleaning is an oven. The air fryer with removable heating coil for cleaning is configured for use with a foodstuff. The air fryer with removable heating coil for cleaning incorporates a thermal shell, a cooking pan, and a control circuit. The thermal shell contains the control circuit. The cooking pan inserts into the thermal shell. The foodstuff is contained in the cooking pan. The control circuit is an electric circuit. The control circuit generates and controls the heat necessary to heat the foodstuff within the cooking pan.

Images (7)



Classifications

A47J37/0641

Small-size cooking ovens, i.e. defining an at least partially closed cooking cavity with electric heating elements with forced air circulation, e.g. air fryers

View 4 more classifications

Landscapes

BR112018008687B1

Brazil

Download PDF

Find Prior Art

Similar

Other languages: Portuguese

Inventor: Marcel SLADECEK, Jan Vaupot

Worldwide applications

2016 • [WO](#) [JP](#) [BR](#) [EP](#) [US](#) [RU](#) [CN](#) [PL](#)

Application BR112018008687-8A events ⓘ

2016-10-24 • Application filed by Koninklijke Philips N.V.

2018-10-30 • Publication of BR112018008687A2

2022-06-14 • Publication of BR112018008687B1

Info: Patent citations (10), Cited by (39), Legal events, Similar documents, Priority and Related Applications

External links: Espacenet, Global Dossier, Discuss

US20220175186A1

United States

Download PDF

Find Prior Art

Similar

Inventor: Dana Davis

Current Assignee : Individual

Worldwide applications

2020 • [US](#)

Application US17/114,626 events ⓘ

2020-12-08 • Application filed by Individual

2020-12-08 • Priority to US17/114,626

2022-06-09 • Publication of US20220175186A1

Status • Abandoned

Info: Patent citations (7), Cited by (9), Legal events, Similar documents, Priority and Related Applications

External links: USPTO, USPTO PatentCenter, USPTO Assignment, Espacenet, Global Dossier, Discuss

Appendix F - Firmware Code

This was done by me

Air_Fryer_Final.ino

```
1  #include <Wire.h>
2  #include <Adafruit_GFX.h>
3  #include <Adafruit_SSD1306.h>
4  #include <Encoder.h>
5
6  #define SCREEN_WIDTH 128
7  #define SCREEN_HEIGHT 64
8  #define OLED_RESET -1
9  Adafruit_SSD1306 display(SCREEN_WIDTH, SCREEN_HEIGHT, &Wire, OLED_RESET);
10
11 #define SW_PIN D7
12 #define HEATER_PIN D0
13 #define FAN_PIN D8
14 #define MIST_PIN D4
15 #define THERM_PIN A0
16
17 #define SERIES_RESISTOR 10000
18 #define NOMINAL_RESISTANCE 10000
19 #define NOMINAL_TEMP 25
20 #define B_COEFFICIENT 3950
21
22 Encoder encoder(D5, D6);
23
24 // Menu states
25 enum State {
26     MENU,
27     SET_TEMP,
28     COOKING,
29     INFUSE,
30     CLEAN
31 };
32
33 State currentState = MENU;
34 int menuIndex = 0;
35 int targetTemp = 180;
36 long lastEncPos = 0;
37 bool mistOn = false;
38
39 const char* menuItems[] = { "Set Temp", "Cook", "Infuse", "Clean" };
40 const int menuCount = 4;
41
42 unsigned long buttonPressTime = 0;
43 bool buttonHeld = false;
44
45 void setup() {
46     Serial.begin(115200);
47
48     pinMode(SW_PIN, INPUT_PULLUP);
```

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```

96     display.println("-- Main Menu --");
97     display.drawLine(0, 10, 128, 10, WHITE);
98     for (int i = 0; i < menuCount; i++) {
99         display.setCursor(10, 14 + (i * 12));
100        if (i == menuIndex) {
101            display.print("> ");
102        } else {
103            display.print(" ");
104        }
105        display.println(menuItems[i]);
106    }
107    display.display();
108 }
109
110 void drawSetTemp() {
111     display.clearDisplay();
112     display.setTextSize(1);
113     display.setCursor(0, 0);
114     display.println("Set Temperature");
115     display.drawLine(0, 10, 128, 10, WHITE);
116     display.setTextSize(3);
117     display.setCursor(20, 20);
118     display.print(targetTemp);
119     display.println("C");
120     display.setTextSize(1);
121     display.setCursor(0, 56);
122     display.println("Press to confirm");
123     display.display();
124 }
125
126 void drawCooking(float currentTemp, bool infuse) {
127     display.clearDisplay();
128     display.setTextSize(1);
129     display.setCursor(0, 0);
130     display.println(infuse ? "Infuse Mode" : "Cook Mode");
131     display.drawLine(0, 10, 128, 10, WHITE);
132
133     display.setTextSize(2);
134     display.setCursor(0, 14);
135     display.print("Now:");
136     if (currentTemp == -999) {
137         display.println("ERR");
138     } else {
139         display.print((int)currentTemp);
140         display.println("C");
141     }
142
143     display.setTextSize(1);

```

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```
143   display.setTextSize(2);
144   display.setCursor(0, 34);
145   display.print("Set:");
146   display.print(targetTemp);
147   display.println("C");
148
149   display.setTextSize(1);
150   display.setCursor(0, 54);
151   display.print("Heat:");
152   display.print(digitalRead(HEATER_PIN) ? "OFF" : "ON");
153   if (infuse) {
154       display.print(" Mist:");
155       display.print(digitalRead(MIST_PIN) ? "ON" : "OFF");
156   }
157   display.display();
158 }
159
160 void drawClean() {
161     display.clearDisplay();
162     display.setTextSize(1);
163     display.setCursor(0, 0);
164     display.println("Clean Mode");
165     display.drawLine(0, 10, 128, 10, WHITE);
166     display.setTextSize(2);
167     display.setCursor(0, 20);
168     display.println("Fan + Mist");
169     display.println("Running");
170     display.setTextSize(1);
171     display.setCursor(0, 56);
172     display.println("Press to stop");
173     display.display();
174 }
175
176 void loop() {
177     long encPos = encoder.read() / 4;
178     bool buttonDown = digitalRead(SW_PIN) == LOW;
179
180     // Detect button press
181     if (buttonDown && !buttonHeld) {
182         buttonPressTime = millis();
183         buttonHeld = true;
184     }
185
186     bool buttonPressed = false;
187     if (!buttonDown && buttonHeld) {
188         buttonHeld = false;
189         buttonPressed = true;
190     }
```

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```
48   pinMode(SW_PIN, INPUT_PULLUP);
49   pinMode(HEATER_PIN, OUTPUT);
50   pinMode(FAN_PIN, OUTPUT);
51   pinMode(MIST_PIN, OUTPUT);
52
53   digitalWrite(HEATER_PIN, LOW);
54   digitalWrite(FAN_PIN, LOW);
55   digitalWrite(MIST_PIN, LOW);
56
57   encoder.write(menuIndex * 4);
58
59   if (!display.begin(SSD1306_SWITCHCAPVCC, 0x3C)) {
60     Serial.println("OLED not found");
61     while (true);
62   }
63
64   display.clearDisplay();
65   display.setTextColor(WHITE);
66   display.setTextSize(1);
67   display.setCursor(0, 0);
68   display.println("Air Fryer Demo");
69   display.display();
70   delay(1000);
71 }
72
73 float readTemperature() {
74   int raw = analogRead(THERM_PIN);
75   if (raw <= 0 || raw >= 1023) return -999;
76   float resistance = SERIES_RESISTOR * ((float)raw / (1023.0 - raw));
77   float steinhart = resistance / NOMINAL_RESISTANCE;
78   steinhart = log(steinhart);
79   steinhart /= B_COEFFICIENT;
80   steinhart += 1.0 / (NOMINAL_TEMP + 273.15);
81   steinhart = 1.0 / steinhart;
82   steinhart -= 273.15;
83   return steinhart;
84 }
85
86 void allOff() {
87   digitalWrite(HEATER_PIN, LOW);
88   digitalWrite(FAN_PIN, LOW);
89   digitalWrite(MIST_PIN, LOW);
90 }
91
92 void drawMenu() {
93   display.clearDisplay();
94   display.setTextSize(1);
95   display.setCursor(0, 0);
```

```
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190 }
191
192 switch (currentState) {
193
194     case MENU: {
195         int newIndex = constrain((int)encPos, 0, menuCount - 1);
196         if (newIndex != menuIndex) {
197             menuIndex = newIndex;
198             encoder.write(menuIndex * 4);
199         }
200         if (buttonPressed) {
201             if (menuIndex == 0) {
202                 // Set Temp
203                 currentState = SET_TEMP;
204                 encoder.write(targetTemp * 4);
205                 lastEncPos = targetTemp;
206             } else if (menuIndex == 1) {
207                 // Cook
208                 currentState = COOKING;
209                 digitalWrite(FAN_PIN, HIGH);
210                 encoder.write(targetTemp * 4);
211                 lastEncPos = targetTemp;
212                 Serial.println("Cook mode ON");
213             } else if (menuIndex == 2) {
214                 // Infuse
215                 currentState = INFUSE;
216                 digitalWrite(FAN_PIN, HIGH);
217                 digitalWrite(MIST_PIN, HIGH);
218                 encoder.write(targetTemp * 4);
219                 lastEncPos = targetTemp;
220                 Serial.println("Infuse mode ON");
221             } else if (menuIndex == 3) {
222                 // Clean
223                 currentState = CLEAN;
224                 digitalWrite(FAN_PIN, HIGH);
225                 digitalWrite(MIST_PIN, HIGH);
226                 Serial.println("Clean mode ON");
227             }
228         }
229         drawMenu();
230         break;
231     }
232
233     case SET_TEMP: {
234         int newTemp = constrain((int)encPos, 0, 250);
235         if (newTemp != lastEncPos) {
236             targetTemp = newTemp;
237             lastEncPos = newTemp;
```

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```
238     }
239     if (buttonPressed) {
240         currentState = MENU;
241         encoder.write(menuIndex * 4);
242         Serial.print("Temp set to: ");
243         Serial.println(targetTemp);
244     }
245     drawSetTemp();
246     break;
247 }
248
249 case COOKING: {
250     float currentTemp = readTemperature();
251     if (currentTemp != -999) {
252         if (currentTemp < targetTemp) {
253             digitalWrite(HEATER_PIN, HIGH);
254         } else {
255             digitalWrite(HEATER_PIN, LOW);
256         }
257     }
258     if (buttonPressed) {
259         alloff();
260         currentState = MENU;
261         encoder.write(menuIndex * 4);
262         Serial.println("Cook mode OFF");
263     }
264     drawCooking(currentTemp, false);
265     break;
266 }
267
268 case INFUSE: {
269     float currentTemp = readTemperature();
270     if (currentTemp != -999) {
271         if (currentTemp < targetTemp) {
272             digitalWrite(HEATER_PIN, HIGH);
273         } else {
274             digitalWrite(HEATER_PIN, LOW);
275         }
276     }
277     if (buttonPressed) {
278         alloff();
279         currentState = MENU;
280         encoder.write(menuIndex * 4);
281         Serial.println("Infuse mode OFF");
282     }
283     drawCooking(currentTemp, true);
284     break;
285 }
```

```
286
287     case CLEAN: {
288         if (buttonPressed) {
289             allOff();
290             currentState = MENU;
291             encoder.write(menuIndex * 4);
292             Serial.println("Clean mode OFF");
293         }
294         drawClean();
295         break;
296     }
297 }
298
299 delay(10);
300 }
```