IMPROVING ERGONOMICS IN THE PROFESSIONAL KITCHEN

Introducing a new method of porcelain heating

MAURICE VAN BUSSEL

MASTER THESIS INDUSTRIAL DESIGN ENGINEERING
DELFT UNIVERSITY OF TECHNOLOGY
JANUARY 2021

Master Thesis | Integrated Product Design
Industrial Design Engineering at Delft University of Technology
January 2021 | the Netherlands

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CLIENT

Qook! | Part of QBTEC
Woerden | the Netherlands

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0.1

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to all the people that supported me, gave guidance and encouraged me throughout this project.

FROM DELFT UNIVERSITY OF TECHNOLOGY :
Bruno Ninaber van Eyben and Gianni Orsini.

FROM QBTEC:
Bas van der Werf, Jeroen van Amstel and all other parties involved.

FRIEND AND FAMILY
To my dear parents, friends and girlfriend. Thanks for the support!

STUDIO NINABER
For the fantastic environment, advice and inspiration.

COOKS
For the time, effort and all the fun conversations. Especially Marc and Arie.

0.2

PREFACE

This report concerns my thesis of the master programme Integrated Product Design at the Faculty of Industrial Design Engineering at Delft University of Technology.

The subject of this report is the professional kitchen. Before studying Industrial Design Engineering I attended and completed a cooking program at a culinary school in Belgium.

After completing my Bachelor's degree in Industrial Design Engineering I decided to gain experience in the culinary world. For over seven months I worked at a Michelin starred restaurant in Rijswijk and a fine dining restaurant in Delft. Working weeks of 60 to 70 hours became the standard and the kitchens in which I had to work were not designed to optimize ergonomic conditions. The image below shows myself preparing plates at a Michelin starred restaurant. A low workbench and a high workload resulted in this poor posture.

For my Master's thesis I decided to combine my two passions. Product design and cooking.

The aim of this graduation project is improving ergonomics in the professional kitchen. After a thorough analysis I decided to optimize one workstation.

This starting point resulted in a new, ergonomically improving, heating method for porcelain dinnerware.

Image 0. Author cooking at Niven in Rijswijk

0.3

EXECUTIVE SUMMARY

This report presents the design process of the development of a new heating concept for the professional kitchen. The project is executed on behalf of the TUDelft and the kitchen manufacturer Qook!.

PROJECT TOPIC

Cooks in Michelin starred and fine dining restaurants cope with long working days under high pressure. Although there are many legislations and rules, on a certain culinary level the circumstances are tough and are accepted as part of the job. Working weeks of 70 to 80 hours and the constant pressure of performing better everyday requires a productive and ergonomic work environment.

This design project aims to improve the physical and cognitive ergonomics, which simultaneously will improve the efficiency of the professional kitchen.

DESIGN DIRECTION

After extensive interviews this design project continues with the aim of optimizing the heating systems of the pass, a workstation that is considered problematic, inconvenient and uncomfortable.

The pass is the workstation that lies on the border of the kitchen and the dining hall. At this workstation the kitchen is controlled, dishes are plated and sent to the customer. The pass includes heating systems for ceramic dinnerware and food.

CONCEPT

A new heating method of ceramic dinnerware is developed. Combined with a special porcelain coating, conceived and manufactured by the German company Schönwald, a concept is developed that uses a field of induction coils to replace the current heating systems.

It improves thermal comfort, manoeuvrability, visibility and the working posture.

During the concept phase a prototype has been built as a proof-of-principle of the newly developed heating system. I conclude with a number of recommendations that can be used for the development of the concept toward a final product.

CHAPTER 1

PROJECT OUTLINE

This chapter describes the outline and starting point of my graduation project. It describes the stakeholders, my personal and professional ambitions, the design topic, the structure of this graduation project and it gives a glossary specific to the design topic.

1.1

PROJECT PARTNERS

QBTEC

QBTEC is a Dutch production company based in Woerden and is Europe's biggest producer of professional frying and cooking installations. QBTEC is the parent company of six brands with different specializations.

One of these six brands is the brand Qook!. My graduation project is executed for this brand. Qook! is the brand that focuses on customized restaurant kitchens for the middle and high segment restaurants.

Qook!'s unique selling point is the seamless integration of all equipment and customizability with unique functionalities.

The kitchens of Qook! are mostly built at the production facility of QBTEC, based in Woerden.

TU DELFT

The Delft University of Technology (TU Delft) is the oldest and largest technical university in the Netherlands.

This graduation project is done on behalf of the faculty of Industrial Design Engineering, and specifically for the Master's programme Integrated Product Design (IPD).

The IPD Master's programme focuses on teaching how to design user-centered innovative products and product service combinations, based on a balance between the interests of users, business and societal challenges. (TUDelft, 2019)

Within this graduation project the TUDelft is represented by professor Bruno Ninaber van Eyben and mentor Gianni Orsini, both part of the Human-Centered Design Department of the faculty of Industrial Design Engineering.

1.2

PROJECT AMBITION

This chapter explains the desired professional and personal ambitions that are set to be accomplished with this graduation project.

1.2.1 PROFESSIONAL

Towards the end of my study Industrial Design Engineering, this graduation project, being an individual and a free-choice project, gives the opportunity to experiment and learn aspects which are still missing in my experience as product designer.

Therefore, the professional ambition of this project is experimenting with and learning the method of designing by prototyping. In previous projects, during the study, freelance work, and an internship, the focus was on design instead of functionality.
This graduation project is used to experience the power of prototyping and optimizing the functionality of the final product.

1.2.2 PERSONAL

The second project ambition is based on personal experience. Before starting my study Industrial Design Engineering at the TUDelft, I completed a one year culinary study in Belgium. Three years later, after completing my Bachelor's degree at the TUDelft, I worked as a full time cook in a Michelin starred restaurant in Rijswijk and a fine dining restaurant in Delft. This experience showed me the challenging work environment of a cook.

Working weeks of 70 to 80 hours and the constant pressure of performing better every day gives requires a productive and ergonomic work environment.

The project ambition of this graduation project is to improve the physical and cognitive ergonomics, which simultaneously will improve the efficiency of the professional kitchen.

With these improvements the working conditions of a cook can be ameliorated while proving relevance to the restaurant owner.

1.2.3 CONCLUSION

The combination of personal experience and the designing by prototyping method are a good fit with the subject of this graduation project.

A professional kitchen environment is -or should be- extremely functional and practical. The aim is to maximize the practicality of the final design by continually prototyping and testing solutions.

1.3

PROBLEM DEFINITION

In this graduation project the work environment of high level restaurants in the culinary industry is observed to define genuine problems and issues. These problems and issues will substantiate the new kitchen product that is designed.

WHAT

Cooks in Michelin starred and fine dining restaurants cope with long working days under high pressure. Although there are many legislations and rules, on a certain culinary level the circumstances are tough and are accepted as part of the job.
The long days are filled with heavy physical tasks and repetitive work while being under time pressure. As the time pressure itself is not tedious, it does take away the attention to a good working posture. This is mostly present in the period that customers are attending the restaurant and order food.

With the optimisation of ergonomics, and thus performance, both parties of interest, cooks and buyers, have benefits of the product to be developed.
On the one hand it improves the well-being of the cooks, and thus less dissatisfaction and illness. On the other hand by improving efficiency, labour time and costs can be reduced which in turn is beneficial for the buyer. (Dul, 2012)

WHO

Cooks who work in restaurant kitchens with a brigade of at least three people and who have at least a ten hour working day and where preparation, service and plating are part off. The focus in these kitchens is food preparation from start to finish.

CONTEXT

This graduation project focuses on restaurants in the upper class segment like fine dining or Michelin starred restaurants where food and food preparation are central. This means an eye for detail and perfection and therefore is time consuming.

Additionally, this environment is stressful due to the variable demand and the need of maintaining a good reputation through high-quality output, every day.

1.4

ASSIGNMENT

This graduation project is initiated by personal experience. The starting point was the search for a design topic that has personal meaning and interest. My background as a cook and the professional ambition formulated in chapter 1.2 lay the foundation for this graduation project.

With the connections of professor Bruno Ninaber van Eyben the company Qook! became part of this project. The first thing set was the project goal:

IMPROVING ERGONOMICS IN THE PROFESSIONAL KITCHEN.

Qook! agreed with this project goal and gave freedom to analyse and shape my own graduation project.

1.5

STRUCTURE

The structure of this graduation project is frequently used in design projects at the faculty of Industrial Design Engineering.

ANALYSIS

During the analysis investigated five topics are investigated; (1) the company, (2) the market, (3) the buyer, (4) the user group and (5)the work environment.

The results of the analysis on these topics are translated into a design direction.

DESIGN DIRECTION

The design direction is based on the most valuable results of the analysis. It narrows down the scope and provides boundaries to the project.

IDEATION

This diverging phase of the project gives ideas that fit the design direction. These ideas are analysed and tested to validate the potential. It ends with a conversion and an idea selection.

CONCEPT DESIGN

The most narrowed down phase of this project is the concept design phase. During this phase, all the knowledge and techniques are applied, that are required to realize the final product idea. It results in a conceptual design of the product idea.

1.6

GLOSSARY

This glossary provides the definitions of the terms used throughout this thesis. Image 1 shows the floor plan of De Centrale, a fine dining restaurant in Delft.

Brigade: Kitchen team

Chef: Leader of a kitchen

Chef de parti: Leader of a parti

Cuisson: The way that something is cooked (e.g. the steak has a medium cuisson = the steak is cooked medium)

Efficiency: Efficiency signifies a peak level of performance that uses the least amount of input to achieve the highest amount of output. (Banton, 2020)

Entremetier: In charge of the hot vegetable and starch preparations

Garde Manger: In charge of the cold savory dishes

Horeca: The Dutch abbreviation for Hotel, Restaurant and Cafe

Mise en place: Organization of ingredients and preparations needed for the menu items that are expected during a service.

Parti: A parti is a workstation in a professional kitchen. The kitchen is divided into workstations that are adjusted to the type of dishes produced. At each parti specific types of dishes are prepped.

Pass: The long workbench where the dishes are plated and finished, and picked up by waitstaff; a pass is mostly equipped with heat lamps.

Pattisier: In charge of sweet preparations like desserts

Plating: Placing the food on a plate, in a specific order and place, and finishing it to be served to the customer.

Roti: In charge of the hot preparations of protein and sauces

Service: The period in which customers are in the restaurant and order food. Food is finished, plated and served on the demand of the customers.

Sous chef: Right hand of the chef and the leader when the chef is not around

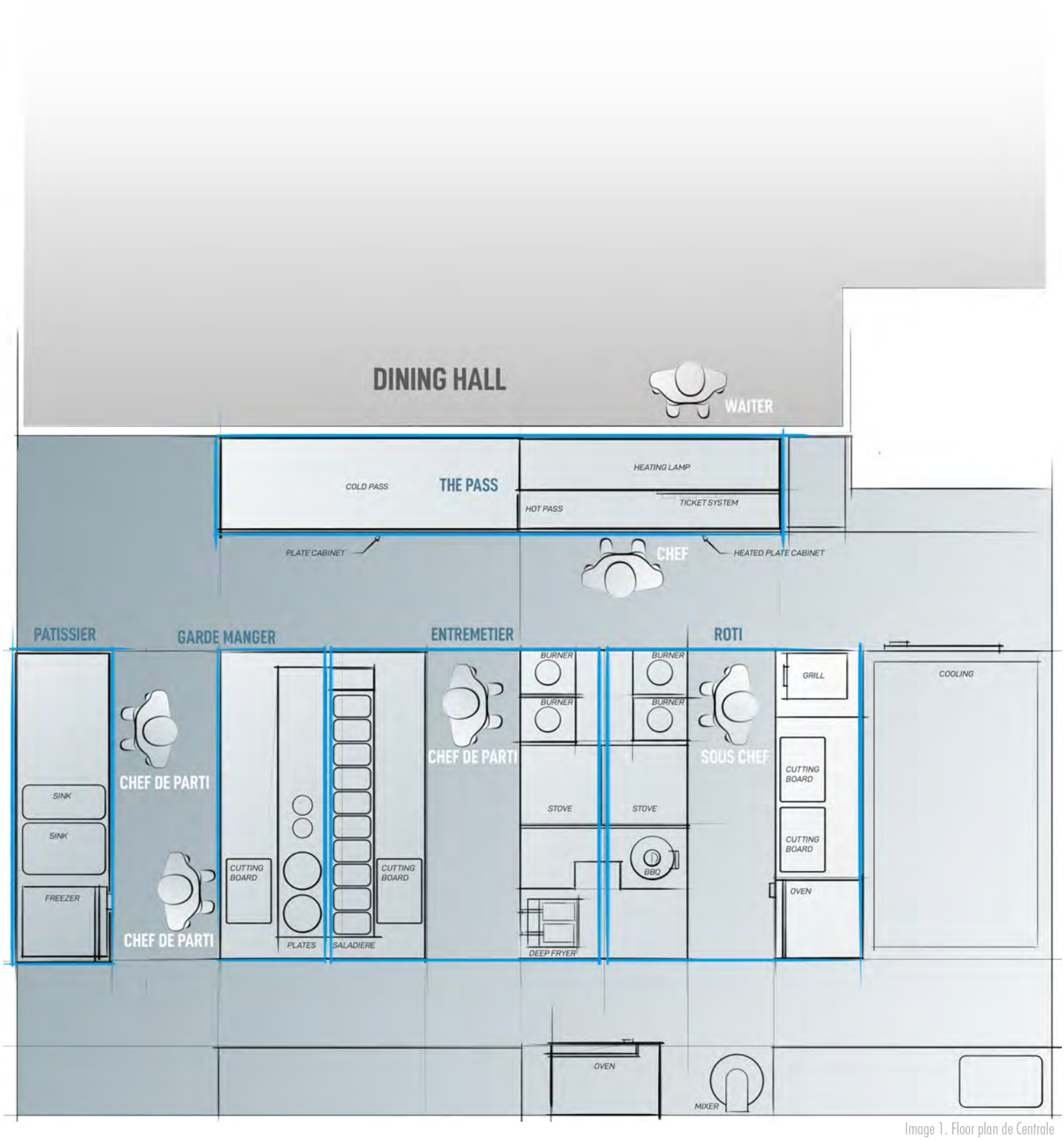


Image 1. Floor plan de Centrale

CHAPTER 2

ANALYSIS

This chapter comprises the research analysis. It consists of an analysis on (1) the Company, (2) the Market, (3) the Buyer, (4) the User Group and (5) the Work Environment. This analysis substantiates the design direction described in chapter 4.

2.1

COMPANY

QBTEC is a Dutch production company based in Woerden and is Europe's biggest producer of professional frying and cooking installations. QBTEC is the parent company of six brands with different specializations.

2.1.1 HISTORY

1953

QBTEC started with the brand name Perfecta producing frying installations.

1965

In 1965 a new brand, Kiremko, was created to develop solutions for the upcoming chip industry that came from the American Fast food trend. Kiremko started manufacturing food processing production lines.

1980

In the eighties, frying installations, focused on the catering industry, are added to Kiremko's portfolio with the name Kiremko Horeca. In 1987 the catering branch is taken over by the Okkerman family and in twenty years time the Okkerman Kiremko family extended the company to a large international player.

1994

The equipment factory Smitto is acquired by Kiremko Horeca.

2007

Perfecta, Kiremko and Smitto are merged to the new overarching brand QBTEC. Production centralized in Woerden.

2011

Qook! is launched and with this brand QBTEC combines their craftsmanship with the expertise of dealers and demands of the catering industry. (Raoul, n.d.)

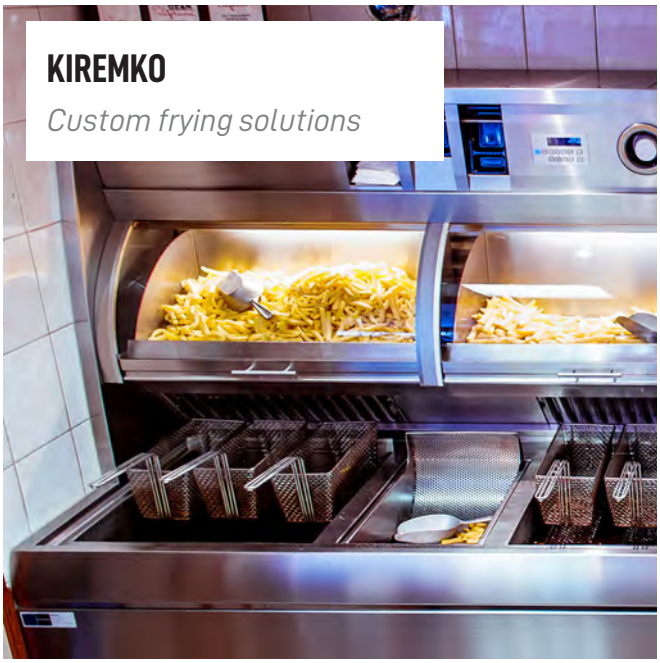
2.1.2 SUB BRANDS

Throughout the years QBTEC added multiple brands to its portfolio. Image 2 show the six different brands.

Qook!, the brand that targets customized restaurant kitchens, is a relatively young brand launched in 2011. The focus of this graduation project is the brand Qook!.

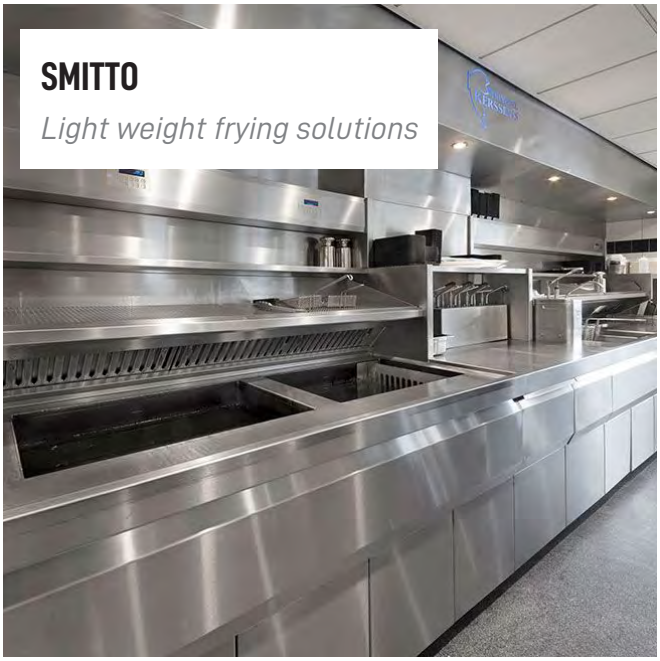
PERFECTA

Chip frying ranges



KIREMKO

Custom frying solutions



SMITTO

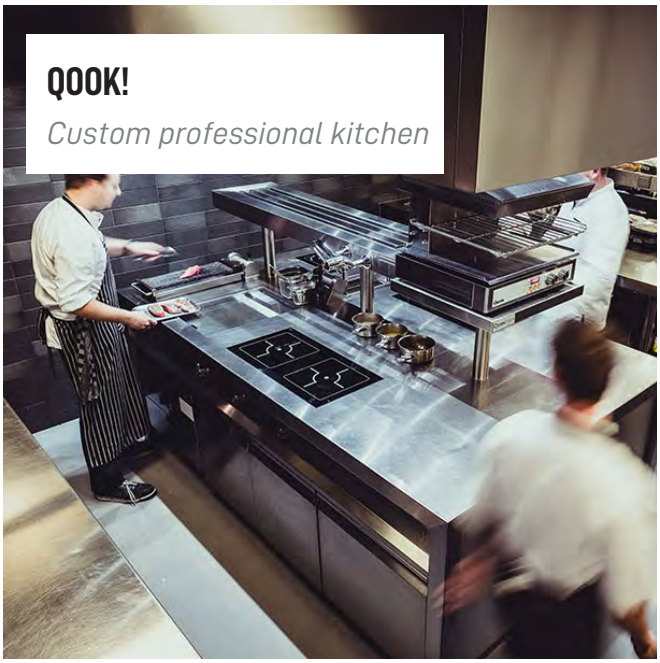
Light weight frying solutions

ADIEU

Cast iron flat top griddle

HIFRI

Low fat frying



QOOK!

Custom professional kitchen

Image 2. Subbrands QBTEC

2.1.3 QOOK!

Qook! offers customized professional kitchens to the catering industry. The brand represents quality and customization.

Qook! mostly sells kitchens to middle and high segment restaurants. As explained by a Qook! sales advisor, middle and high segment restaurants have more use of a custom-build kitchen whereas the lower segment restaurants buy modular parts and assemble kitchens themselves.

2.1.3.1 BRAND VALUES

Qook!'s sales advisors have been working in the catering industry for many years and now advise Qook!'s clients on all parts of a professional kitchen such as equipment, layout and climate control.
The unique selling point of Qook! is the seamless integration of all equipment needed and the fully customizability with unique functionalities. Summarised by the words:

HIGH QUALITY
CUSTOMIZED
UNIQUE FUNCTIONALITY
SEAMLESS
FLEXIBLE

2.1.3.2 PORTFOLIO

Page 23 and 24 shows Qook!'s portfolio. The first page illustrates customization, cleanability and the seamless integration of equipment in a Qook! kitchen.

The second page shows the signature design elements that Qook! is applying to their kitchens. Signature elements of a Qook! kitchen are the table top thickness and the sandblasted logo. Additionally, the letter Q of the logo is used for air inlets.

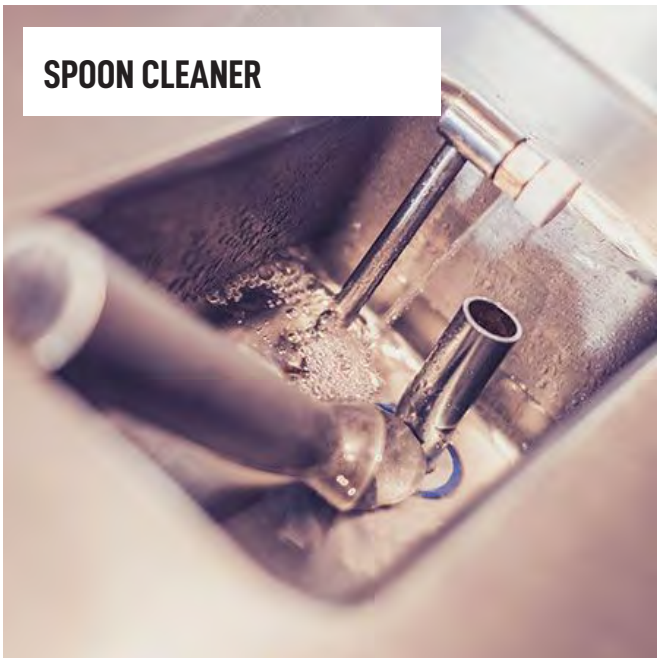
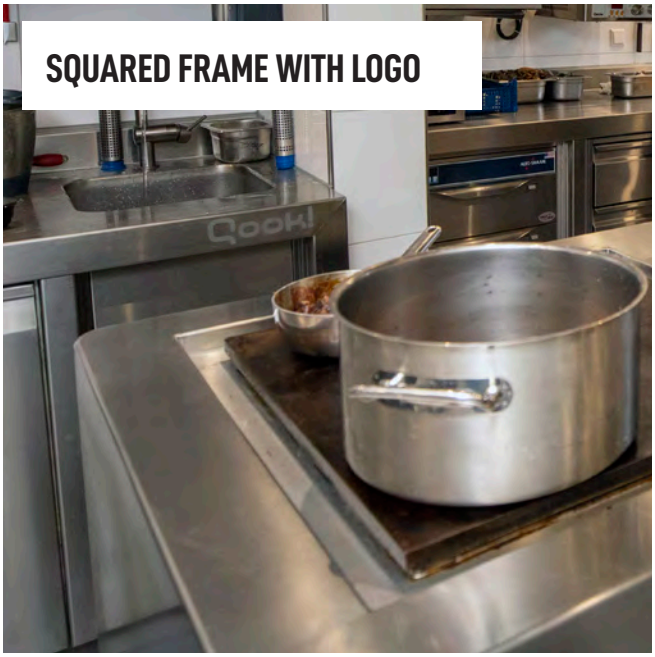


Image 3. Features of a Qook! kitchen



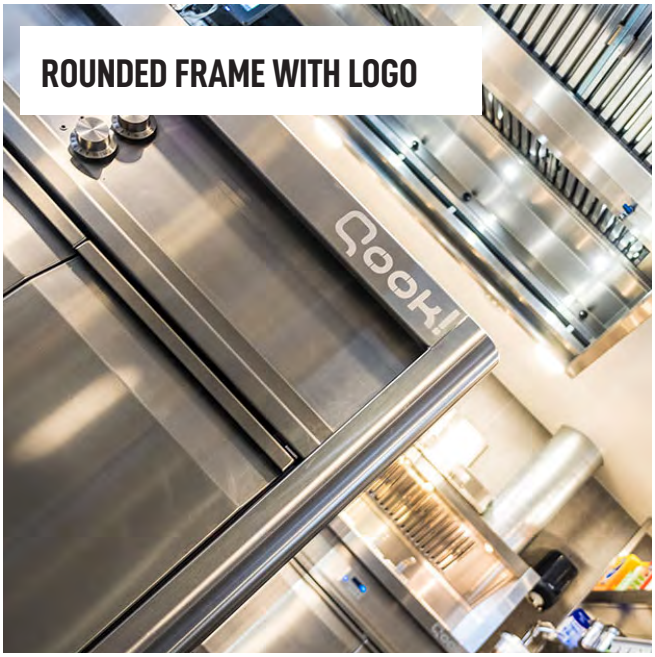


Image 4. Signature design elements Qook!

2.1.3.3 FORM FOLLOWS FUNCTION

Form follows function is a design principle related to industrial design. This principle means that the shape of a product should mainly be driven by its intended function.

This design principle relates to the working method of Qook!. As the professional kitchen is a practical work environment the products are function driven. Aesthetics come second.

The function driven working method is a good fit in the catering industry. With the large product range that Qook! offers most functionality demands can be answered. Although Qook! is flexible, and can offer any customization with stainless steel parts, they rely on the products that are offered by their partners. In-house product development is not part of Qook!'s company strategy.

Some unique functionalities can be achieved with the use of stainless steel customization and the available product offering. However, this is something that can also be done by the competitors described in chapter 2.2.

Not only innovating by new implementations of the available product offer but also by new product development Qook! can distinguish itself from other brands.

Image 5. A kitchen by Qook!

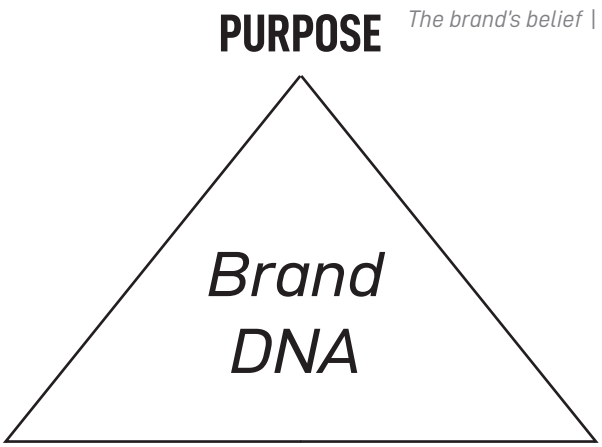


Image 6. Brand DNA (Vorst 2020)

2.1.3.4 BRAND DNA

Formulating the brand DNA in collaboration with Qook! gives aesthetic directions used later in the design process. The Brand DNA consists of Purpose, Positioning and Personality. Although the brand exists since 2011, a clear brand DNA is not yet determined. This analysis can offer a better defined direction for the brand's marketing.

PURPOSE

A brand purpose is about the beliefs of a brand and what a brand wants to accomplish.

In the case of Qook! the following purpose is formulated:

We believe that cooks perform best in a high quality and specialized kitchen

POSITIONING

The positioning of a brand consists of the value proposition which is a combination of product category, target group, and functional and emotional benefits. In collaboration with Qook! the following value proposition is determined:

Qook! is the kitchen manufacturer that offers qualitative and customized kitchens to restaurant owners, and delivers the ability to perform and make users feel efficient and in control.

Image 7. Brand archetypes (Mark and Pearson 2006)

PERSONALITY

To determine the brand personality, a list of twelve archetypes is used, developed by Marc and Pearson (2006). These twelve archetypes, illustrated with image 7, are common characteristics that can be appointed to a brand.

Of these twelve archetypes the following are selected as a match with Qook!. This is done in collaboration with the sales advisors of Qook!.

Ruler
Creator

The brand archetypes can be used to create a brand identity that is recognizable and delivers meaning to the customer. Not only marketing can be strengthened by the use of archetypes but the kitchen design can also communicate the brand identity.

RULER

Ruler is the archetype that should be most prominent. Part of this archetype is the desire of control. This archetype fits with brands that help people to be more organised. These brands offer products with a lifetime guarantee and high-status products used by powerful people to enhance their power.
Based on this archetype, and the conversations with Qook! sales advisors, the aesthetic choices of the kitchen should evoke class and robustness.

CREATOR

The creator archetype is part of Qook! because the brand seeks technical innovation. The endless possibilities that Qook! offers is supported by the slogan of the company director Gijs Okkerman:

"Everything is possible"

The innovation that fits with the Creator archetype can be found in the new and innovative kitchen solutions that Qook! offers to clients.

The aesthetic choices that are made in this graduation project should mostly be directed to the ruler archetype and innovation should be delivered by function.

2.1.3.5 AESTHETICS

Image 8 highlights the aesthetic elements of a current Qook! kitchen. These aesthetics should communicate the personality of the brand DNA.

The table top, consisting of one seamless piece, running along the top and sides of the furniture, gives the it a strong and powerful stance. The 80 mm thick workbench contributes to the robust appearance.

Specifically for the Qook! furniture of image 8 the thin horizontal surfaces, highlighted with blue, do not enhance the robust appearance. These surfaces are thin and do not look durable compared to the table top.

Equally, the abundance of horizontal lines cause the furniture pieces to becomes busy, which do not radiate a robust and classy feel.

Even though each kitchen delivered by Qook! is customized and answers the specific demands of the client, an established set of aesthetic design elements should be applied to the design of every kitchen.

An opportunity lies in the strengthening of the design vision and translating this vision systematically and accurately into every designed piece of furniture.

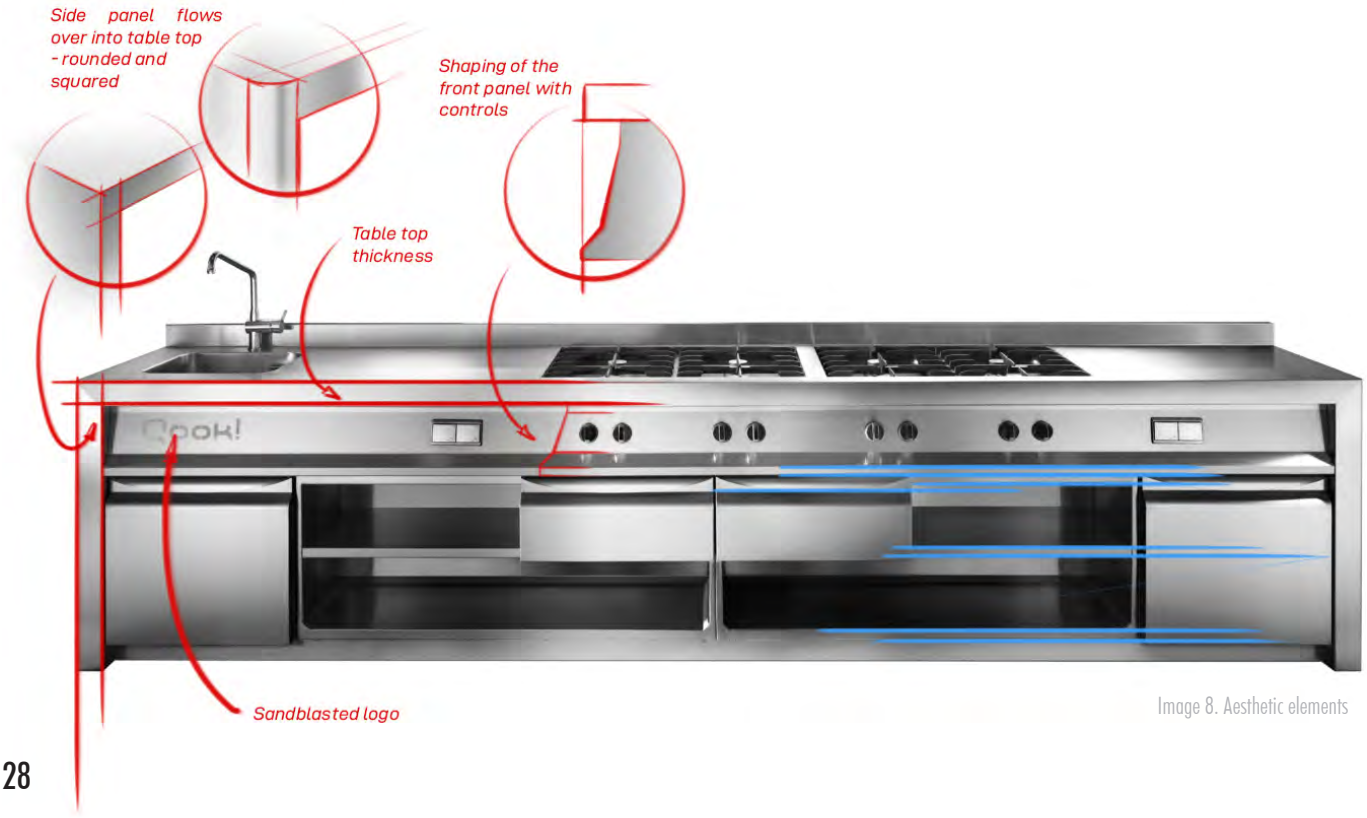


Image 8. Aesthetic elements

2.1.4 CUSTOMER JOURNEY

A typical Qook! kitchen is fully customized and a fusion between the advice of the salesman and the requirements and wishes of the client.

Image 9 shows the roadmap of a new Qook! kitchen.

The remarkable thing of the workflow of Qook! is that the product development is initiated by client contact instead of the R&D department. The R&D department of QBTEC consists of two employees who mainly work on user interfaces for the deep frying installations of all brands.

Instead of developing components at their in-house R&D department the new components are created by the client together with the salesman. Offering these non-existent solutions to the client is a tactic of the sales advisors to win over the client.

The drawing room staff will figure out if the new component is feasible. If so, this new component is added to the portfolio.

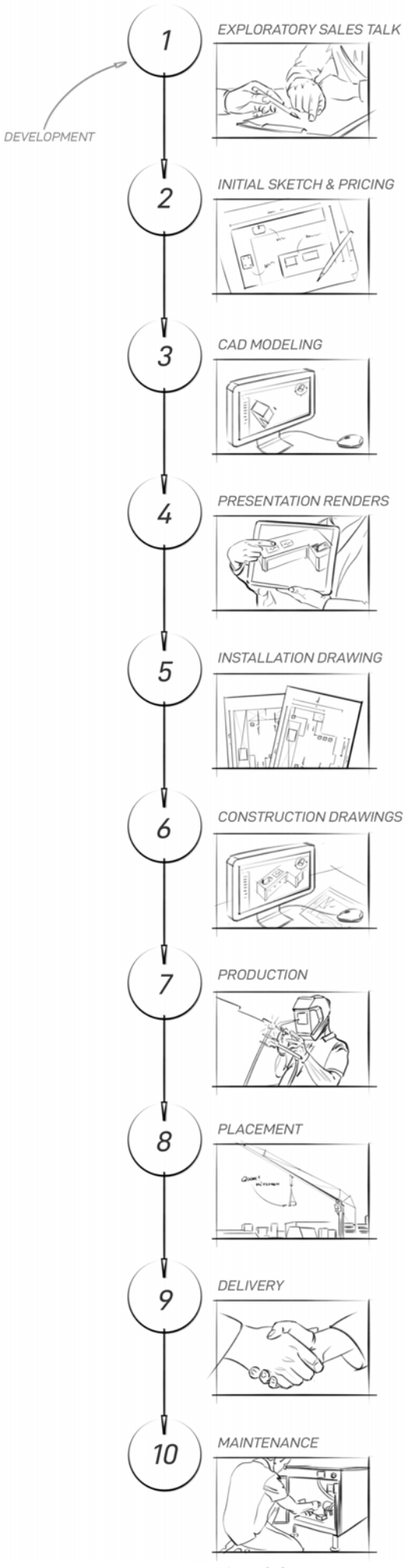


Image 9. Customer journey

2.1.5 PRODUCTION

The production starts in the drawing room. Using Solid Edge 3D CAD software, the design is drawn digitally and a production drawing is made.
After final adjustments the drawings are transferred to files that can be processed by the machines in the factory.

With the use of laser cutting machines all parts are cut and engraved with a code so workers can track parts. After the sheet metal parts are folded by automated folding machines, it is prepared by the workers for the welding stage.
Robots and humans weld the parts, and finalize it by cleaning up the edges with a grinding machine.

Additionally, QBTEC makes use of ready-made products from bolts to induction stoves.
A big part of building a Qook! kitchen is the installation of all components. The wiring, gas and electricity are part of it.

The frame of the benches and the sheet metal that is applied onto the frame are all made of stainless steel type 304. The stainless steel sheet metal comes with a linear brushed finish.

Image 10. QBTEC employee welding

2.1.6 CMF

The surfaces of the Qook! kitchens are finished with brushed stainless steel sheets. All brushed surfaces of the Qook! kitchen units are oriented in the way that the brush pattern is in parallel direction.

Additionally, the Qook! kitchen units are grinded to have clean and smooth edges which are also kept in a brushed matt finish.

The Qook! logo is sandblasted through a stencil resulting in a difference in surface finish between the logo and the brushed finish of the sheet metal.

There are no other surface treatments apart from the brushed steel and the smooth corners. Restaurant kitchens are very practical products and therefore there is no direct need for extensive surface finishing or coloring.

Image 11. Sandblasted Qook! logo

2.1.7 CONCLUSION

As Qook! is part of a production company there is no systematic research and design involved. The company simply works with trial and error. If something works, they add it to their portfolio.

The design principle form follows function is used to fit the company and nature of products used in the professional kitchen. Functionality and usability are the main focus. However, adding iconic aesthetic elements could distinguish Qook! from other brands.

Due to the lack of a deeper purpose of the brand, and proper guidelines for aesthetics, a valuable development would be to strengthen the brand DNA, not only by design but by the full brand marketing. This graduation project will include some aesthetic suggestions.

2.2

MARKET

This chapter will provide an overview of the current market of restaurant kitchens as well as innovation and trends in the catering industry. It starts with a description of the Horecava, a Dutch annual hospitality trade fair held in Amsterdam since 1957.

2.2.1 HORECAVA

A visit to the Horecava gave insights in existing kitchen solutions. Different brands, displaying their kitchens, are asked how they apply ergonomics in the kitchen. Below are five different ergonomic improvements listed.

STANDARD HEIGHT OF 960 MM
ROUNDED EDGES
INDUCTION STOVES
SEAMLESS KITCHENS
COMPLETE KITCHEN SOLUTIONS

Although these features improve ergonomics, they are not motivated by the desire to improve ergonomics. The interviewed companies displaying the kitchens explain that these features are the result of client demands.

Furthermore, these companies explain that the restaurant owner decides about the value and necessity of investing in improving ergonomics.

An employee of Rational, an equipment producing company, explained that restaurant owners do not have any interest in the well-being of their cooks.

The following quotes summarize this.

"THE STAFF IS ADJUSTED TO THE KITCHEN, NOT VISA VERSA"

And:

"THE STAFF WILL GET REPLACED, THE KITCHEN NOT"
(Employee of Rational,2020)

This employee of Rational explains that he had been a cook for 20 years. During this time he was being misused by the industry and because of this his back is worn out. Although one opinion does not determine the whole industry it became clear that ergonomics is not as important for owners.

2.2.2 COMPETITION

Qook! sales advisors identified six clear competitors for Qook!. These six custom kitchen builders are displayed in images 12 to 17 and their brand values and signature design elements are shown.

From this analysis it can be concluded that signature design elements are not strongly present in every brand, due to the practical nature of professional kitchens.

Additionally, competing brands of Qook! share similar brand values. Hence, it is important to understand these competing brands in order to make a distinguishable product for Qook!.

ROSVAL

CRAFTSMANSHIP | *EXPERIENCE* | *QUALITY*

Rosval is a Dutch kitchen manufacturer with over 40 years of experience. They aim for the middle and high segment restaurants. Rosval advertises with customization in combination with quality. Rosval's signature design element is the thick floating table top and built-in illuminated logo's.

Image 12. Kitchen by Rosval

METOS

QUALITY | *SUSTAINABILITY* | *INNOVATION*

Metos, part of the Italian ALI group, has many years of combined experience and strives for innovation and high quality products. Part of Metos' portfolio are restaurant chains like Ikea. Analysing Metos' kitchens does not show a very clear design DNA. The only repeated feature is the forward angled front edges.

Image 13. Kitchen by Metos

BOUTER

ADVICE | *DETAIL* | *QUALITY*

Bouter, part of the catering wholesaler Sligro, is a Dutch company that stands for their high level of advice and direction.

The signature design element of a Bouter kitchen is the radius of the rounded edges and the thickness of the table top hanging over the lower structure.

Image 14. Kitchen by Bouter

VAN GESTEL

FUNCTIONAL | ORIGINAL | ADVICE

Van Gestel is a Dutch company that partners with the catering wholesaler Hanos. Van Gestel advertises with industry experience and know-how and a original kitchen for each client. Looking at design DNA it is hard to recognize any signature features. Most kitchens are built from modular parts instead of bespoke components.

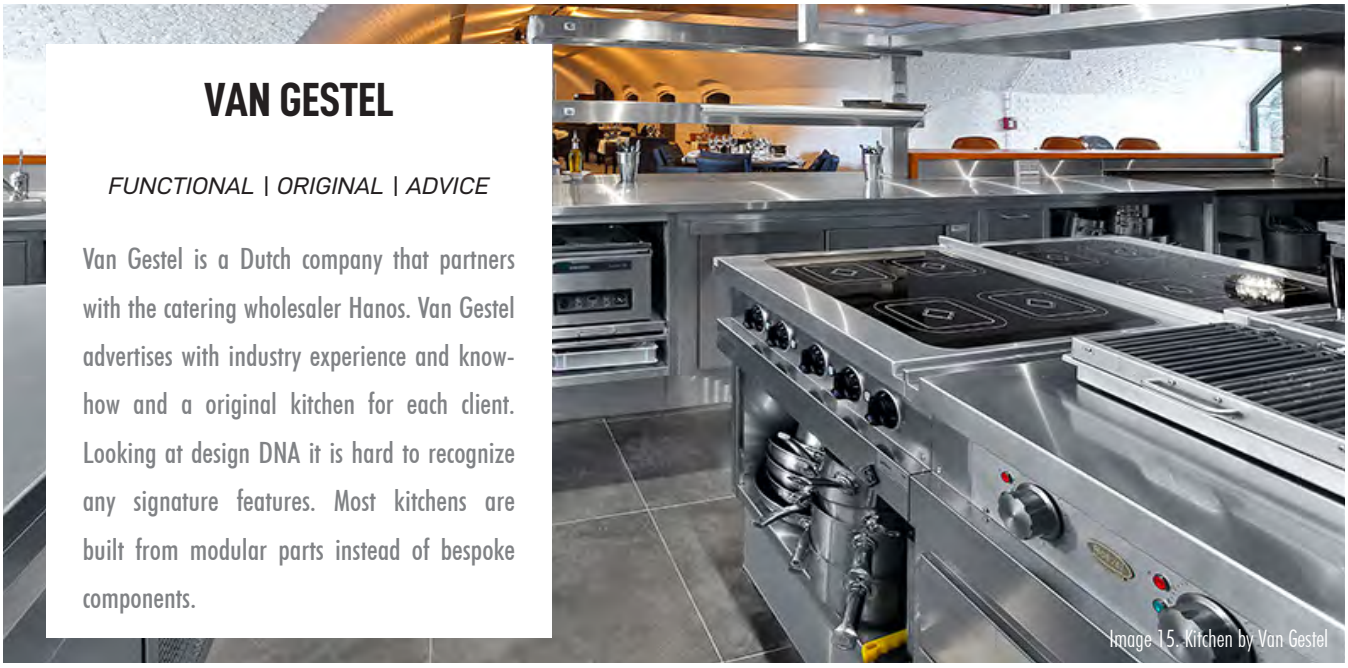


Image 15. Kitchen by Van Gestel

PALUX

QUALITY | INNOVATION | EFFICIENCY

Palux is a German family business and it stands for innovative products, efficient integral kitchen concepts and high quality products.
Signature elements in Palux kitchens are the forward tilted front panels, with controls, and the use of colour and surface finishing.

Image 16. Kitchen by Palux

MAES INOX

CUSTOM | EXPERIENCE | QUALITY

Maes Inox is a Belgium custom kitchen builder. It focuses on the middle to high segment and builds kitchens for many Michelin starred restaurants.
Signature elements of Maes Inox are the rounded and thick table top together with the recessed stove controls.

Image 17. Kitchen by Maes Inox

2.2.3 INDUSTRY INNOVATIONS

Due to technological progress food technology is developing at a fast pace. Below, three of the most important trends are explained. Knowledge about development of the food industry is key to anticipate on the future market and gain competitive advantage.

2.2.3.1 HEATING TECHNOLOGIES

Improved heating technologies can simplify and relieve pressure during mise en place and service. A relatively new heating technology in the industry is the induction stove.
First, the induction stove has a high efficiency in terms of energy consumption. Second, it is very quick and precise and temperature and time can easily be monitored. Third, because of the low energy loss and low heat loss it is improving the temperature in the kitchen.

Another heating technology that is being used in kitchens is sous vide cooking. With this cooking method protein is cooked in a warm water bath that can be controlled to 0.5 degree Celsius. It enables cooks to get the perfect cuisson during the mise en place. With this technology the cooks can be more efficient and have less pressure during service.

More heating technologies, like intelligent ovens, drawers for holding food at the right temperature and moisture level, are constantly evolving. The aim is to alleviate the work of the cooks by taking over tasks with technology.

Image 18. From top to bottom: induction stove | sous vide cooking | intelligent oven

2.2.3.2 SEMI-FINISHED PRODUCTS

Another development in the catering industry is the use of semi-finished products. The offer is of higher quality, increasingly tailor made and of a larger variety than it used to be. This matches with the changes in the industry that will be discussed in chapter 2.4 The User.

These semi-finished products relieve work pressure by taking over tasks that normally would have been done by cooks. Additionally, it helps with food waste of restaurants. For example, small, precut portions of protein can be ordered reducing a waste of food and energy.

This is an example of taking tasks away from the restaurant and outsourcing these tasks to the supplier.

2.2.3.3 USER INTERFACES

Another recent development in the professional kitchen is the use of touch interfaces. These interfaces, equipped with specialized systems like Annoncer, replace the printed tickets. With these systems the communication between the kitchen and waiting staff is more efficient and direct. A participant of the interviews of chapter 2.4, explains that with the use of Annoncer, during the service, one staff member less is needed.

This technology is another example of replacing tasks with technology.

Image 19. From top to bottom: Cutting kitchen Rungis (food supplier) | Prepared and cooked salsify | Interface use in a restaurant kitchen

2.2.4 FUTURE OF FOOD

There are changes in the food industry and in the consumer expectations and desires. In the Netherlands, a prosperous country, the awareness of eating meat is growing and the negative aspects of the meat industry are brought to light.
Moreover, Dutch society is increasingly individualistic and often both parents of families work. This creates a higher demand on prepared food and quick eating solutions.

A technology that is supporting this trend is Moley robotics. This set of robotic arms can be programmed to make any dish to the liking of the owner. With this technology restaurant quality food can be prepared at home.

Another development that is worth mentioning is the presence of the Covid-19 virus. In the television program Tegenlicht, made by Frank Wiering, about the Covid-19 virus, Lidewij Edelkoort, a trend forecaster, mentions that people, due to the virus, are eating out less and are cooking more at home (Wiering, 2020).
Edelkoort predicts a new age where the amateur is prominent. This could mean less outdoor consumption and hence a shrinking catering industry. Moreover, Edelkoort predicts that close-by production and the use of local produce become important.

Although changes in the food industry are inevitable, food will remain a daily need. It could be that the value and perception of food might change and eating out might again become something more exclusive.

Image 20. Moley robotics (top) | Edelkoort in the episode of Tegenlicht

2.2.5 CONCLUSION

This Market chapter shows that competing kitchen manufacturers share similar brand values. Due to the practical nature of this industry most of these competing brands do not have signature elements. As said in previous chapters, enhancing the design vision could be an opportunity for Qook!.

Moreover, the technology push is present in the professional kitchen. There will be a replacement of tasks by technological and food innovations. It is key to anticipate on these future developments.

Lastly, due to the Covid-19 pandemic, eating out might become something exclusive again.

2.3

THE BUYER

As the kitchen users are not necessarily the kitchen buyers, it is relevant to explore the situation and motivation of this target group, not as users, but as buyers of the product. As Qook! is a profit driven company the commercial benefit of a new product should be addressed.

2.3.1 TWO GROUPS

The Qook! sales advisor team consist of two employees that have been working in the catering industry for many years. This experience, combined with the company knowledge, enables the advisors to give advice on every aspect of a kitchen.

An interview with one of the sales advisors of Qook! gave insight in the motivation and the decision making process of the buyers of Qook! kitchens. The buyers can be divided into the two groups shown to the right.

Image 21. Restaurant Dumbo

RESTAURANT OWNER WITH NO OR LITTLE COOKING EXPERIENCE

With this client the sales advisor of Qook! plays an important role. The owner specifies the type of kitchen and number of cooks and the sales advisor takes the lead with an initial design concerning routing, lay out and equipment.

Image 22. Restaurant Joelia

RESTAURANT OWNER WITH A LOT OF EXPERIENCE AND WORKING AS A CHEF

Restaurant owners of the second group have a deep understanding of the kitchen they want for their business. In this case the owner takes the lead and the sales advisor has a supporting role. The owner provides the initial plan and the sales advisor does the fine tuning and detailing.

2.3.2 MOTIVATION

A Qook! kitchen is built for ten to fifteen years of use. These kitchen are being sold at 200.000 to 300.000 Euro. This is a large investment and therefore the client requires a kitchen that remains valuable over time.

For this reason, the desires of the chef and cooks of group one are not important. A cook is a transient. The emphasis is on the general functionality of the kitchen. The kitchen is not just built to the likings of the current kitchen brigade but should be functional for any cook in the future.

Group two has a clear view on what is happening in a kitchen. Therefore, this buyer might be more willing to make a fit with his brigade. However, it will be a design made by the owner following her/his vision.

2.3.3 CONCLUSION

A tight fit between the kitchen and the workers is temporary and changes when workers change. Therefore, adapting a kitchen to a specific group of workers is not relevant for the kitchen buyer.

The challenge is to adapt the work environment not to the individual worker but to all workers that might be working in this work environment. Therefore, the focus should not just be on the cooks' requirements and wishes but onto the general functional utility.

Additionally, the benefit of the new product in terms of operating costs and productivity should be clear.

2.4

THE USER

Chapter The User elaborates on the user group for the product to be designed. In this chapter the industry characteristics are explored and the life of the cook is analysed and explained. It starts with a day in the life of a cook.

2.4.1 DAY IN THE LIFE OF

This description is being included because due to all cooking shows that are being broadcast, the life of a cook is romanticized. This "day in the life of" is based on eleven interviews with cooks from fine dining restaurants.

Harry is a sous chef in a Michelin starred fine dining restaurant and works five days a week. A normal day starts at 9.30 AM with a cup of coffee talking to the brigade about the day ahead.

At 10.00 they start the mise en place. Mise en place, refers to the setup and organization of preparations and ingredients required for the menu items that are expected during the service. From 10.00 AM until 11.45 AM the cooks prepare the mise en place for lunch service.

The kitchen is cleaned, set up, and at 12.00 PM lunch starts. From the moment the first guests arrive until around 2.30 PM the cooks are preparing lunch dishes.
The mise en place for dinner service starts after lunch. This takes until 4.30 PM and the kitchen is cleaned again until 5 PM.

Every kitchen is divided into workstations or, in kitchen terminology, parti's. Each parti is responsible for their own type of dishes. For example, the Garde Manger parti is responsible for all the cold savoury dishes and this parti does all the mise en place and plating for these dishes.

From 5 PM to 5.30 PM the brigade has dinner. Then the kitchen is set up and prepared for dinner service until 6 PM.

Dinner service starts at 6 PM. From 6 PM until around 10.30 PM the cooks are preparing and plating all dishes. When all the cold savoury dishes, from the Garde Manger parti, are served, the cooks working at this parti clean and assist the patissier who is responsible for all desserts. This way, all cooks finish at the same time and clean the kitchen as one brigade. While the brigade is cleaning, Harry enters all orders for the next day.

Cleaning and ordering takes approximately 45 minutes and around 11.30 PM the cooks can go home.

This routine is repeated day after day. Each day there is a deadline and the constant pressure to deliver, especially in fine dining restaurants. What specific type of restaurants are addressed in this project is explained in the next chapter, Field Research (p. 49).

2.4.2 FAMOUS CHEFS

Image 23. Anthony Bourdain

ANTHONY BOURDAIN

Travel documentarian and author, first known for his bestselling book 'Kitchen confidential'.

"What's been lost in all this food-crazy, chef- and restaurant-obsessed nonsense is that cooking is hard - that the daily demands of turning out the same plates the same way over and over and over again require skill other than, and less telegenic than, sprouting catch phrases and schmoozing." (Bourdain, 2000)

Image 24. Rene Redzepi

RENE REDZEPI | CHEF OF RESTAURANT NOMA

Voted as best restaurant of the world in 2010, 2011, 2012 and 2014.

"The old martyrship of being a cook is disappearing. We almost ruined our own trade, by making it too tough, too hard, too macho, there is no more left. People are entering our trade for the wrong reasons. Then they get totally surprised when they work 85 hours a week. And then they feel tired one day and then they are out. We need to change this. (Redzepi, 2014)

Image 25. Marco Pierre White

MARCO PIERRE WHITE

Youngest chef and first British chef to be awarded with three michelin stars.

A passage from his book 'The devil in the kitchen'.
"My God, what had I done to my poor body? I didn't really accept it at the time, but I was undoubtedly messed up, physically, mentally and emotionally. The frightening thing was, I didn't feel tired or exhausted because my craving for the next fix of adrenaline kept me going." (White, 2006)

2.4.3 DESKTOP RESEARCH

This part of The User chapter shows results of the desktop research done concerning the industry characteristics of the catering industry. The consultation of statistics, literature and forums generated these results.

The quotes of the chefs on page 43 already give some idea on how this industry is being perceived and how it is or should be changing.

2.4.3.1 INDUSTRY CHARACTERISTICS

The results are categorized by type of information source. In the next chapter, Field Research, the desktop results are checked and validated.

LITERATURE

"If you can't take the heat, stay out of the kitchen." (Johns, 1999). This phrase reflects the macho culture that used to dominate the professional kitchen environment. Johns (1999), who wrote a discussion paper about kitchen violence and the culinary art, also quotes the passage "To learn the best stuff, you've got to take the s**t that comes with it". These quotes, taken from six high quality restaurant chefs explain about kitchen violence and culinary art.

Another interesting observation of Johns (1999) is that a cause of kitchen violence is that the kitchen is a stressful place because of the variable demand and the tight specifications placed upon the food.

Image 26. Anthony Bourdain cooking

Additionally, according to Johns (1999):

"Kitchens are proverbially hot places, where temperatures frequently climb to uncomfortable levels, and there is often also a lot of noise from machines and shouting voices. Such pressures are greatest in restaurants that must maintain their reputation through high-quality output, for example through Michelin three-star recognition."

Although the kitchen is a rough place, with violence, abuse and high pressure many cases go unreported according to Johns (1999). This fact is supported by Stevens (1992). He says "Reportable injury statistics are notoriously unreliable because of the very high level of under reporting that is known to exist.
A reason for this could be the machismo and the 'take it or leave it' culture controlling the kitchens.

In the book Kitchen Confidentials, Anthony Bourdain (1956-2018), the famous author and documentarian, confirms this machismo culture. He also suggests some codes of conduct and behaviour of a good chef. One of these is the following:

"Never call in sick; except in cases of dismemberment, arterial bleeding, sucking chest wounds or the death of an immediate family member." (Bourdain, 2000)

Another passage of Bourdains book describes his early encounter with the culinary world in 1974:

"Pasta was blanched and shocked and transferred into huge batches into steaming colanders, falling everywhere, the floor soon ankle-deep in spaghetti alla chitarra, linguine, garganelli, taglierini, fusilli. The heat was horrific. Sweat flowing into my eyes, blinding me as I spun in place." (Bourdain, 2000)

Although this passage is melodramatic it does show the harsh environment a professional kitchen can be.

Getting back to a more scientific description of the kitchen, Johns (1999) concludes his paper with some recommendations and suggests an improvement of working conditions to reduce kitchen violence. Additionally, he suggests ergonomically designed kitchens and better control of heat, ventilation, light and space.

Although these sources, describing characteristics of the catering industry, are dated, it gives an impression of the circumstances of that time.

Nowadays, circumstances in the catering industry, as in every industry, are better than twenty or more years ago (Flanagan, 2006). However, to what extent, will be addressed using forums and further on by means of interviews in the chapter Field Research.

STATISTICS

According to statistics of the CBS (Central Bureau of Statistics, the Netherlands) the Dutch catering sector has the lowest sick leave percentage of all industries with a percentage of 2.2% in 2016 (Beiro, 2017) whereas the maximum sick leave percentage is 5.3% for the public administration sector.

A similar study in the UK shows that the catering industry has a sick leave percentage of 1.5% (Comer, 2017) whereas the average sickness absence rate is 1.7%. So in the UK and in the Netherlands the sick leave percentage of people working in the catering industry is lower than average. The long working days, abuse and high pressure would suggest otherwise.

Reading further into the numbers of the CBS, Beiro (2017) explains that the low sick leave percentage is linked to the young age of most employees in the catering industry. The possibility to take more days off and the flexible employment in this sector make the sick leave percentage lower.

Another CBS report describes that the percentage of 'accidents at work' show the second largest number for the catering industry ("Arbeidsongevallen vooral", 2015). However, even though the percentage is high, it is common that the employees do not take leave after an accident.

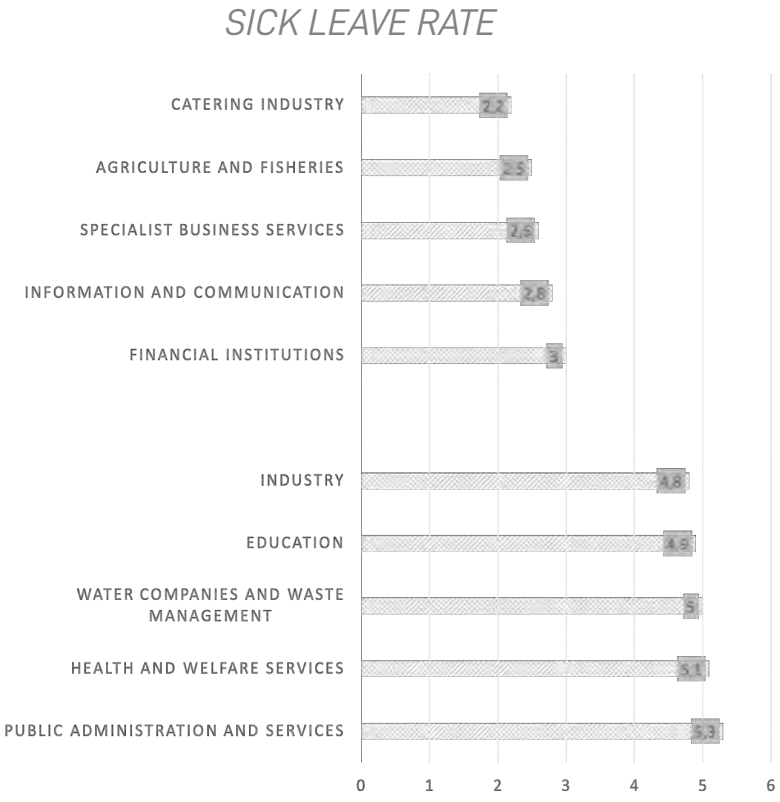


Image 27. Sick leave percentage (Beiro, 2017)

To conclude aforementioned statistics, the explanation of the low sick leave percentage is the flexibility of the industry, the employees of young age as well as the apparent motivation to continue work after a work related accident. The question that rises from this conclusion is: why are the workers motivated to keep working? Is it because of the macho culture or is there another explanation?

Apart from physical damage the survey Service With(out) a Smile? (Royal Society of Public Health, 2019) looked into the mental health of hospitality workers. It shows that 24% of the respondents required medical or psychological help and 20% reported having severe mental health problems. Additionally, hospitality workers experience the following repercussions related to their job:

- Increased stress (84%)
- Less time for other activities (73%)
- Disrupted sleep (71%)
- Anxiety (69%)
- Fatigue (68%)
- Low mood or tearfulness (65%)
- Increased irritability or anger (58%)
- Depression (50%)
- Ate less (48%)
- Diminished friend or family relationships (46%)

WOMEN VS MEN

Another remarkable characteristic of the catering industry is the male-dominated workforce of the kitchen.

According to the director of SVH (Stichting Horeca Vakbekwaamheid (Association of professional competence in the catering industry)), around 10% of the staff, of restaurant kitchens in the Netherlands, is female (Roemaat, 2012).

A British, female three Michelin starred chef says: "Restaurant kitchens are testosterone-driven. It's a tough world; the hours are bad and the conditions are harsh. But the atmosphere changes when there's a girl in the kitchen - it's nicer. The guys talk more softly, snap less and speak with a bit more respect" (Smyth, 2013).

The percentage of women in the kitchen is low and a singular distinct reason is hard to find. Several articles mention the stressful atmosphere and harsh environment in combination with long days, and working nights and weekends, as reasons that make women choose a different occupation.

FORUMS

Some of the sources of previously mentioned information are outdated. An honest and topical information source are forums.

Dutch forum 'Kokswereld' is consulted to gain information about the physical discomfort. The thread 'Fysieke klachten (ergonomie) & het koksvak' started by Will (2009) gives an overview of the physical discomforts in the kitchen. To summarize the comments made in this thread, back pain and leg pain are common as well as discomfort due to temperature. The back pain is mostly caused by a wrong working height, pressure and a poor working posture.

Additionally, a respondent supports the 'take it or leave it' mentality by the following quotes:

"Wie goed wil zijn moet pijn lijden"
(You cannot be good without sacrifices)

"Niet lullen maar poetsen"
(Work, don't talk)

"Ergonomie is een woord wat koks niet kunnen uitspreken en ze begrijpen het woord ook niet, dus laat maar....."
(Ergonomics is a word cooks cannot pronounce and they also do not understand the word, so leave it....)
(Timmerman, 2007)

Another forum similar to 'Kokswereld' is the global community ChefTalk. Posting a question on ChefTalk, concerning the health effects of the professional kitchen and the importance of improving ergonomics, gave these results.

Respondents confirm the discomfort present in the kitchen due to heavy lifting, incorrect working height and high temperature.
There is a part of respondents that agree with the improvement of ergonomics while another part believes these hard working conditions cannot be solved and are part of the job. Additionally, a respondent says that it is up to the owner to improve ergonomics and concludes with this quote:

"You can't fix or design around cheapness. If the owner won't pay for it, they won't pay for it."
(Foodpump, 2020)

This respondent points out that you can design any improvement you want, but it is a matter of money and willingness of the owner to invest in these kind of improvements.

To conclude, it is clear the work environment and circumstances in the catering industry are far from ideal. There are physical dangers and mental challenges which both can have repercussions on the well-being of the employee.

2.4.4 FIELD RESEARCH

This chapter provides information obtained from field research. Semi structured interviews provide results with an up-to-date view of the industry characteristics. Furthermore, the interviews are used for a thorough view on the work environment of cooks in different restaurants.

2.4.4.1 SEMI STRUCTURED INTERVIEW

The semi structured interview, is a blend of closed- and open-ended questions, often accompanied by follow-up why or how questions (Adams, 2015). Using this method, additional information can be obtained which is absent during a quantitative interview.

Based on my own professional kitchen experience, the interview questions are tailor made for this specific target group and industry. Personal hunches are used for follow up questions and topics. Being expert by experience makes it easier to understand and communicate with cooks.

2.4.4.2 TARGET GROUP

The target group of this graduation project consists of cooks working in fine dining restaurants. Firstly, because it fits Qook!'s portfolio and second, because of the nature of these restaurants.

The kitchens of fine dining restaurants have a brigade of at least three cooks that make around ten hour work days part of which are the preparation, service and plating. The focus in these kitchens is on food preparation from start to finish. This enables a high level of quality control together with freedom of ingredient use.

The project is focused on this specific restaurant type to include the full spectrum of problems that may appear while cooking in a professional atmosphere.

Kitchens with less than three cooks and without a start to finish production do not entail the same ergonomic challenges.

The interviews are conducted in and around Rotterdam. Rotterdam is the second biggest Dutch city offering a broad variety of restaurants.

Image 28. Fine dining restaurant Heroine, Rotterdam

2.4.4.3 RESULTS

The interview is held with eleven participants that work or have worked in fine dining restaurants with an age varying from 18 to 42 years old. The job title of these eleven cooks vary from student to executive chef. One of the participants is a professor at a culinary school in Rotterdam.

The results are divided into two categories. Firstly, industry characteristics that are present or changing. Secondly, work environment (i.e. the kitchen) specific information obtained from the interviews.

INDUSTRY CHARACTERISTICS

The stigma " take it or leave it" is disappearing

This is confirmed by a culinary school student and a professor of a culinary school. The new generation of cooks do not accept the long days in combination with bad ergonomics, the harshness and the low salary.

Still, there are a lot of restaurants that do not pay overtime. Although this change in mentality is noticeable, there is a specific group that will keep on working long days with bad circumstances because they are passionate about their profession.

The low sick leave rate is a result of team work

The current low sick leave rate in the culinary industry is mainly caused by the fact that kitchen work is team work. The high sense of responsibility and loyalty to the other cooks, combined with not wanting to abandon your brigade give the cooks a certain mentality. This mentality can be summarised with the phrase:

"You can work if you can walk"

As the "take it or leave it" stigma is disappearing, there is a change visible in this team work mentality. Nowadays, it is more common that cooks stay home sick. However, participants mention that the team work mentality is linked to the type of business cooks work in. In large chain restaurants, sick leave happens more often.

The use of semi-finished products is increasing

The change in mentality of the new generation of cooks creates a change in craftsmanship. Because of the high demand for cooks and the fact that cooks become increasingly critical of their work environment, there will be an increased use of semi-finished products.

With these semi-finished products the working hours are easier to control and criticism of the new generation of cooks will be taken into account. Additionally, the quality of semi-finished products is getting better and more tailor made.

Despite this change, craftsmanship will remain. In the top segment of restaurants there is a need to create one's own identity that is linked to a start-to-finish production. A start-to-finish production enables a high level of quality control together with freedom of ingredient use.

Young and less experienced cooks are not focusing on the right working posture

Mentioned by the culinary school professor, a participant of the interviews, young and unexperienced cooks are not concerned with a good working posture. There is also a lack of correct personal equipment that helps to take care of a good working posture and the physical challenges in the kitchen.

Some of the older and experienced cooks mention that due to the ignorance of a good working posture when young, they now pay the price with back pain and leg problems.

Female vs. Male

The testosterone-filled kitchen can be harsh and stressful. An interviewed female cook mentioned the unkind communication due to pressure. This is not as clearly mentioned by any of the male cooks. The female interviewee also mentioned that the low percentage of female cooks might be caused by the high pressure and heavy workload in the professional kitchen. However, many participants mention that the percentage of female cooks is rising.

Pressure in the kitchen is functional and necessary

Although pressure in the kitchen can be high, the participants perceive pressure as something that is pleasant and functional.

Participants mention that without pressure, performance and the quality of work goes down. Most participants say:

"Pressure keeps you sharp"

Although pressure keeps you sharp, an abundance of pressure can lead to errors, as mentioned by a participant who works in a restaurant with a breakfast, lunch and dinner service.

WORK ENVIRONMENT

Efficiency is key

Wandering from one side of the kitchen to the other is a waste of time and energy. A kitchen should support the cooks in any way to improve efficiency and it entails the following elements:

Equipment and devices

Workflow

Routing

Almost each participant mentions the importance of efficiency of a restaurant kitchen. A well-designed kitchen should enable this.

Physical discomfort is mostly present in the back and legs

Participants mention that during the mise en place it is feasible to control the working posture. However, when it is busy there is a lot of pressure and the cooks are focused on the food. At this point, a good working posture is difficult to control and most health complains are caused by the service and the plating.

Participants mention that in almost every kitchen the height of work benches is not optimal. Due to the thermal bridge and the height of the pass, plating is perceived as uncomfortable.

Moreover, the discomfort is related to the age of the cooks. Young cooks, most of whom are around twenty years old, do not have many complaints and for that reason do not see the importance of the attention to a good working posture. The culinary school professor confirms this.

Clean and neat: extremely important in a kitchen

The importance of a clean and neat kitchen has two reasons. Restaurant are obliged to serve safe and clean food. This is being controlled with HACCP regulations.

Secondly, it is important because of the serenity that it gives. Some participants say that if you cannot work clean, you cannot cook tasty food. Where young cooks mention the importance of a clean and neat kitchen due to the obligation of serving safe food, more experienced cooks say:

"A clean workplace is a clean mind"

Noise is always present in the kitchen

Due to the equipment and machines that are used in the kitchen noise is inevitable. Participants say that noise can be annoying, but that it can hardly be avoided.

Climate control is crucial for the quality of food and the quality of the work environment

Important features of climate control are the air quality and the temperature of the work environment. The air quality is important for the cooks and should contain high levels of oxygen.

The temperature of the workplace is important for the cook but also for the food that is produced. It should be a comfortable temperature to work in and it should not cool down the food too quickly.
The part of the kitchen that is responsible for the hot dishes is often separated from the cold dishes.

An uncomfortable temperature and poor air quality can result in slowness and a drop in productivity.

2.4.5 OVERVIEW RESEARCH

Below, the most important findings are summarised. The results are a combination of literature, statistics, forums and interviews.

DESKTOP RESEARCH	FIELD RESEARCH
'Take it or leave it' stigma is present in the kitchen.	*'Take it or leave it' stigma is disappearing because of the change in mentality among the new generation of cooks.*
Pressure is high due to the variable demand.	*Although pressure is functional and necessary, an abundance of pressure leads to errors.*
Percentage of female cooks is low.	*Percentage of female cooks is low but is rising*
Physical discomfort in back and legs.	*Physical discomfort in back and legs, mostly during service.*
Discomfort due to temperature.	*Climate control is crucial for the quality of the food and the quality of the work environment.*
Low sick leave rate in industry because of flexibility and young age as well as the motivation to continue working after an accident.	*Sick leave rate is low because kitchen work is team work.*
Noise is always present.	*Efficiency is key.*
Mental health problems are present in the industry.	*The use of semi-finished products is increasing.*
	Clean and neat: extremely important in a kitchen.

2.4.6 RESULTS

The user group is analysed based on desktop and field research. With field research, desktop results are confirmed, unproven, updated or contradicted.
Contradicting and unproven results are briefly described below.

LOW SICK LEAVE RATE

With desktop research the low sick leave rate is being explained by the flexibility of the catering industry in combination with young age and an apparent motivation to keep working after an accident.

Field research does not support this explanation completely. All cooks mention that the low sick leave rate can be explained by the teamwork and loyalty toward the fellow cooks. Moreover, eleven participants elaborating on their daily routine, do not show a flexible work environment. Each day, there is a deadline and a need to perform.
The difference between the Desktop and Field Research is that Desktop Research considers the full catering industry while Field Research just focuses on cooks in fine dining restaurants.

Although the connection between young age and a low sick leave rate is supported by desktop research, it is contradicted by the field research. Older cooks mention that taking sick leave is more common among young cooks than it is among older cooks.

The motivation to keep working after an accident can be explained by the teamwork and loyalty towards the fellow cooks. On this topic, desktop and field research are in line.

HIGH PRESSURE

Field research points out the necessity and functionality of pressure in the kitchen. Participants do not mention any negative effects of kitchen pressure.
Desktop research, however, does show a negative mental impact. This contradiction might be explained by the size of the respondent group of the survey 'Service With(out) a Smile?' in comparison to the eleven participants of the field research. Moreover, it is possible that the eleven participants of the field research are not aware of mental problems that might be present or might occur in the future.

RELEVANCE

Although results are not all analogous, the relevance of the results should be noted. For this specific project not all results can and will be used.
Therefore, further research into contradicting results is not part of this graduation project. The results that are found are considered to be sufficient for the substantiation of this project.

2.4.7 CONCLUSION

This graduation project is done for the kitchen developer Qook!. Therefore, this conclusion summarizes the results that are valuable for this graduation project done for this company.
Industry characteristics are worth mentioning and should be kept in mind, but are not changed or improved in this project.

The key finding of the User Group analysis is that the well-being of the cook is not regarded as a priority.
The results that are considered valuable for this project are listed below.

1. Physical discomfort in back and legs, mostly during service.

2. Although pressure is functional and necessary, an abundance of pressure leads to errors.

3. Climate control is crucial for the quality of the food and the quality of the work environment. There is discomfort due to temperature.

4. Noise is always present.

5. Clean and neat: extremely important for the restaurant kitchen.

6. Efficiency is key.

The first four listed results can be appointed to ergonomics. The exact meaning of ergonomics will be explained in chapter 2.5. Result five and six can be appointed to the work environment. In this project these six results will be incorporated in the designed concept.

2.5

WORK ENVIRONMENT

This chapter explains ergonomics and the application of ergonomics in the work environment. Additionally, it shows the benefit of an ergonomics-driven work environment for the well-being of the company (restaurant) and for the well-being of the worker (cook).

2.5.1 ERGONOMICS

This sub chapter explains ergonomics. The International Ergonomic Association (IEA) uses the following description for ergonomics:

> *Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theoretical principles, data and methods to design in order to optimize well-being and overall performance. (IEA, 2000)*

The IEA is a global non-profit organisation that deals with ergonomic science and the improvement of the quality of life of the global society. The terms ergonomics and human factors (HFE) are used as one unit by the IEA. HFE, as a scientific discipline, uses fundamental characteristics that are valuable for this project.

Dul (2012) describes that HFE focuses on systems in which humans interact with their environment. The environment is complex and consist of the physical environment, the organisational environment and the social environment.

This focus can be applied to the kitchen and thus to this graduation project. In this project the system is the worker (cook) that is interacting with the work environment (kitchen).

To further elaborate on HFE the three fundamental characteristics of HFE are listed below.

2.5.1.1 SYSTEM APPROACH

A fundamental characteristic of HFE is the system or holistic approach that sets HFE apart from other disciplines like cognitive psychology and human movement science.

As described by Dul (2012) "When defining problems and formulating solutions, system boundaries are defined, and the focus of HFE can be on specific aspects of people, on specific aspects of the environment, or on a specific level, but the broader context of the human within the environment is always taken into consideration ('contextualisation')".

2.5.1.2 *DESIGN DRIVEN*

"HFE seeks to improve performance and well-being through systems design. Analyses and assessments result in recommendations and actions for this design." (Dul, 2012)

This design-driven approach differentiates HFE from other disciplines, like sociology, that does not share a problem solving approach that results in actions.

2.5.1.3 *PERFORMANCE AND WELL-BEING*

"HFE recognises that any system always produces two outcomes: performance and well-being. By fitting the environment to the human, HFE can contribute to optimising these joint outcomes." (Neumann and Dul, 2010).

Performance can be described as productivity, efficiency, effectiveness, quality, innovativeness, flexibility, safety and security, reliability and sustainability (Dul, 2012).

Well-being can mean health and safety, satisfaction, pleasure, learning and personal development.

With the analysis done in chapter The User, recommendations can be made for the improvement of kitchen design.

The HFE method is a good fit for this project due to its design-driven approach. Furthermore, with the joint outcomes of performance and well-being, the values of both users and buyers are addressed.

To further elaborate on ergonomics, the next sub chapter describes the three types used.

2.5.1.4 *TYPES OF ERGONOMICS*

Below, three types of ergonomics are explained. These descriptions are taken from the 'Designing for People' website which is a collaboration of The Design 4 Real People Action Group and Chartered Institute of Ergonomics and Human Factors (CIEHF). These types of ergonomics are also used by the IEA but described as ergonomic factors (see image 29).

Image 29 illustrated that the types of ergonomics are connected. In the centre is HFE as the discipline that includes and connects the three types of ergonomics.

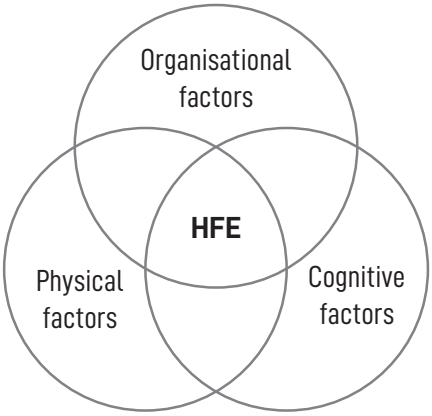


Image 29. Ergonomic factors (Human Factors/ Ergonomics (HF/E), n.d.)

1. PHYSICAL ERGONOMICS

Physical ergonomics is concerned with human anatomical, anthropometric, physiological and biomechanical characteristics as they relate to physical activity. The relevant topics include working postures, materials handling, repetitive movements, work-related musculoskeletal disorders, workplace layout, safety and health. Physical ergonomics is also concerned with how the physical environment around you might affect your performance. (Ergonomics, n.d.)

2. COGNITIVE ERGONOMICS

Cognitive ergonomics is concerned with mental processes ('brain work'), such as perception, memory, reasoning, and motor response, as they affect interactions among humans and other elements of a system. The relevant topics include mental workload, decision-making, skilled performance, human-computer interaction, human reliability, work stress and training as these may relate to human-system design. (Ergonomics, n.d.)

3. ORGANISATIONAL ERGONOMICS

Organisational ergonomics is concerned with the optimisation of socio-technical systems, including their organisational structures, policies, and processes. The relevant topics include communication, crew resource management, work design, design of working times, teamwork, participatory design, community ergonomics, cooperative work, new work paradigms, organisational culture, virtual organisations, remote and mobile working, and quality management. (Ergonomics, n.d.)

2.5.1.5 HFE ON WORK SYSTEMS

Addressing the ergonomics of a work environment improves the well-being of the worker. A result can be less physical and cognitive stress, improving worker conditions.
However, how does the improvement of ergonomics ensure the well-being of the company and prove its value to the buyer?

According to Dul (2012) the company (i.e. buyer) can benefit as it ensures performance in terms of:

- Better productivity by reduced time for performing work procedures
- Better quality and reliability of production processes and the produced goods and services
- Lower operating costs due to lower levels of health problems, motivational deficits, accidents, absenteeism, and related productivity loss
- More innovation by increased employee creativity
- Better reputation for hiring and retention of talented employees, and positive worker and consumer associations with the firm and its products/services
- Better decision-making through improved information about the effects of system design on employees

The workers using the HFE improved products can benefit in terms of improved physical, psychological and social well-being, higher motivation, growth and job satisfaction, and improved performance (Dul, 2012).

The IEA and the cited paper of Dul (2012) prove the value of the HFE improvement for workers and the company. According to Hendrik, HFE design in work systems is simply and unquestionably good business (Hendrik, 2003).

As the value of the HFE approach is proven of interest to both of the involved parties (i.e. the buyers and the users), a translation to the kitchen is necessary. The next sub chapter explains how each type of ergonomics is linked to the professional kitchen.

2.5.2 KITCHEN ERGONOMICS

This sub chapter relates kitchen work to the three types of ergonomics used in this project.

2.5.2.1 PHYSICAL ERGONOMICS

In order to understand all the physical factors that have application to the professional kitchen a model is created. See image 30.
This model shows that the professional kitchen can be divided into three levels:

1. Workspace
2. Workstation
3. Work equipment

Each level includes different physical ergonomics.

WORKSPACE

Workspace is the highest level. It includes thermal comfort, indoor air quality, layout, noise and acoustics, and lighting.
Specifically for noise and acoustics, Leather (2003) describes that where ambient noise levels are markedly lower, the negative impact of job strain is minimized.

Physical ergonomics are improved by optimizing all factors of the workspace. With the installation of a fully equipped kitchen the aforementioned factors should be taken into account.

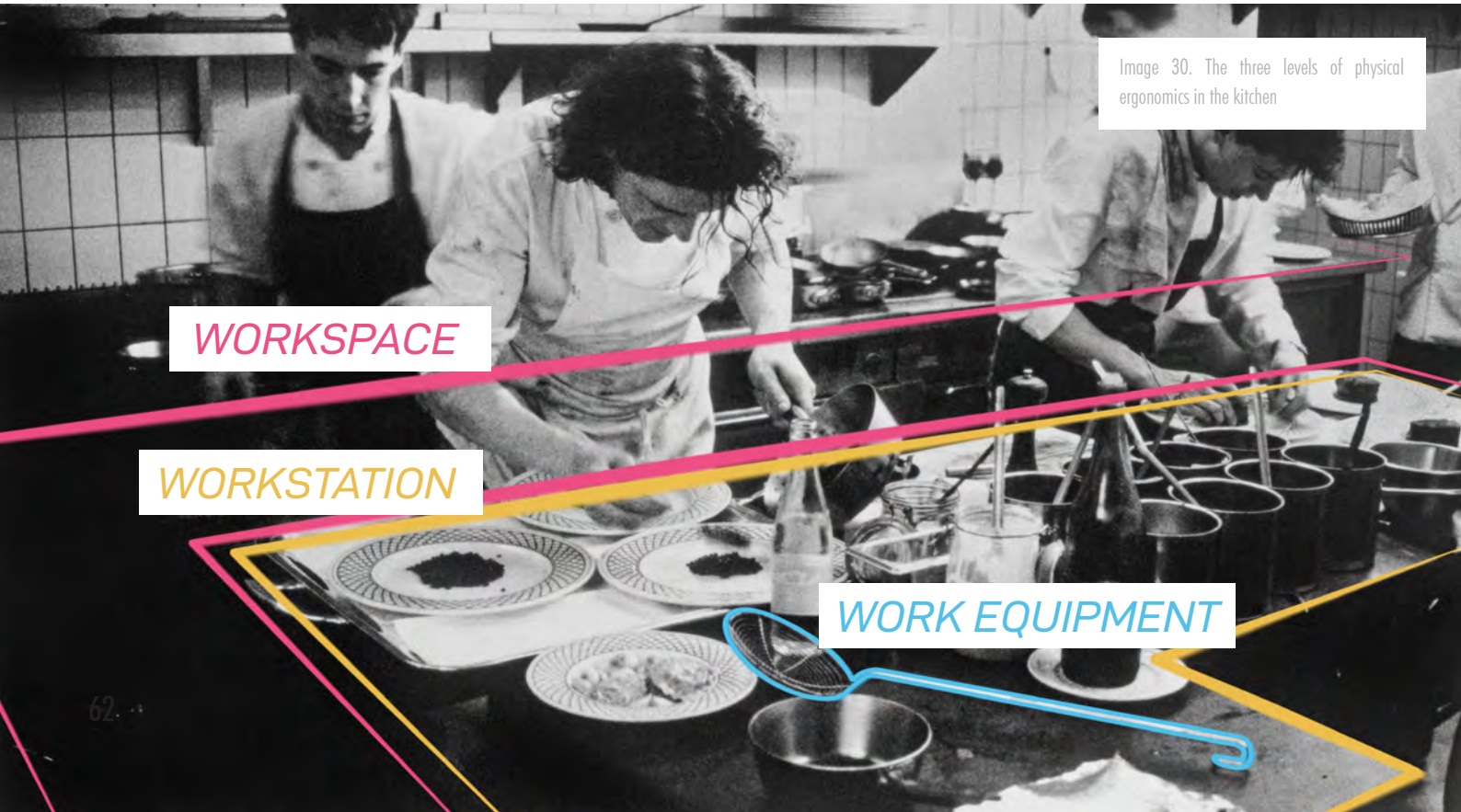


Image 30. The three levels of physical ergonomics in the kitchen

WORKSTATION

The workstation is one level smaller than the workspace. The workstation is a workbench, or series of workbenches, that have multiple features included, in a specific layout, supporting the specific tasks appointed to a chef de parti. For example, the workstation named Roti is responsible for the warm preparations of meat, fish and sauces. Therefore, this workstation contains a stove, an oven and cooled drawers.

Each workstation has a specific series of tasks. Because professional kitchens work with a deadline each day, the order in which the tasks are performed is crucial.
If this order is not right, the deadline can be missed and food cannot be served.

The workstations should support the cooks to execute the tasks with the best use of energy and time, which can be improved with physical ergonomics.

WORK EQUIPMENT

The smallest level is work equipment. Like the workstation, the work equipment should support the cooks to execute their tasks.
The work equipment however, consists of mechanical and electric tools that do not have one specific location. These tools are easy to relocate and are used by every parti. Examples of this equipment are blenders, spatulas, sieves and mixers.

2.5.2.2 *COGNITIVE ERGONOMICS*

Cognitive ergonomics concerns brain work and can be found in multiple kitchen systems. As kitchen work is the execution of a series of tasks in a specific sequence, planning is an important system. The planning is part of the mise en place and of the service. A good planning system can reduce mental workload. An example is Annoncer, the digital ticket system.

Another example of cognitive ergonomics is the memory of knowledge. As a cook, you need preparation knowledge, hygiene knowledge and communication knowledge. In the kitchen there are multiple systems supporting these features like timers, recipes and cleaning lists.

2.5.2.3 ORGANISATIONAL ERGONOMICS

Organisational ergonomics concerns the optimisation of socio-technical systems. Applied to the kitchen, it can be seen as the optimisation of the combination between social structures and the physical work environment (workspace, workstations and work equipment).

The layout linked to the hierarchy is a good example. In most kitchens the chef is positioned at the front of the kitchen in a way that she/he can see each cook. From here the chef directs the cooks and controls the output of food. The kitchen layout enables the chef to perform his tasks.

Most kitchens work with a hierarchy that ensures a well performing kitchen in terms of quality output and time and energy sufficiency. If social structures change, the physical work environment should change with it.

2.5.2.4 CONCLUSION

The three types of ergonomics help to understand multiple kitchen systems. These ergonomic types in relation to the kitchen are summarised by image 31.

In this project the physical and the cognitive ergonomics are applied, as these two types show most relevance with regards to the product portfolio of Qook!.

Chapter 3. Design Challenge will further explain the physical and cognitive ergonomics used in the continuation of this graduation project.

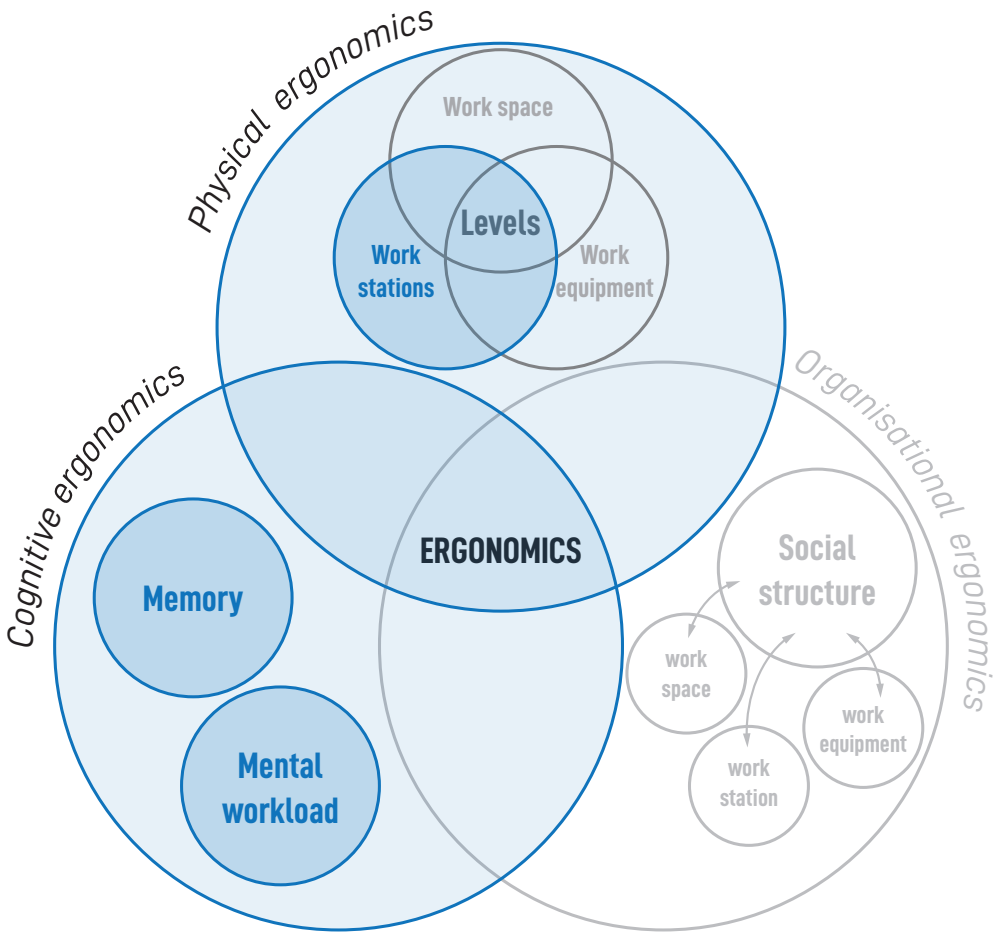


Image 31. Summary of types of ergonomics applied to the kitchen. Highlighted with blue are the types of ergonomics applied in this project.

2.5

OVERVIEW ANALYSIS

This chapter gives a complete overview of the important results of chapter 2.1 to 2.4. These results will be used in formulating the Design Challenge in chapter 3 as well as during the design process.

The selection of results is based on relevance towards the project goal, company fit and expected value.

2.1

COMPANY

BRAND VALUES OF QOOK!
HIGH QUALITY
CUSTOMIZED
UNIQUE FUNCTIONALITY
SEAMLESS
FLEXIBLE
TRUST

THE PRODUCT DEVELOPMENT IS LIMITED TO THE CO-CREATION BETWEEN CLIENT AND SALES ADVISOR

QOOK!'S BRAND PERSONALITY CAN BE ENHANCED WITH AESTHETICS

2.2

MARKET

THERE ARE MANY COMPETITORS IN THE MARKET AND THERE IS A NEED TO DISTINGUISH AS BRAND

TECHNOLOGY PROVIDES OPPORTUNITIES FOR THE DEVELOPMENT OF WORKLOAD RELIEVING KITCHENS

2.3

THE BUYER

A KITCHEN SHOULD BE DESIGNED TO BE FUNCTIONAL FOR ANY COOK IN ANY FUTURE SO THAT THERE IS LOWER OPERATING COST AND IMPROVED PRODUCTIVITY

THE ECONOMIC BENEFIT SHOULD BE CLEAR TO THE KITCHEN BUYER

2.4

THE USER

PHYSICAL DISCOMFORT IS PRESENT IN THE BACK AND THE LEGS, MOSTLY DURING SERVICE

ALTHOUGH PRESSURE IS FUNCTIONAL AND NECESSARY, AN ABUNDANCE OF PRESSURE LEADS TO ERRORS

CLIMATE CONTROL IS CRUCIAL FOR THE QUALITY OF THE FOOD AND THE QUALITY OF THE WORK ENVIRONMENT. THERE IS DISCOMFORT DUE TO TEMPERATURE

NOISE IS ALWAYS PRESENT

CLEAN AND NEAT: EXTREMELY IMPORTANT FOR THE RESTAURANT KITCHEN

EFFICIENCY IS KEY

2.5

WORK ENVIRONMENT

THE IMPROVEMENT OF ERGONOMICS CAN LEAD TO BETTER PRODUCTIVITY

PRODUCTIVITY AND WELL-BEING ARE INTERTWINED

ERGONOMICALLY IMPROVING A KITCHEN CAN LEAD TO AN IMPROVEMENT OF THE WELL-BEING OF THE COOKS AND THE WELL-BEING OF THE RESTAURANT

THE IMPROVEMENT OF PHYSICAL AND COGNITIVE ERGONOMICS ARE THE BEST FIT FOR QOOK!

PHYSICAL ERGONOMICS CONSIST OF THREE LEVELS:

WORKSPACE
WORKSTATION
WORK EQUIPMENT

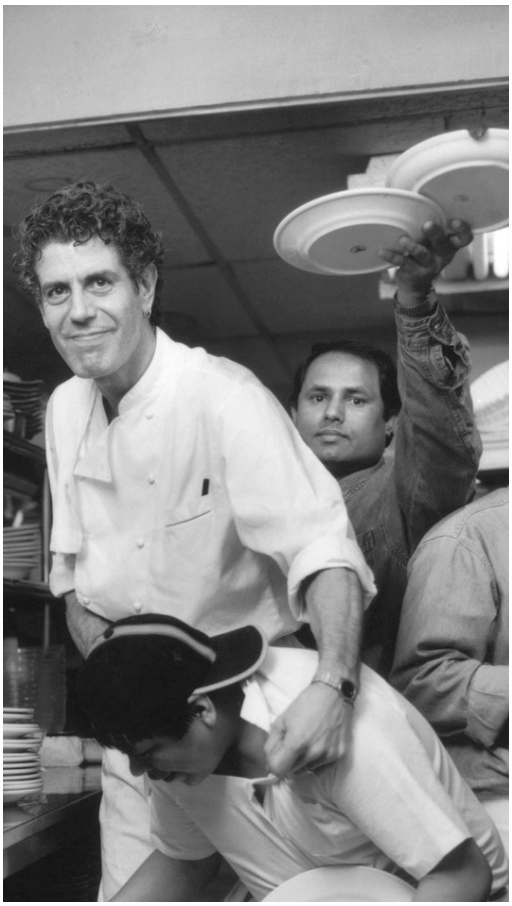


Image 32. Anthony Bourdain working in his restaurant, Les Halles, 1980s

CHAPTER 3

DESIGN CHALLENGE

In this chapter the project scope is narrowed down and a design challenge is formulated. This forms the basis for an elaborate analysis on a specified topic.

3.1

DESIGN OUTLINE

Based on the previous chapter a smaller selection is made. This selection, categorized in five topics, is used for the continuation of this project.

1

USER

1.1 CLEAN AND NEAT: EXTREMELY IMPORTANT FOR THE RESTAURANT KITCHEN

1.2 EFFICIENCY IS KEY

1.3 PHYSICAL DISCOMFORT IS PRESENT IN THE BACK AND THE LEGS, MOSTLY DURING SERVICE

1.4 CLIMATE CONTROL IS VIABLE FOR THE QUALITY OF THE FOOD AND THE QUALITY OF THE WORK ENVIRONMENT. THERE IS DISCOMFORT DUE TO TEMPERATURE.

2

ERGONOMICS

2.1 ERGONOMICALLY IMPROVING A KITCHEN CAN LEAD TO AN IMPROVEMENT OF THE WELL-BEING OF THE COOKS AS THE WELL-BEING OF THE RESTAURANT

2.2 THE IMPROVEMENT OF PHYSICAL AND COGNITIVE ERGONOMICS ARE THE BEST FIT FOR QOOK! AND FOR THE GRADUATION STUDENT'S GOALS

2.3 PHYSICAL ERGONOMICS CONSIST OF THREE LEVELS:

WORKSPACE
WORKSTATION
WORK EQUIPMENT

3

BUYER VALUES

3.1 A KITCHEN SHOULD BE DESIGNED TO BE FUNCTIONAL FOR ANY COOK IN ANY FUTURE SO THAT THERE IS LOWER OPERATING COST AND IMPROVED PRODUCTIVITY.

4

BRAND VALUES

4.1 THE AESTHETICS OF THE KITCHEN SHOULD CONVEY ROBUSTNESS AND INNOVATION THROUGH FUNCTIONALITY

5

MARKET

5.1 THERE ARE MANY COMPETITORS IN THE MARKET AND THERE IS A NEED TO DISTINGUISH AS BRAND

3.3

DESIGN GOAL

This chapter provides the goal of this project. It is used as reference and validation tool during the project.

ERGONOMIC IMPROVEMENTS TO OPTIMIZE EFFICIENCY

The above mentioned project goal is not specific enough. Therefore, a specified challenge is formulated shown on page 72.

Moreover, this project focuses on the workstation level of the kitchen. This level is considered a good fit with Qook! and with my project ambition as a graduation student.

3.3.1 THE PASS

The parti that will be the focus of this project is the pass. The pass is the workstation where multiple cooks come together to plate and finish the dishes. From this station the chef directs the cooks and signals the waiters to pick up the food and bring it to the customers.

The improvement of the pass is a logical continuation of this project for three reasons.
Firstly, plating is considered a physically uncomfortable task.

Secondly, multiple features are implemented in this station like heat lamps, heated plate cabinets, containers for garnish but also the ticket system. Multiple tasks are executed at the same time by multiple cooks.

Thirdly, the pass is often located at the front of the kitchen and is visible from the dining hall. With the addition of aesthetic features the pass can have a signature look and the brand can be strengthened.

Image 33. Author plating at the pass

DESIGN CHALLENGE

WITH THE IMPROVEMENT OF **ONE SPECIFIC PARTI**, *THIS PROJECT WILL SHOWCASE A METHOD OF* **OPTIMIZING EFFICIENCY** *USING* **ERGONOMIC IMPROVEMENTS**.

THE PARTI TO BE IMPROVED DURING THIS PROJECT IS **THE PASS**

Image 34. The pass

CHAPTER 4

DESIGN DIRECTION

In this chapter a design direction is formulated. This design direction is the result of a second interview done with a part of the aforementioned participants. This chapter is the starting point for the ideation.

4.1

THE PASS

The pass is the long workbench where the dishes are plated and picked up by waiting staff. It is often equipped with heat lamps.

At fine dining restaurants the pass is an important parti and has many crucial functions described below.

In short, the main function of the pass is guiding the transition of food, prepared in the kitchen, to the waiting staff and to the client. The quality of the food should be maintained in this transition.

PICKUP

First of all, the pass is the parti on the border of the kitchen and dining hall, and the place where waiting staff pick up the plated dishes. The pass is the communication line to the waiting staff. It is controlled by one kitchen member who keeps track of the food that goes out and monitors allergies and special orders.

ORDERS

This parti is also the place where the orders come in. Although there are multiple systems, digital and analogue, the pass is the central station where all the orders are collected. The cook who is stationed at the pass (i.e. the chef), controls the speed and rhythm of the courses made in the kitchen.

PLATING

The orders come in and go out at the pass, but are also plated at this station. Part of a pass are heat lamps, heated plate cabinets, garnish and spoons.
When an order is called by the chef, the chef de parti's respond with a confirmation and a cooking time. At the end of this cooking time the chef arranges the designated plates on the pass underneath the heat lamps.
The cooks, working on the order, place the pots and pans on the pass and start plating, supported by the chef. The task of the chef is to monitor the quality of the dishes. When the dishes are finished the chef rings the bell and the waiting staff pick up the plates to serve.

HEATING

There is a difference between hot and cold dishes. Cold dishes can be plated with less time pressure as it cannot cool down. For warm dishes the speed of plating is crucial.
A warm dish needs a warm plate, heat lamps to keep the plated food and the plate warm, and a fast plating and pickup. This makes the plating of hot dishes stressful and difficult to manage without a good workflow.

4.1.1 WORKFLOW

As the defined design direction concerns the optimisation of efficiency it is important to understand the workflow at the pass. Below the steps are described of the workflow of one single order.

1. Order comes in

The chef receives the order and announces the dishes that the cooks need to prepare at that specific moment.

2. Cooks respond

The cooks respond with a confirmation and a cooking time that is agreed upon by the chef de parti's that are involved in making the dishes asked. All ingredients that need any preparation are collected by the cooks and they work towards the time set.

3. Plates

While the time set is nearing its end, the chef arranges the plates required. The chef collects the garnish, checks the tickets for irregularities and clears space.

4. Plating

The prepared food arrives at the pass and the cooks start plating. Plating is executed by two or more cooks depending on the restaurant size.

In fine dining restaurants plating is an important part of a dish because a dish should be pleasing to the eye. Therefore, each dish has a specific sequence and location for its ingredients. It is like an assembly line in a factory. Each cook places one element onto every plate and then continues with the next element. Structured, with precision and speed, the dishes are plated. Chapter 5.6 explains the plating process in detail.

5. Order goes out

The waiting staff is called in and while the chef checks the tickets, she/he sends the dishes out to the correct table.

There are dishes that consist of multiple plates or that have jugs for sauce or other garnish that are added by the waiting staff at the table.

4.1.2 SECOND INTERVIEW

A second extended interview is done with a part of the cooks interviewed in the research phase. This second interview provides extended information about the functions of the pass. Image 35 illustrates the most prominent functions of the pass.

The functionality is categorized in three different topics:

- Temperature control
- Plating
- Order and Pickup

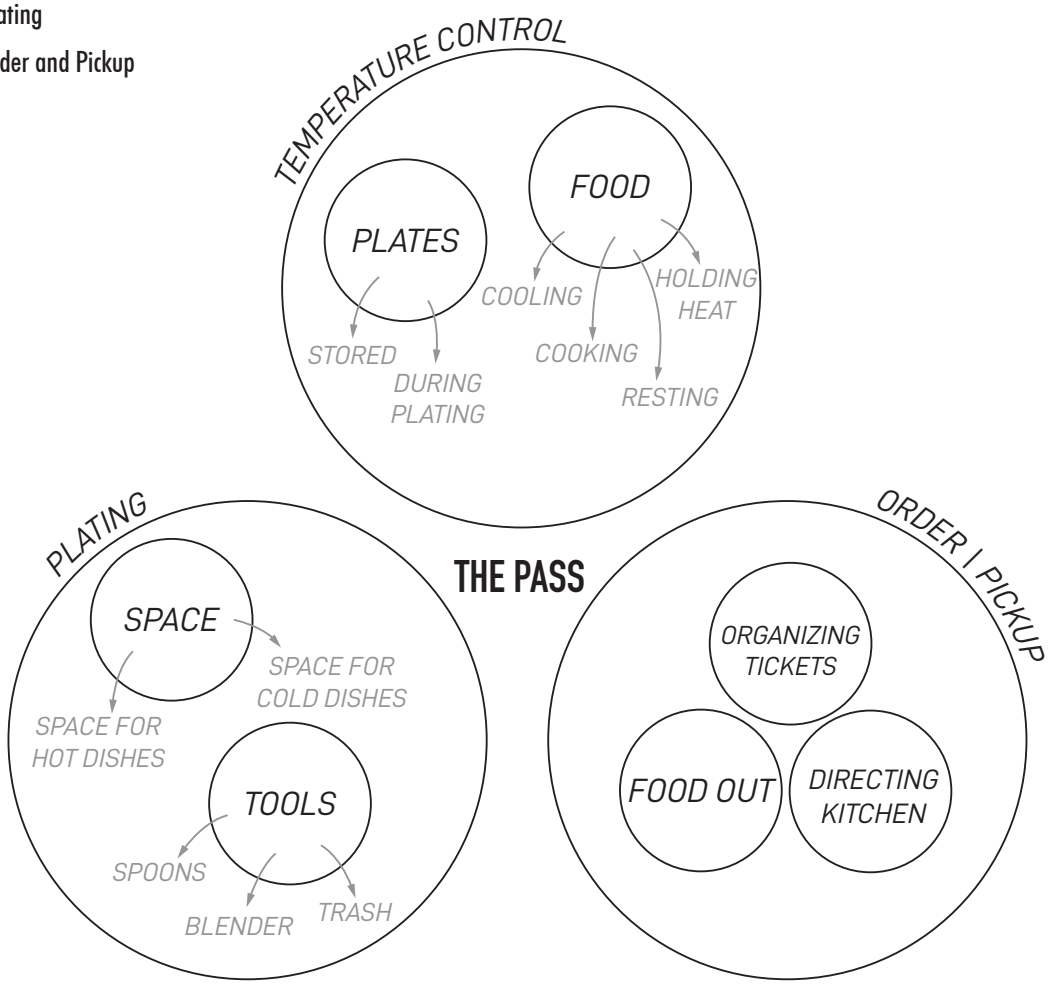


Image 35. Functions of the Pass

4.1.3 CRITICAL ASPECTS

Interviewees mention critical aspects of the pass. These critical aspects can cause discomfort and are categorized by three topics.

WORKING POSTURE

A working posture that is difficult to retain can be appointed to multiple aspects.
Page 80 shows these aspects with matching pictures.

PLATE CABINET

Plates, made of a ceramic material are heavy, especially when carrying a large stack. In most kitchens, the plate heating cabinet is underneath the workbench of the pass. Therefore, getting a stack of hot plates can be a heavy task, being in an uncomfortable position. Although isolated, these plate cabinets radiate heat towards the front of the workbench. Therefore, standing in front of this cabinet gives discomfort.

EQUIPMENT

Fine dining restaurants offer a wide variety of dishes and use different ingredients and garnish for each dish. With this large variety come many different tools.

The equipment should be easy to reach and enable an efficient workflow. The correct placement of equipment is crucial.

Image 36. Plate heating cabinet (top), Plating by cooks

MULTI TASKING

While plating the chef has to focus on the circumstances in the dining hall and the kitchen. Working with the ticket system and directing cooks at the same time consumes energy and brainpower, making it difficult to maintain a correct working posture.

WORKING UNDERNEATH A HEAT LAMP

A heat lamp should heat the plate with the food, thus the distance between lamp and plate should be small. However, a lamp which is close to the plate obstructs the view and makes it difficult to manoeuvre underneath it. Additionally, the temperature of the heat lamp causes discomfort.

CLOSE TO THE PLATE

As fine dining dishes need to be plated with a specific sequence, precision and speed, cooks tend to move the body close to the plate. This bent-forward working posture can cause pain in the back, shoulders and neck.

Image 37. Working posture

4.1.3 HOT AND COLD

In most restaurants there is a separation of the hot and cold pass. The cold pass is simply a large flat workbench where dishes are plated. There is an open cabinet for plates underneath the workbench and often a built-in cooler for garnish.

The hot pass is more complex. It is also a large flat workbench where dishes are plated. However, it is equipped with heat lamps, a plate heating cabinet and the ticket system.

The ticket system is mainly placed at the hot pass because of the structure of the kitchen. The chef mainly oversees and helps at the warm side of the kitchen.

Additionally, due to the warm ingredients, and the risk of cooling and overcooking, the warm dishes should be plated quickly and efficiently. There should be little time between the finishing of a dish and the picking up by waiting staff.

For the above mentioned reasons the hot pass is the focus of this graduation project. The hot pass process is most critical.

4.2

DEFINE

This chapter provides a clear definition of what is designed in the graduation project.

4.2.1 DESIGN DIRECTION

Page 83 shows the design direction that fits the design challenge.

The formulated direction gives focus and contains guidelines for a realistic and valuable end product for Qook!.

An optimisation of the heating system of the pass is selected as topic based on the critical aspects mentioned by the interviewees.

The heating system of the pass is perceived to be problematic, inconvenient and uncomfortable. The next chapter, Ideation, starts with research on different heating systems and possible solutions.

4.2.2 CONTEXT

Although fine dining already belongs to a certain category, a more specific definition is made. The functionality and rough dimensions of the pass is based on the type of food and number of possible customers at once.

Shown in image 38, the ideation and concept design will focus on restaurants with a maximum of 75 covers serving tasting menus with self-invented dishes that have five or more elements on the plate. Next to the tasting menu there is an 'a la carte' menu. The hot dishes include protein, vegetables, sauce and other garnish.

Image 38. Design context

DESIGN DIRECTION

DESIGN A PASS THAT CONTAINS AN **OPTIMISED HEATING SYSTEM FOR PLATES, PLATING, AND FOOD**, *PLATING SPACE FOR* **12 MAIN COURSE DISHES**, *WHILE* **IMPROVING ERGONOMICS**.

4.2.3 LIST OF REQUIREMENTS

Below the list of requirements is described that provides the boundaries of this project. This list is based on user interviews and the user context. These requirements are used in the ideation phase.

FUNCTIONALITY

TEMPERATURE CONTROL

1. A system that heats plates and the food, during the plating
1. An integrated space for the heating of plates, to ensure a steady plate temperature of 50 degrees Celsius

PLATING

1. Available space to plate 12 main courses - surface of $2m^2$.

ORDER | PICKUP

1. A workbench that is accessible from two sides. One side for cooks, one side for waiting staff to pick up dishes and communicate with the kitchen leader
2. A workbench that enables the kitchen leader to direct the kitchen while keeping overview, plate dishes and send out food

DIMENSIONS

1. A width compatible with 12 main course plates
2. A depth compatible with 12 main course plates
3. A combination of width and depth that fits the two-side functioning pass
4. A combination of width and depth that enables cooks to perform the tasks without physical obstruction and with a quick access to tools and food to be plated

ERGONOMICS

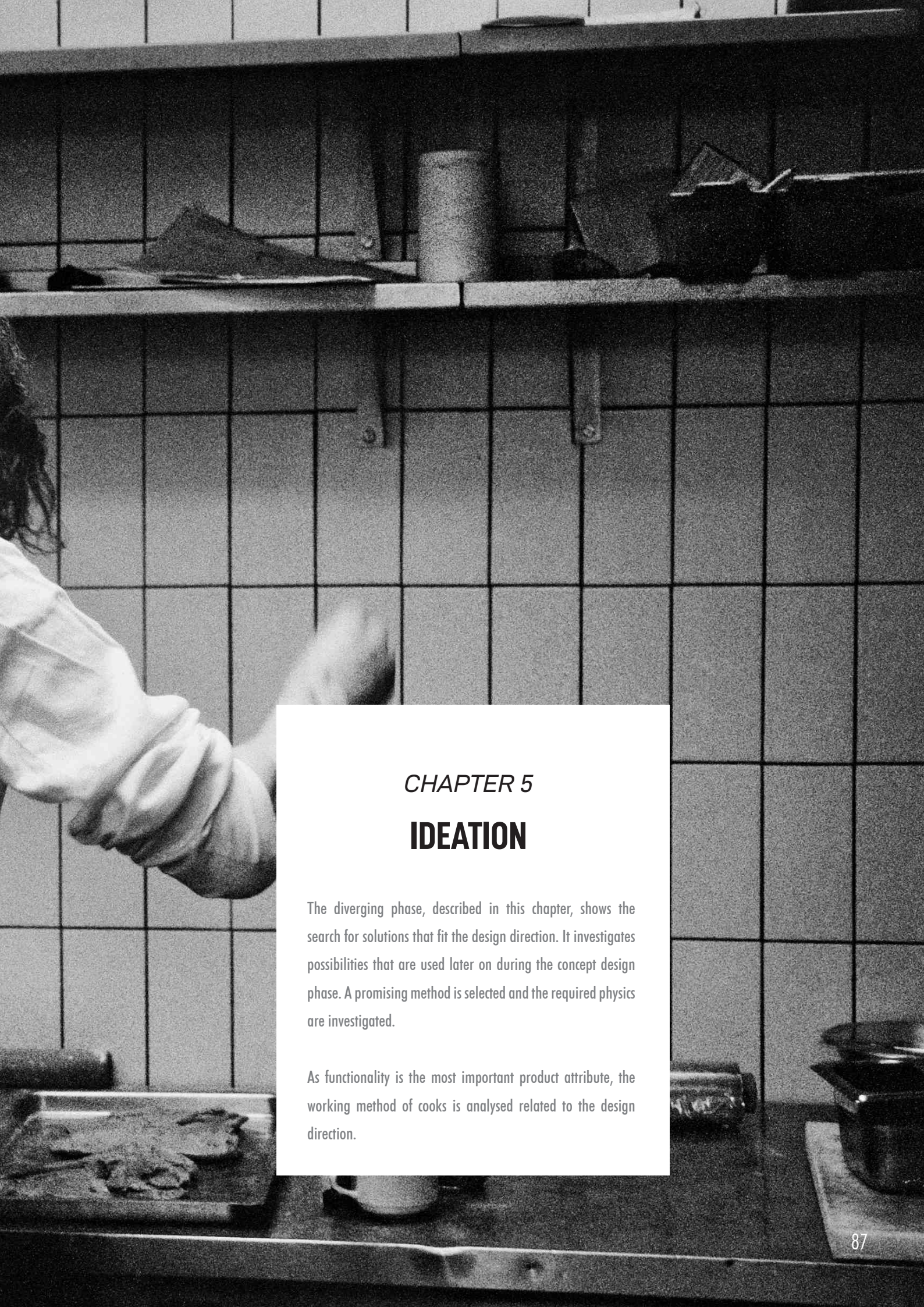
1. A height that fits the type of tasks
2. Ergonomic height suitable for the average Dutch female and male
3. A lay-out that supports the tasks and the cooks executing it
4. Freedom of movement
5. Thermal comfort
6. Good visibility for task execution
7. Well-lit working area
8. Easy to organise

CLEANING

1. The total unit can be cleaned in 10 minutes
2. Easy to clean: no sharp edges, easy accessibility

MATERIALS

1. Frame build with stainless steel square tubes
2. Working surface in stainless steel or a new type of material with similar characteristics
3. Use of low-maintenance materials
4. Materials that can endure high temperatures (up to 200 degrees Celsius)
5. Materials that are hygienic and comply with HACCP regulations
6. Materials that do not show any substantial wear after 10 years of use
7. Materials that comply with the production processes of Qook! or do not require substantial investments to implement



CHAPTER 5

IDEATION

The diverging phase, described in this chapter, shows the search for solutions that fit the design direction. It investigates possibilities that are used later on during the concept design phase. A promising method is selected and the required physics are investigated.

As functionality is the most important product attribute, the working method of cooks is analysed related to the design direction.

5.1

METHOD

The design direction describes a pass with an improved heating system. This heating system should be in line with the list of demands on page 84 and 85.

After a quick analysis of the current pass that Qook! designs and produces the ideation continues with research into heating sources. From this research the most promising idea is developed.

5.2

CURRENT SOLUTION

A visit to the restaurant By Flipp showed the current solution of Qook! in a fine dining restaurant. Image 39 illustrates this pass.

5.2.1 THE PASS BY QOOK!

This pass consists of a plate heating cabinet and two kinds of heat lamps. Most dishes are plated on the right hand side underneath the black heat lamps. The plate heating cabinet is deliberately placed on the left in order not to cause too much thermal discomfort. The heating bridge is also equipped with heat lamps, more powerful than the black heat lamps. The chef says the following about the heat lamps:

"I'd rather have a bridge which is longer and runs all the way over the pass. However, the current solution that Qook! offers is not aesthetically pleasing. That is why I chose for the hanging, height-adjustable, heat lamps. These are not as powerful but are better looking.

Moreover, the bridge that is installed is very powerful. The waiting staff cannot hold plates that are heated with the heat lamps in this bridge. If placed higher it would still function well. The current distance between work bench and bridge is 300mm.
The hanging heat lamps are not powerful enough.

Heat lamps are mainly used to keep food and plates warm. The maximum time a plate stays at the pass is 4 to 5 minutes. Delicate food, like fish, is placed at the last moment and then picked up by the waiting staff."

Image 39. The pass by Qook!

5.3

HEATING SOLUTION

This chapter shows an analysis of ten different heating methods. With this analysis an idea is created that will be developed and tested in the next chapters.

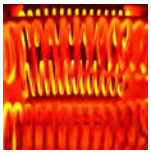
5.3.1 RESEARCH

The table shown on these two pages, called a Morphological Chart, provides an overview of the heat sources that are researched and tested in some cases.

With the eight above described demands, based on the list of requirements of chapter 4.2.3, the applicability of each heating method is determined.

These demands are most important for functionality and ergonomics. With a rating of zero to 3 the heating sources are judged and a conclusion is made.

This list of heating sources is non-exhaustive. The heat sources are selected by consulting Thermal-Elements, a company in Rijswijk, and desktop research.

HEAT SOURCE		1. KEEPING A CERAMIC PLATE AT 50°C
INDUCTION Electromagnetic heating due to eddy current and hysteresis - typical frequency of 25-50 kHz		**3** With a specialized plate, that is able to heat up in electro magnetic field it is possible to hold a temperature of 50°C.
HALOGEN HEATING TUBE (IR)* Wavelength = 1 μm Maximum temperature = 2600°C (Infrared Ceramic & Quartz Heating, n.d.)		**3** Due to the potentially high temperature level the ceramic element is over-engineered. 50°C is easily reached and temperature change can be quick.
TUNGSTEN HEATING TUBE (IR)* Wavelength = 1.6 μm Maximum temperature = 1500°C (Infrared Ceramic & Quartz Heating, n.d.)		**3** Due to the potentially high temperature level the tungsten tube is over-engineered. 50°C is easily reached and temperature change can be quick.
QUARTZ HEATER (IR)* Wavelength = 1.5-8 μm Maximum temperature = 772°C (Infrared Ceramic & Quartz Heating, n.d.)		**3** Due to the potentially high temperature level the heater is over-engineered. 50°C is easily reached and temperature change can be quick.
HIGH FREQUENCY HEATING		**3** High frequency heating can only function when placed inside the heater. It can hold a temperature of 50°C.
CERAMIC HEATING ELEMENT (IR)* Wavelength = 2-10 μm Maximum temperature = 750°C (Infrared Ceramic & Quartz Heating, n.d.)		**2** Due to the potentially high temperature level the ceramic element is over-engineered. 50°C is easily reached. However, temperature control is difficult.
RESISTANCE COIL		**3** A resistance coil can be powerful enough to hold a temperature of 50°C
TERMOFOL (IR)* Infrared heating foil | Normally used for floor heating Maximum temperature = 50°C | 220W/m^2		**0** This specific infrared heating foil is not powerful enough and the plate will reach around 40°C.
HEAT BLOWER (CONVECTION)		**2** Using hot air to hold a temperature is possible. However, it is an ineffective way since air easily moves though space.
HEATING PLATE (CONDUCTION) Maximum temperature = 100°C		**1** Although the contact surface between the ceramic plate and the heating plate is small it is possible to hold the temperature at 50°C.

3 = CAN MEET DEMAND IN AN EXCELLENT WAY

2 = CAN MEET DEMAND IN A GOOD WAY

1 = CAN MEET DEMAND IN A MEDIOCRE WAY

0 = CANNOT MEET DEMAND

*IR = Infrared (radiant heat)

DEMANDS

2. KEEPING THE FOOD ON A CERAMIC PLATE AT 50°C	3. HEATING A CERAMIC PLATE FROM 20°C TO 50°C WITHIN 30 SECONDS	4. QUICK TEMPERATURE CONTROL	5. MINIMAL RESIDUAL HEAT	6. NO DEHUMIDIFICATION OF THE AIR AND THE FOOD ON THE CERAMIC PLATE	7. WORKING CLOSE TO THE HEAT SOURCE SHOULD NOT GIVE DISCOMFORT	8. FUNCTIONAL WITH A DISTANCE OF 400-500 MM BETWEEN THE HEAT SOURCE AND FOOD	TOTAL
1 Where the food is in contact with the ceramic plate there is heat transfer. If food has good contact with the plate it can work sufficiently.	**3** With a thin aluminum layer underneath the ceramic, and the power set to the lowest setting of 300W, the induction hob can satisfy this demand.	**3** Induction heating is known to be quick and highly responsive. In combination with a specialised ceramic that reacts to induction, it can be fast.	**3** Only the solids reacting to the magnetic field will heat up, in this case the specialised ceramic. Therefore, there is a very low residual heat.	**3** Only the ceramic plate reacts to the induction hob.	**3** Just the ceramic plate will heat and there is no additional heat that can cause discomfort.	**0** Heating with a electromagnetic field, only works when the object to be heated is within 20 mm of the source.	**19**
3 With a correct distance to the food and the correct power supply the heating source can keep food at 50˚C. 1µm so a high penetration.	**1** Although the heating source is powerful it cannot heat the plate from 20˚C to 60˚C within 30 seconds.	**3** Halogen heating tubes allow rapid on/off cycles.	**1** Although radiant heat does not heat air, this heating tube does heat solids close to it. Therefore there is residual heat.	**3** Radiant heat does not heat and dehumidify air. Additionally, the radiation penetrates the surface of food and does not dry it.	**0** For the heat source to have an adequate heat radiation the source surface temperature will be above 500 ˚C.	**3** The surface temperature of the heating source will increase with a larger distance. Due to the available power it is achievable.	**17**
3 With a correct distance to the food and the correct power supply the heating source can keep food at 50˚C. 1µm so a high penetration.	**1** Although the heating source is powerful it cannot heat the plate from 20˚C to 60˚C within 30 seconds.	**3** Within seconds the tungsten heating tube can reach maximum temperature (1500˚C).	**1** Although radiant heat does not heat air, this heating tube does heat solids close to it. Therefore there is residual heat.	**3** Radiant heat does not heat and dehumidify air. Additionally, the radiation penetrates the surface of food and does not dry it.	**0** For the heat source to have an adequate heat radiation the source surface temperature will be above 500 ˚C.	**3** The surface temperature of the heating source will increase with a larger distance. Due to the available power it is achievable.	**17**
2 With a correct distance to the food and the correct power supply the heating source can keep food at 50˚C.	**1** Although the heating source is powerful it cannot heat the plate from 20˚C to 60˚C within 30 seconds.	**3** The quartz heater allows rapid on/off cycles.	**1** Although radiant heat does not heat air, this heating tube does heat solids close to it. Therefore there is residual heat.	**3** Radiant heat does not heat and dehumidify air. Additionally, the radiation penetrates the surface of food and does not dry it.	**0** For the heat source to have an adequate heat radiation the source surface temperature will be above 500 ˚C.	**3** The surface temperature of the heating source will increase with a larger distance. Due to the available power it is achievable.	**16**
3 A microwave is a source of high frequency heating. Food contains water so it is possible to hold the temperature of food at 50˚C with this method.	**1** It is possible to heat a ceramic plate in a microwave at 800 Watts. It will heat up to 50 degrees in a minute.	**3** High frequency heating (microwave) is fast and effective.	**1** When contained it is a very precise heat source. However, all that comes into the heat source will heat up.	**0** High frequency reacts to dipoles. As water is a dipole it will heat and the air will dehumidify.	**0** The electromagnetic waves, radiated by a high frequency heat source can cause water to boil quickly. As a human body contains water it is not safe.	**2** With the right frequency and power supply a large distance is possible. However, air will also heat and therefore reduce efficiency.	**13**
2 With a correct distance to the food and the correct power supply the heating source can keep food at 50˚C.	**0** Although the heating source is powerful it cannot heat the plate from 20˚C to 60˚C within 30 seconds.	**1** The ceramic heating element consist of a high resistance wire embedded into a thick ceramic layer. Heating the ceramic layer takes time.	**1** Although radiant heat does not heat air, this heating tube does heat solids close to it. Therefore there is residual heat.	**3** Radiant heat does not heat and dehumidify air. Additionally, the radiation penetrates the surface of food and does not dry it.	**0** For the heat source to have an adequate heat radiation the source surface temperature will be above 500 ˚C.	**3** The surface temperature of the heating source will increase with a larger distance. Due to the available power it is achievable.	**12**
2 The resistance coil will heat up air and the surface of the food if positioned close. The heat does not penetrate the food.	**1** Although the heating source is powerful it cannot heat the plate from 20˚C to 60˚C within 30 seconds.	**3** A resistance coil is highly responsive due to the working principle. When turned on it will rapidly heat up.	**0** A resistance coil heats air and radiates heat. It gives a high residual heat.	**0** A resistance coil will dehumidify air due to convection heating.	**0** Convection and radiant heat will reach high temperatures and working close to the heat source is not comfortable.	**2** Setting the heating coil to the right power will enable the source to meet the demand. However, air will form a barrier and reduce efficiency.	**11**
0 The plate's temperature will stagnate at 40˚C. Therefore, it is not possible to keep the food at 50˚C.	**0** This Termofol is not powerful enough to satisfy this demand.	**1** The foil can heat up to maximum temperature within 5 minutes.	**1** Radiation heat does not heat air. However, it does heat all objects around the foil that come into contact with the radiation.	**3** Radiant heat does not heat and dehumidify air.	**3** As the heat source is not powerful it does not give discomfort	**0** The foil is not powerful enough to meet this demand.	**8**
1 Convection heat will heat the surface of the food. However, it is not direct or efficient.	**0** Convection is not a power source powerful or efficient enough to satisfy this demand.	**1** Heating a gas or liquid can be fast however rapid temperature control is difficult.	**1** With convection a liquid or a gas is heated. If air is used as medium it gives very high residual heat.	**0** Convection heat with air as medium will dehumidify the air.	**1** Hot and dry air gives discomfort.	**0** A high powered convection heater can meet the demand. However, air is not an effective heating medium.	**6**
1 The heat plate can heat the ceramic plate to a max. of 65˚C. By conduction the ceramic plate can hold the food at 50˚C where there is contact.	**0** With a maximum temperature of 100˚C, the heating plate is not powerful enough to satisfy this demand.	**0** For the heating plate to reach a 100˚C it takes 15 minutes.	**0** The heat plate heats all solids, liquids and gases that come in contact with it. Therefore there is high residual heat.	**0** Due to convection heating the air dehumidifies.	**1** Convection and working close to the heat plate gives discomfort.	**0** The surface of the heating plate becomes hot. Next to conduction the heating plate is not able to meet this demand.	**3**

5.3.2 RESULT

The Morphological Chart on page 90-91 shows that induction is the heat source that scored highest. Induction meets most demands in an excellent manner and this method is chosen to develop further and test to validate the functionality. Image 40 shows the insides of a single pot induction cooker and image 41 shows the product idea that is a result of the chart on page 90-91. Induction is used to heat ceramic dinnerware from underneath.

The two main functions of the heat source are ceramic plate heating and food heating.
Ordered food should arrive warm at the customer's table. A hot ceramic plate has an adequate impact on the retention of heat. However, the higher the food is stacked on the plate, the less contact with the plate itself. Therefore, the impact of a properly heated plate on the heat retention of food should be investigated at a later stage.

5.3.3 CONCLUSION

The principle that is chosen to investigate further concerns heating from below the pass surface, using induction. A special type of ceramic reacts to the induction heating mechanism.

Next step is to prototype and test the induction plate combination. The following chapter explains the principle of induction heating, how it can be applied to ceramics and the specifications of the induction hob suited for the application of plate heating.

5.3.3.1 BENEFITS

This new heating method, that will be investigated in the next chapter, should result in ergonomic improvements. The main benefits of this product idea are listed below.

- Quick and precise heating
- It only heats the ceramic dinnerware so no residual heat
- The heating source is underneath the ceramic dinnerware so there is no obstruction of view and movement caused by the heat lamps

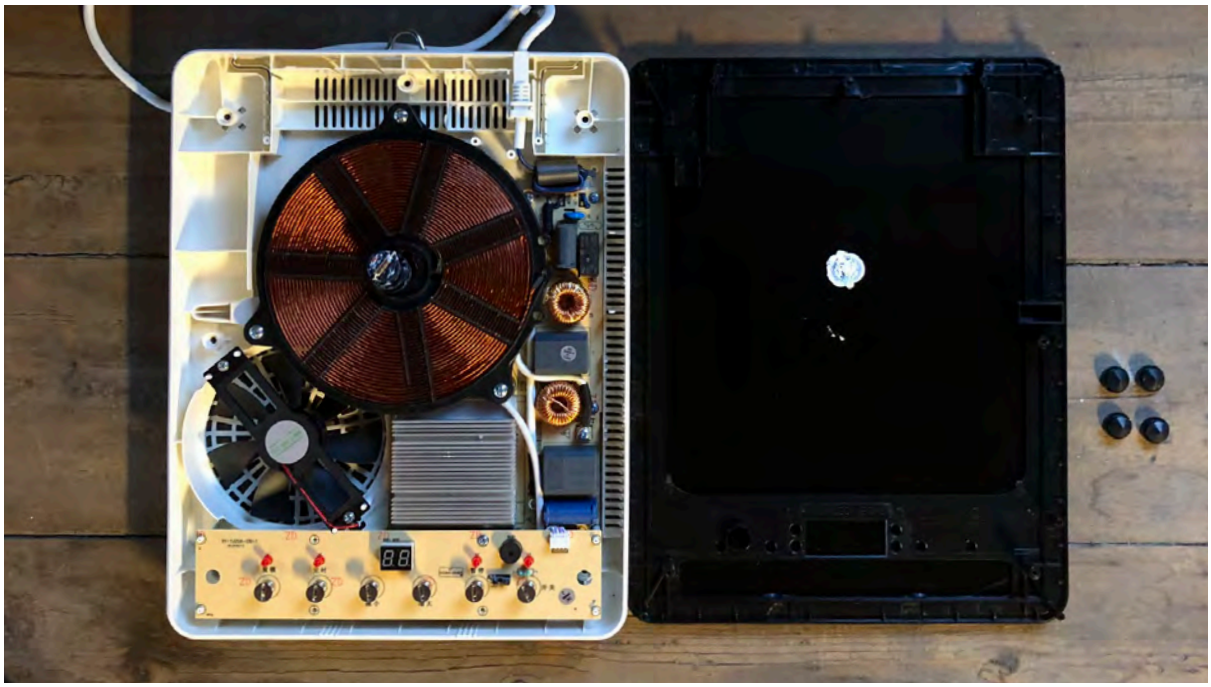


Image 40. Inside of the Ikea induction hob

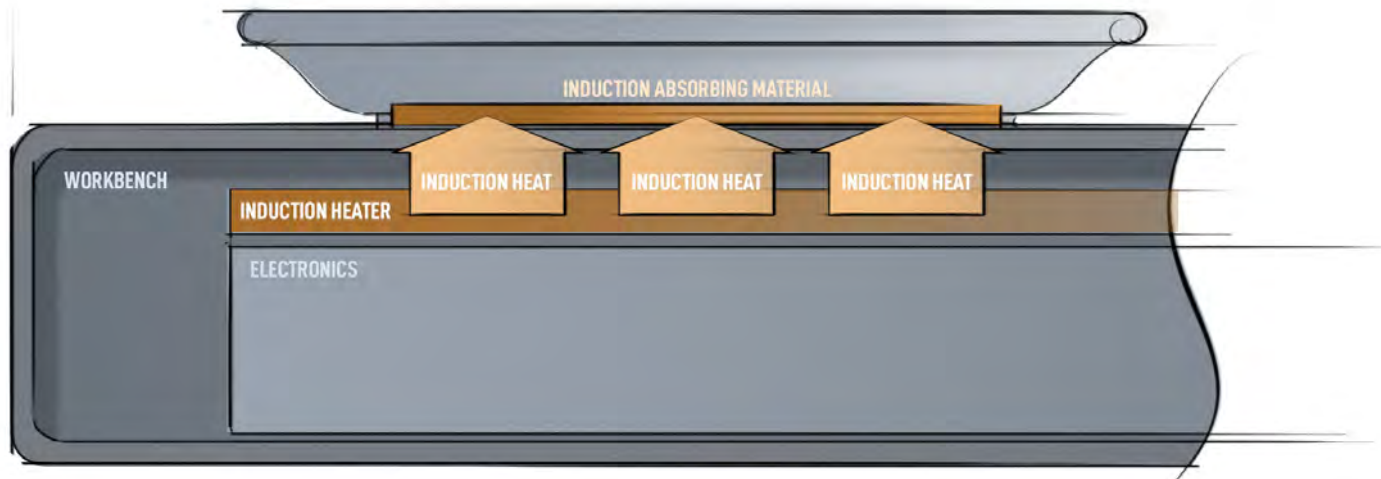


Image 41. Underneath heating with induction

5.4

INDUCTION HEATING

Induction cooking is a technique which is increasingly used in domestic and professional kitchens. With the high efficiency and the low residual heat it is a great ergonomic improvement.
An induction hob consists of one or a series of coils that produce an alternating electromagnetic field (see image 40). This electromagnetic field produces heat with two phenomena. Eddy current and hysteresis.

5.4.1 EDDY CURRENT

When a conductor (an electrical conducting material like iron) is placed into an alternating electromagnetic field this field will induce an alternating current in the conductor. This current will flow perpendicular to the electromagnetic field. Due to the Joule heating (resistance heating) the conductor will heat up. For these phenomena to work the conductor should give enough resistance. This resistance is dependent on the Skin Effect.

5.4.1.1 SKIN EFFECT

The Skin Effect, illustrated with image 42, occurs with an alternating current that is induced by an alternating electromagnetic field. The Skin Effect phenomenon makes the current, induced by the alternating electromagnetic field, distribute at the skin (surface) of the conductor. The book 'Optimal Control of Induction Heating Processes' describes that approximately 86% of the power (current) will be concentrated in the surface of the conductor (Rapoport & Pleshivtseva, 2007).

Fisk (2014) also describes the Skin Depth. The Skin Depth is defined as the depth below the surface of the

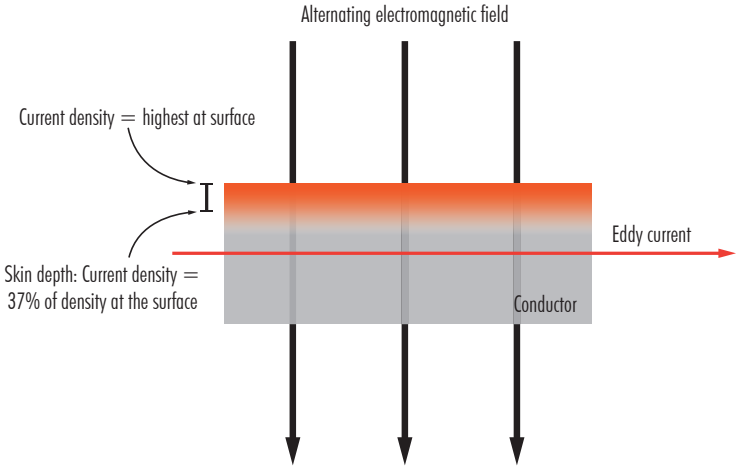


Image 42. Skin effect

conductor at which the current density has fallen to e^{-1} (37%) of its surface current density. (Fisk, 2014)
Additionally, the higher the frequency of the alternating electromagnetic field, the smaller the Skin Depth.
As different materials have different characteristics Skin Depth is one of them. The Skin Depth (δ) depends on the frequency (f), magnetic permeability (μ) and the electrical conductivity (σ) of a material (Fisk, 2014). See the formula below (1).

$$\delta = \frac{1}{\sqrt{\prod f \mu \sigma}} \quad (1)$$

For example, with an alternating electromagnetic field of 50 Hz, the following skin depths are the result of the above formula.

Iron: $\delta = 0{,}319$ mm
Aluminium: $\delta = 11{,}6$ mm
Copper: $\delta = 9{,}22$ mm

This big difference between iron, aluminium and copper is mainly caused by the value of magnetic permeability. Magnetic permeability is expressed as the resistance of a material to form a magnetic field. As iron is a ferromagnetic material it can easily form a magnetic field and therefore has a high magnetic permeability (μ).

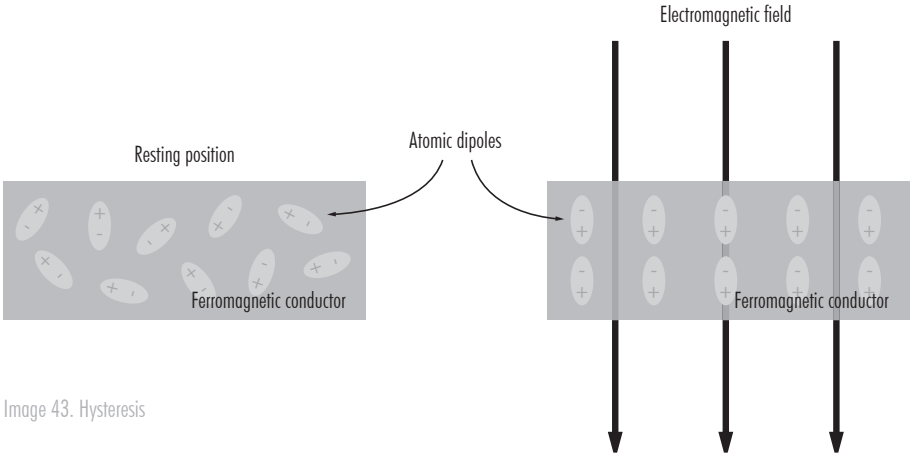


Image 43. Hysteresis

The impact of the Skin Effect to Joule heating is big. As the current distribution is at the surface of the conductor it contributes to the resistance. With a small Skin Depth the current will mostly be distributed in a small surface layer of the conductor. As resistance depends on material thickness, the smaller the Skin Depth the higher the resistance and thus a bigger heat production.

As copper and aluminium have a large skin depth the current will not bare much resistance. Therefore, these materials are less suitable for heating with an alternating electromagnetic field (induction). Iron, a ferromagnetic material has a small skin depth and is mostly used in cooking appliances for induction heating.

5.4.2 HYSTERESIS

The second phenomenon that creates heat in a conductor, placed in an alternating electromagnetic field, is Hysteresis. This phenomenon only occurs with ferromagnetic materials. Image 44 illustrates how a ferromagnetic material reacts to an electromagnetic field.

A ferromagnetic conductor contains atomic dipoles. Atomic dipoles are atomic particles that have a positive and negative load, like a permanent magnet. In resting position these atomic dipoles are randomly oriented in a way that the total forms an equilibrium.

When this ferromagnetic conductor is placed within an electromagnetic field the atomic dipoles are being oriented in the same direction as the electromagnetic field. Additionally, dipoles group together and form magnetic domains.

When this ferromagnetic conductor is placed into an alternating electromagnetic field the atomic dipoles try to orient in the alternating magnetic field. However, the dipoles cannot change as fast as the alternating magnetic field changes and lag behind, which is called Hysteresis. The domains (groups of dipoles), in this case, continuously change dimension and boundaries.

The lagging of dipoles together with the shift of dimension and boundaries of the domains give atomic friction. This friction causes heat.

5.4.3 HEAT CONTROL

An induction hob can be used like a regular gas stove and the temperature of the cooking vessel can be controlled.

The Ikea Tillrede induction hob used for tests in this chapter is a 2000W, 8.5A and 24.4 kHz device that plugs into 230V AC power line. In the instruction manual of this device nine different power settings are described as following:

1	2	3	4	5	6	7	8	9
100 W	300 W	600 W	900 W	1100 W	1300 W	1500 W	1700 W	2000 W

It shows that this specific induction hob is controlled by power. So, what happens when the power is increased?

Firstly, an increase in power (P) gives a larger magnetic force (H). This is described with the following formulas (2&3):

$$H = \frac{I \cdot N}{L} \quad (2)$$

$$P = I \cdot V \quad (3)$$

In this formula I is current, N is the numbers of turns in an induction coil, L is the length of the coil and V is the voltage.

With an increase in power, and a steady voltage, the current will increase and in turn the magnetic force H will also increase. The increase in magnetic force will increase the Eddy Current and increase Hysteresis loss.

The induction hob with the 9 different power settings, varying from 100W to 2000W, will be used to discover the suitable power the ceramic material will need.

5.4.4 EXPANSION

This research into induction heating is done for the purpose of creating ceramic dinnerware that can be heated with an alternating electromagnetic field as well as a suitable induction hob for this ceramic. As explained a ferromagnetic material is best suited to produce heat with the use of induction.

In the next sub chapter, 5.4.5 Ceramics, different ideas and techniques are shared. What should be noted is the difference in thermal expansion.

Ceramics have different material characteristics than metals. If a metal is combined with a ceramic, and the combination is heated, it can cause stress in the combined material due to a different thermal expansion. Since these two need to be combined, an important characteristic to look into is the thermal reaction of the combined material.

5.4.5 CERAMICS

To validate if a ceramic can be heated with induction multiple prototypes are made. There are three types that are tested. All types are made with a ceramic tile of 200x200x6 mm.

1. The first type is the most straightforward and consists of a steel foil of 0.1 mm thick that is attached to the ceramic tile. Afterwards the combination is glazed and fired in a ceramic oven at 1100˚C.

2. The second type makes use of metal powders. Metal powders could be suitable because it can be mixed through the glaze. Additionally it could reduce the effect of thermal expansion since these small and loose particles are embedded in the material instead of consisting of one big piece.

This technique is based on the article 'Study on the Preparation Technology of a Ceramic Panel with a Magnetic Interlayer for an Induction Cooker (Pan, 2019). In this research the best result was achieved with 56 wt% (wt% = percentage by mass) of copper powder, 20 wt% of iron powder, 9 wt% glass powder and 15 wt% of organic carrier. The copper in this mix gives good heat

conduction and the iron is the ferromagnetic compound required for induction heating.

The copper and iron powder for this test are mixed with 24 wt% of ceramic glaze. This is the electromagnetic layer. After applying this layer to the ceramic tile the combination is fired in a ceramic oven at 980 ˚C.
The same is done with a mix of 30 wt% of copper and iron, and 40 wt% of glaze and a mix of 55 wt% of iron mixed with 45 wt% of glaze.

3. The third type that will be prototyped is a mix of clay and metal powder. One mix will be 55 wt% of iron powder together with 45 wt% of clay. A layer of 2 mm of this mix will be combined with a layer of 5 mm of normal clay. This disk, with a diamter of 200 mm, will then be fired at 980 ˚C.

The same will be done with a mix of 20 wt% of iron, 56 wt% of copper and 24 wt% of clay.

All these ceramic tiles will be tested on an induction hob with an infrared camera to analyse the heat production and transfer.

5.4.6 CONCLUSION

Prototyping the ceramic metal combinations proved to be more complex than expected.
During the testing phase only the ceramic with metal foil seemed functional. It showed that for induction heating to work enough metal substance is needed. Using small metal particles, this substance lacks and a current flow is not possible.
Developing a material that reacts to an alternating magnetic field and that can be embedded into ceramics or porcelain has proven complex.

During this development a German porcelain company was discovered that already produces a special coating for induction. The next chapter describes this special porcelain.

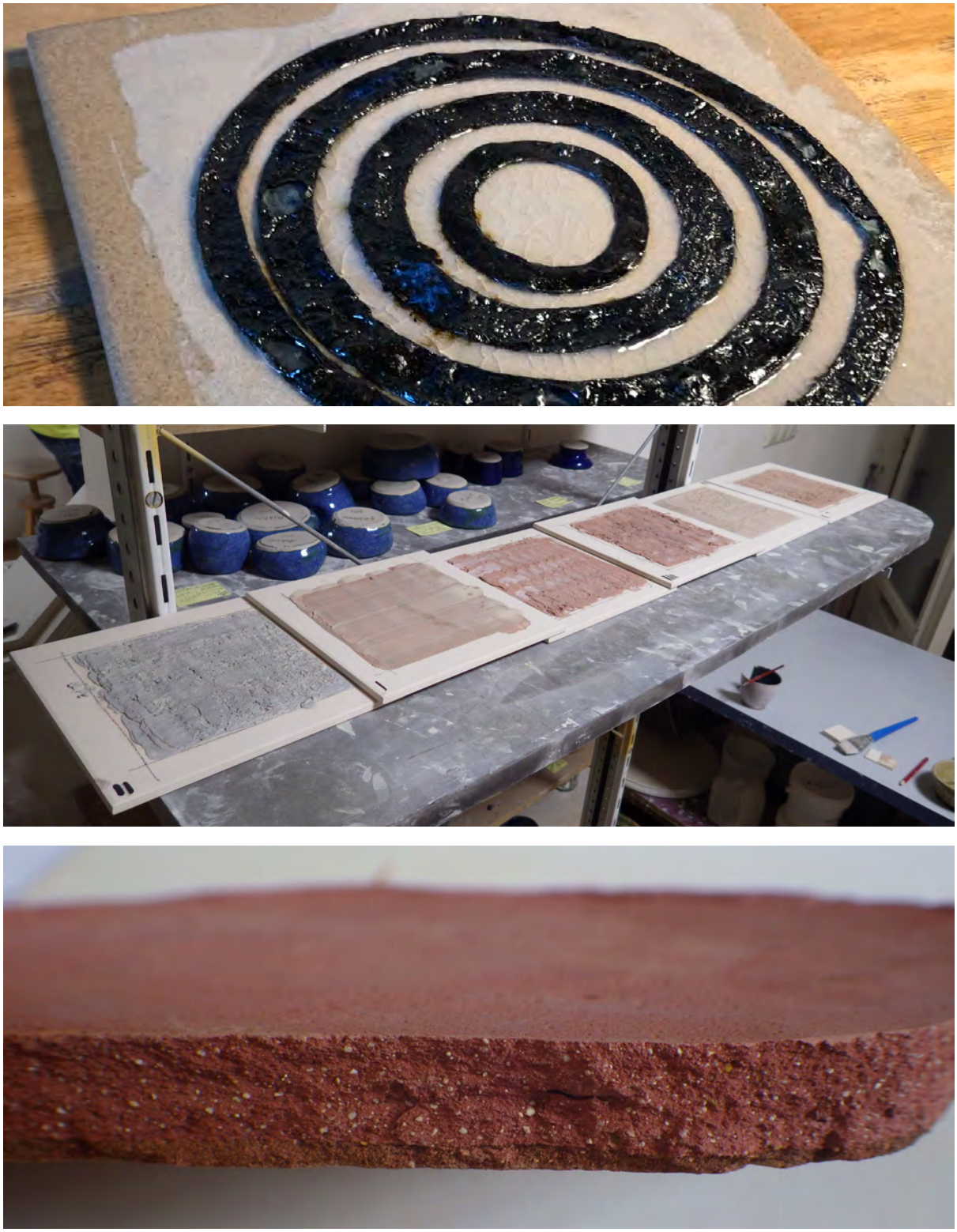


Image 44. Ceramic prototypes from top to bottom: steel foil | metal glaze | clay metal mix

5.5

SCHÖNWALD

Schönwald is a large German porcelain manufacturer that produces porcelain (a type of ceramic) for a variety of catering industries. The porcelain with special induction coating, illustrated in image 45, is used in hospitals and nursing homes for the reheating of food.

It took Schönwald, part of the larger overarching group BHS tabletop AG, over eight years to develop this special induction coating.
This coating, consisting of silver and other unknown materials, is fired after the protective glaze is already applied and fired. Basically, it can be seen as a conduction layer of paint. The benefit of this technique is that it can be applied to a large variety of porcelain.

The plate, illustrated below, and a small bowl, are used to test the functionality of the special porcelain and the feasibility of the desired application.

Image 45. Schönwald's induction coating

5.5.1 TESTING

Image 46 to 48 show three graphs with the results of the test performed with a plate and bowl equipped with Schönwalds induction coating.
The induction hob used for these test is the Ikea Tillreda. With the 100W setting this hob heats for a duration of 20 seconds and a pause period of 20 seconds. The 300W setting heats with a duration of 10 seconds and a pause period of 10 seconds. The 600W setting heats continuously.

Analysing the graphs shows that if a plate is continuously heated with 100W, a temperature rise of 20 to 50 degrees Celsius takes ~27 seconds. With 300W the same temperature rise takes ~22 seconds, and with 600W it takes ~15 seconds.

For the bowl to rise from 20 to 50 degrees Celsius it takes ~16 seconds with 100W, ~11 seconds with 300W and ~17 seconds with 600W (it seems that a power setting of more than 300W does not have effect on the bowl).

This means, less mass, less time needed to heat.

Additionally, the tests were performed until the porcelain reached a temperature of around 85 degrees Celsius. This quick temperature rise did not result in any damage of the porcelain. The induction hob that will be designed for these plates will heat plates to a maximum of 60 degrees Celsius within 30 seconds. Therefore, it is expected that the plates will not be damaged during the heating.
Next research step could be to test the plates with a large repetition of heating and cooling cycles. Microcracks, not visible to the eye, might develop due to the rapid heating.

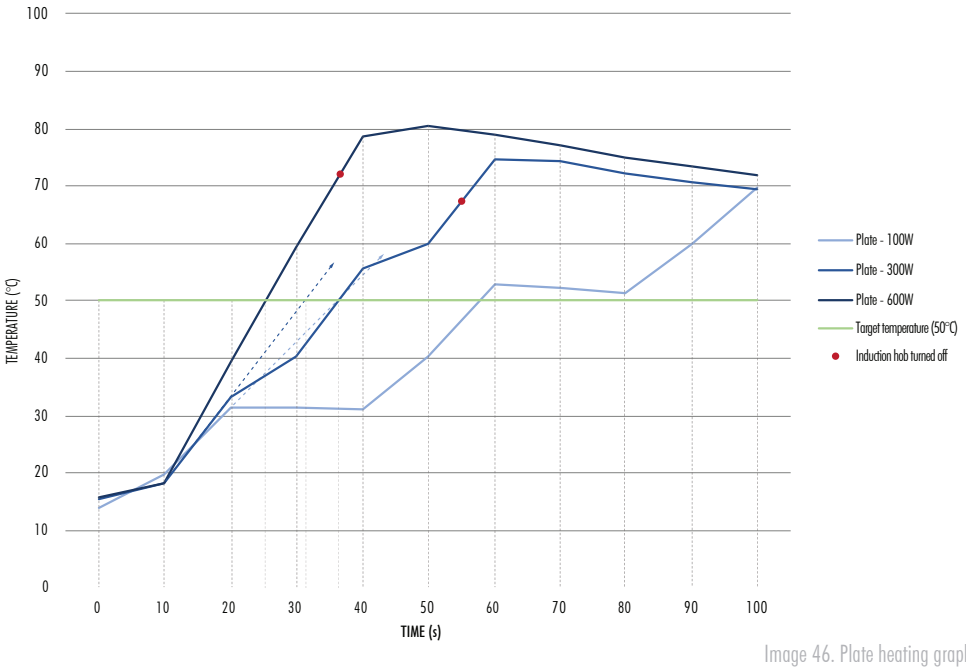


Image 46. Plate heating graph

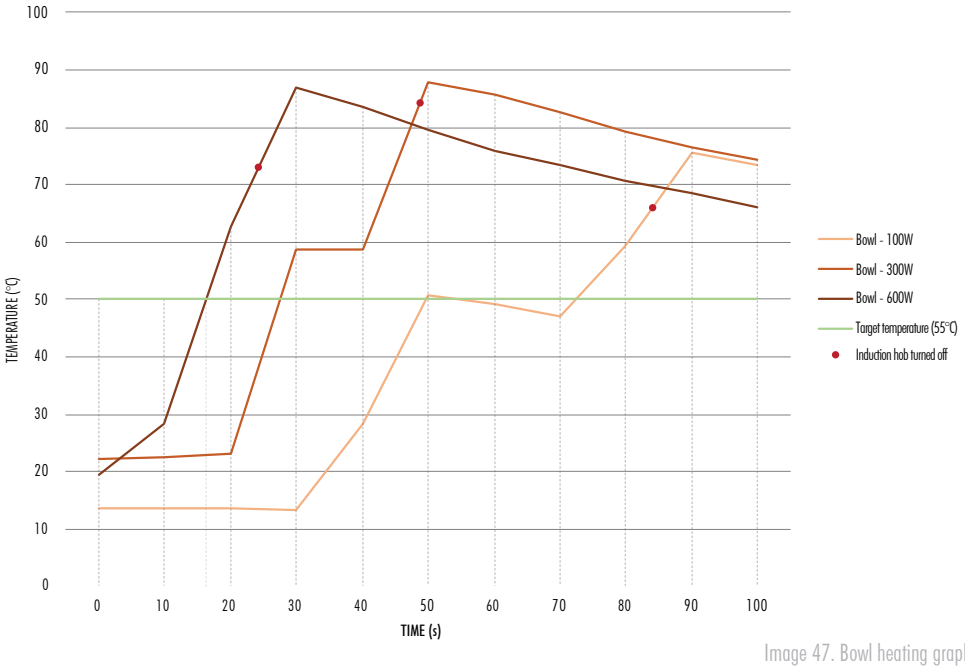


Image 47. Bowl heating graph

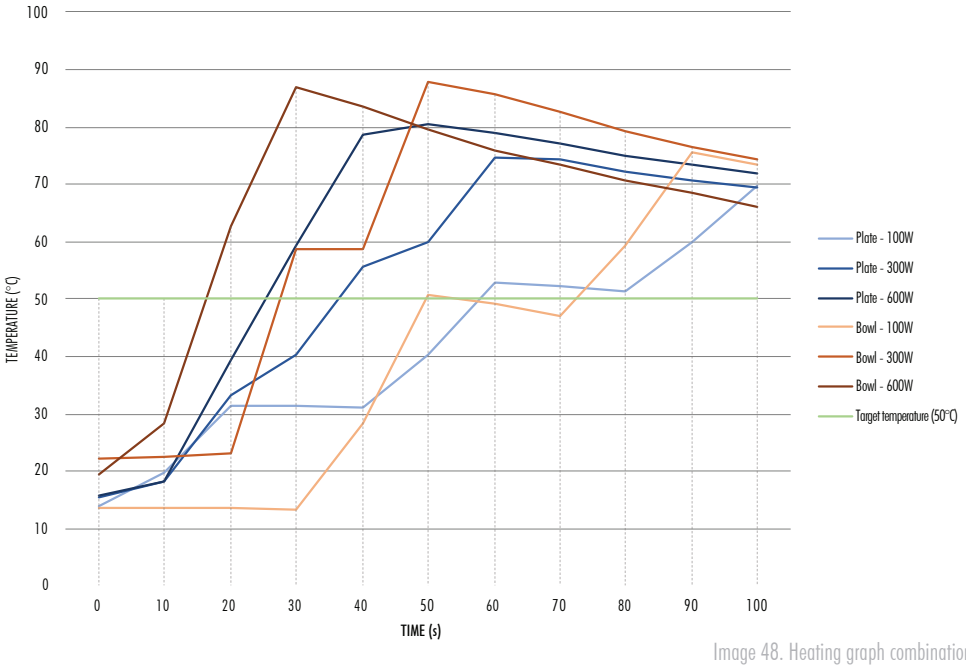


Image 48. Heating graph combination

5.5.2 COATING

The special induction coating developed by Schönwald is now used in nursing homes for the reheating of food. The porcelain combined with the special coating for this specific industry is aesthetically not suitable for fine dining restaurants as it looks old-fashioned. Therefore, Schönwald is contacted to discover the possibilities of the coating.

A selection of Schönwalds standard porcelain is made that better fits the fine dining restaurants. These porcelain items are treated with the specialized coating to see if it is possible.

Because the coating must be applied on a glazed surface the only demand is that the porcelain must contain glaze at the bottom of the porcelain dinnerware.

Image 49 shows the different, special made porcelain for this project.

Image 49. Special coated porcelain

5.5.2 CONCLUSION

Schönwalds induction porcelain offers the possibility to meet the demands stated in the table of chapter 5.3.1. Due to the possibility to heat the porcelain fast without damage, it can be a new way of dinnerware heating.

Next chapter explains plating order and techniques that are common in the professional kitchen. With this knowledge the induction hob specification and functionality will be designed.

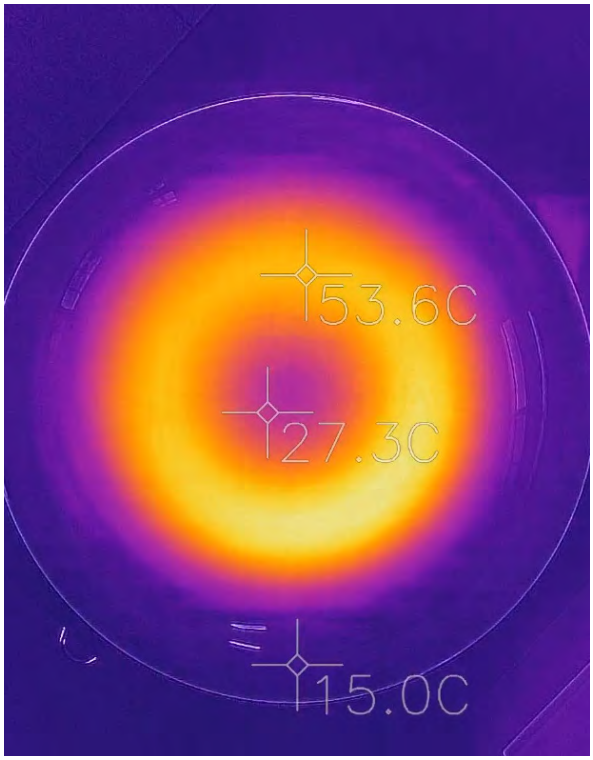


Image 50. Thermal image of heated big plate

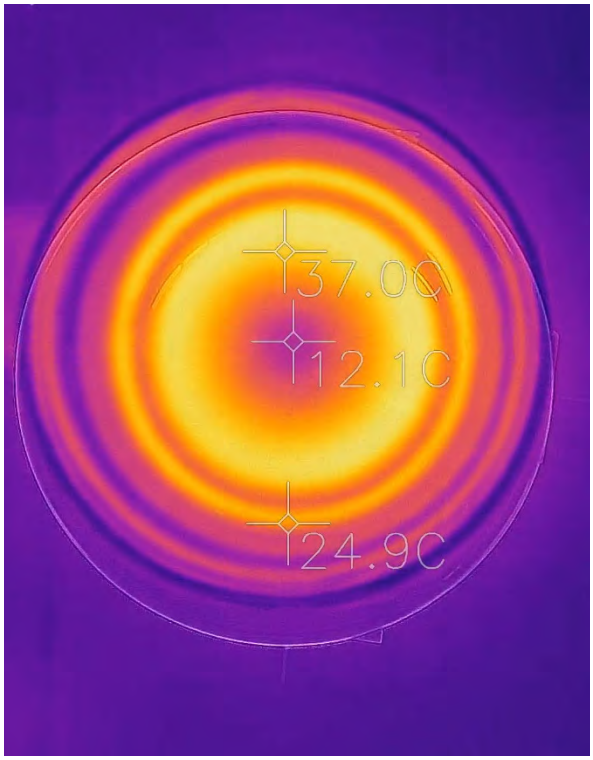


Image 51. Thermal image of heated bowl

5.6

PLATING

In this chapter the order of plating and plating techniques are discussed. This will lead to the starting points of the induction hob's use and functionality.

Image 52 to 55 show four different dishes of fine dining restaurants.

5.6.1 PLATING ORDER

Each hot dish produced in modern European fine dining restaurants mostly consists of five elements. These elements are often plated in an order that is specific for the type of ingredient. For example, fish is a very delicate product and can overcook quickly. Therefore, fish is placed just before the plate leaves the pass.

The main categories of the ingredients are shown in the following list. This list is ordered in the same way that it is plated. Starch, vegetable and fruits are in most cases the first elements that are plated. An example of a plating routine is explained on page 106.

1. Starch | Vegetable | Fruits
   - > Potato
   - > Dough varieties
   - > Grains
   - > Beans
   - > Seasonal vegetables
   - > Seasonal fruits
2. Garnish
   - > Crisps
   - > Herbs
   - > Flowers
   - > Crumbles
3. Protein
   - > Fish
   - > Shellfish
   - > Meat
   - > Poultry
   - > Tofu (Fermented products)
4. Liquid
   - > Sauce
   - > Emulsion
   - > Foam
   - > Soup

Image 52. Restaurant Fred, Rotterdam

Image 53. Restaurant Fred, Rotterdam

Image 54. Restaurant Bertmans, Rotterdam

Image 55. Restaurant de Centrale, Delft

5.6.2 PLATING ROUTINE

STEP 1.

Modern European fine dining restaurants build up dishes with crème like purees of vegetable or starch products. These are mostly put on the plate first. They have a large contact area with the plate and hold temperature well due to the high moisture content.

STEP 2.

A vegetable and starch garnish that is glazed in a cooking pot. This is a widely used technique. Other methods are frying, roasting or deep-frying. With these heating methods the cooked vegetables are heated up to 100 ˚C or higher.

STEP 3.

A room temperature vegetable garnish. These green rolls made of courgette are pre-rolled during the mise en place. A tray of these roles are kept at an easy accessible spot.

STEP 4.

After the vegetable and starch ingredients, the garnish is placed. The garnish mostly consists of crisps, herbs or flowers and will quickly deteriorate.

STEP 5.

Quickly after the garnish the protein is placed onto the plate. Proteins can be delicate specific. Therefore, it cannot be kept too long on a plate and continue cooking due to the heat lamps. After the protein is plated the dish is taken to the customer.

STEP 6.

Fine dining restaurants often finish dishes at the table of the customer for the theatrical effect as well as quality. Sauces or other liquids are poured on by the waiting staff in front of the customer.

Image 56. Plating routing at restaurant Herione, Rotterdam

5.6.3 PLATING TECHNIQUE

Next to the order of plating, it is important to look at the setup or technique of plating that is common in fine dining restaurants. Images 57 and 58 show the plate layout at the pass. Image 57 shows a direction from left to right but it can be vice versa. Each cook places the same item on each plate and then starts with a new item at the first plate on the left side. This working method is crucial for speed and efficiency.

Another important layout technique to be observed is the method of placing a second row of plates at the pass. This row of plates are moved half a plate to the right, also called hexagonal packing. With this configuration the cooks save space for garnish, pots and pans.

The induction hob, designed to heat plates, should enable this working method commonly used by cooks.

5.6.4 CONCLUSION

As vegetables and starch products are the first to plate, these items stay on the plate longest. The heated plate and other temperature controlling devices should ensure that these items stay hot. As protein, garnish and sauce are plated at the last moment the temperature controlling devices should have the biggest impact on the vegetable and starch products. It is important to test the new heating system with these type of products in a later stage.

Another observation teaches us that dishes are also plated vertically. This means that not all ingredients touch the plate. If the plate is the only heating device, it might give problems with heating the highest plated food that does not contact the plate. This should be part of the test phase as well.

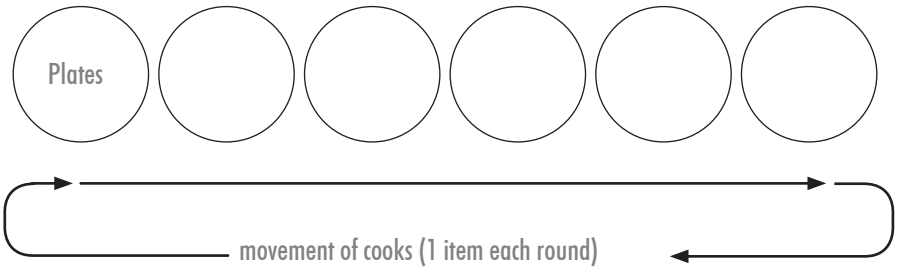


Image 57. Plating layout single row

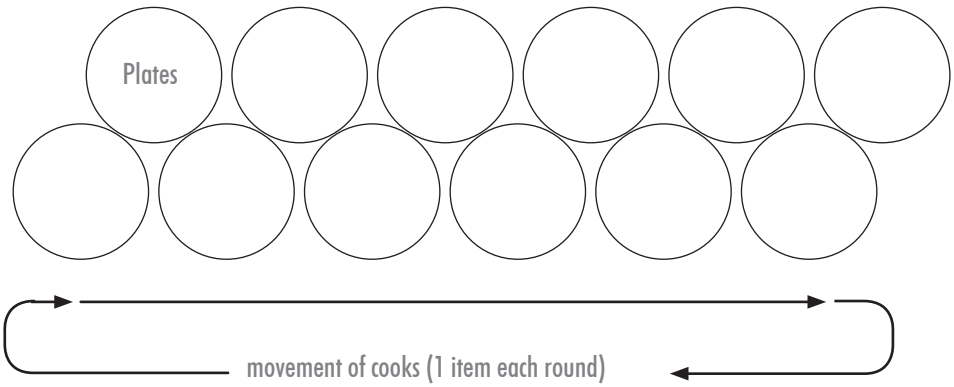


Image 58. Plating layout hexagonal packing

5.7

SUMMARY

Chapter 5. Ideation can be summarised by the following results:

- Underneath plate heating is possible with induction
- The company Schönwald produces a special coating that can be applied to every porcelain item with a glazed bottom surface
- The special coating enables the porcelain to heat from 20 to 50 degrees Celsius within 30 seconds.
- The new heating method should affect starch and vegetable items placed on the heated porcelain
- The new heating method should enable cooks to work in a line
- The new heating method should enable the cooks to place porcelain in a straight horizontal row and enable the hexagonal packing of porcelain.
- Tests should be done on the heat retention of vertically plated dishes
- The new heating method should have the biggest impact on vegetable and starch products. It is important to test the new heating system with these type of products in a later stage.

CHAPTER 6

CONCEPT DESIGN

The concept design phase is the result of the analysis done in the previous chapter. The investigated physics, techniques and workflow are summarised in one product concept.

A prototype is made to test the working mechanisms and to give a set of recommendation that should be developed for the continuation of this project.

The result of the concept design phase is a well-founded concept that can, with additional development, improve ergonomics in the professional kitchen.

6.1

WORKFLOW COOK

Normal, household induction hobs, made for cooking, are used as follows:

1. The induction hob is turned on
2. The cooking vessel is placed on the hob
3. The user sets the applicable heating setting with the digital interface
4. The hob detects the cooking vessel
5. The hob starts heating

The new heating method that is developed in this project is made to be used during service. During service the constant demand of customers require the cooks to run a highly efficient kitchen. The kitchen should be practical and enable this efficiency.

The current situation is shown with image 59.
A hot stack of plates is taken out of the plate heating cabinet and placed on the long work bench that is heated with heat lamps.

The porcelain induction hob should be used with the following steps:

1. Induction hob is turned on at the start of the service
2. A cook places the porcelain item on the hob
3. The hob turns on and heats the porcelain item to 50 °C and keeps it at this temperature
4. When the porcelain item is removed the hob stops heating

No digital interface is part of the porcelain induction hob (PIH). The hob should simply be turned on and work.

Image 60 shows interaction of a cook with the PIH.

Image 59. Plate heating cabinet (top), Plating by cooks

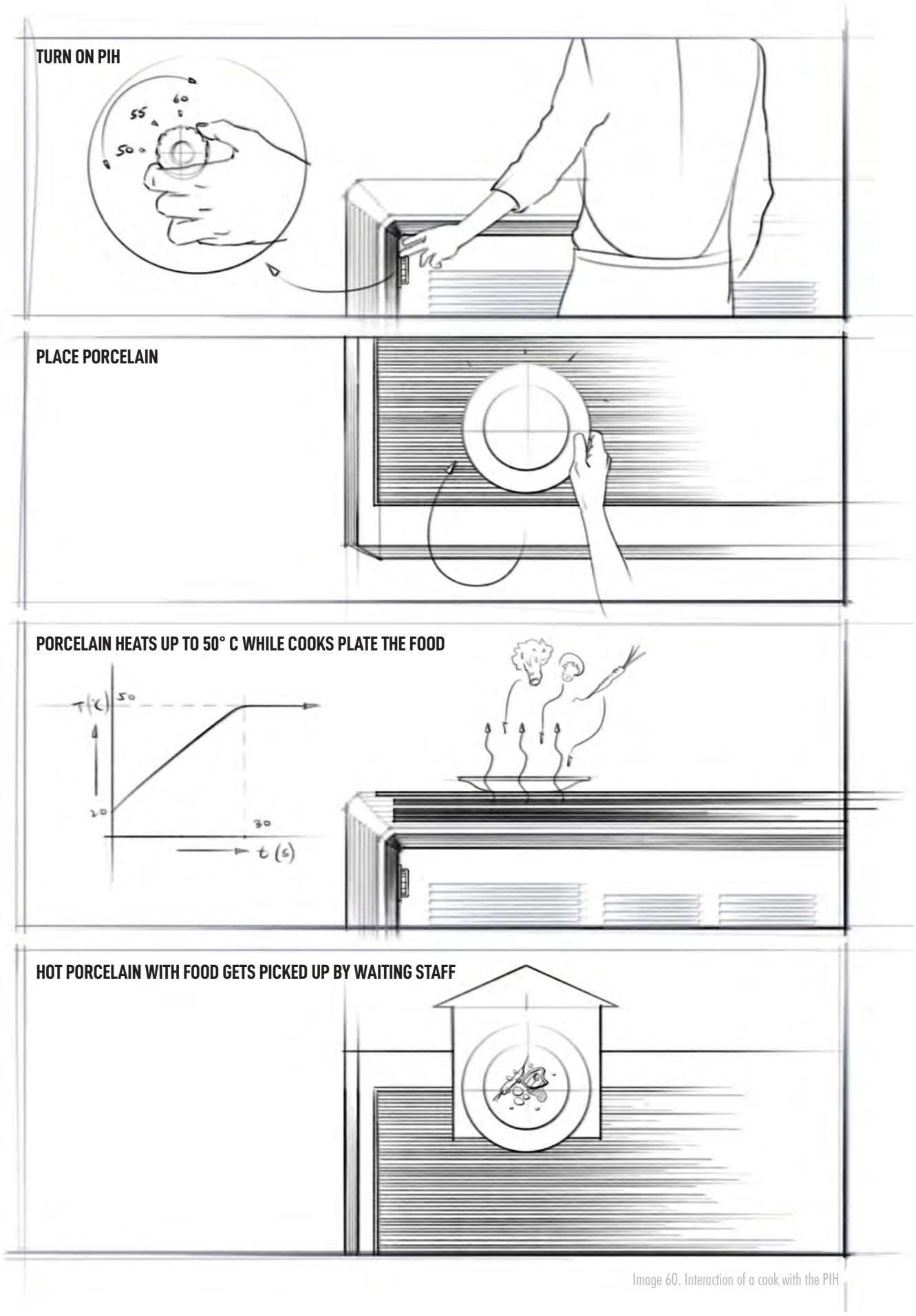


Image 60. Interaction of a cook with the PIH

6.2

WORKFLOW SYSTEM

The workflow of the system should closely match the working method of the cooks. Cooks take a number of porcelain items and place them on the PIH. Automatically, the hob should heat each item to 50 degrees Celsius and sustain this temperature until the item is removed.

Image 61 show the flowchart of the electronic system.

To operate according to this flowchart the electronic system consists of a porcelain detecting system and a temperature sensor at each coil.

This project incorporates the development of the detecting system and shows how it could be optimised. The temperature control system is not developed in this project. However, existing induction hobs have temperature control features which shows that it is an existing technique. Next sub chapter will explain the idea behind the temperature control system.

6.2.1 TEMPERATURE CONTROL

The centre part of each coil in the induction hob is open. In this open centre a temperature sensor is placed in a rubber housing. This rubber housing will press the temperature sensor to the covering surface of the PIH. The temperature sensor is coated with a thermal paste to conduct heat better.

The porcelain is placed on the hob and starts to heat. The heat generated in this porcelain will partly transfer to the covering surface of the PIH. This covering surface in turn transfers heat to the temperature sensor placed closely underneath.

The temperature of the porcelain at one moment in time will not be equal to the temperature measured with the sensor at the same moment in time due to the transfer time of the heat.
However, it is possible to calibrate this difference. For example, assume the temperature of the porcelain is 50°C. The sensor measures a temperature of 30°C at the same moment. This difference of 20°C can be calibrated with software so that when the sensor measures 30°C it knows that actually the porcelain temperature is 50°C.

This working principle is an estimation and therefore the temperature control system is one of the systems that still needs to be developed and tested.

Next chapter shows the coil layout and the basic architecture that the system needs.

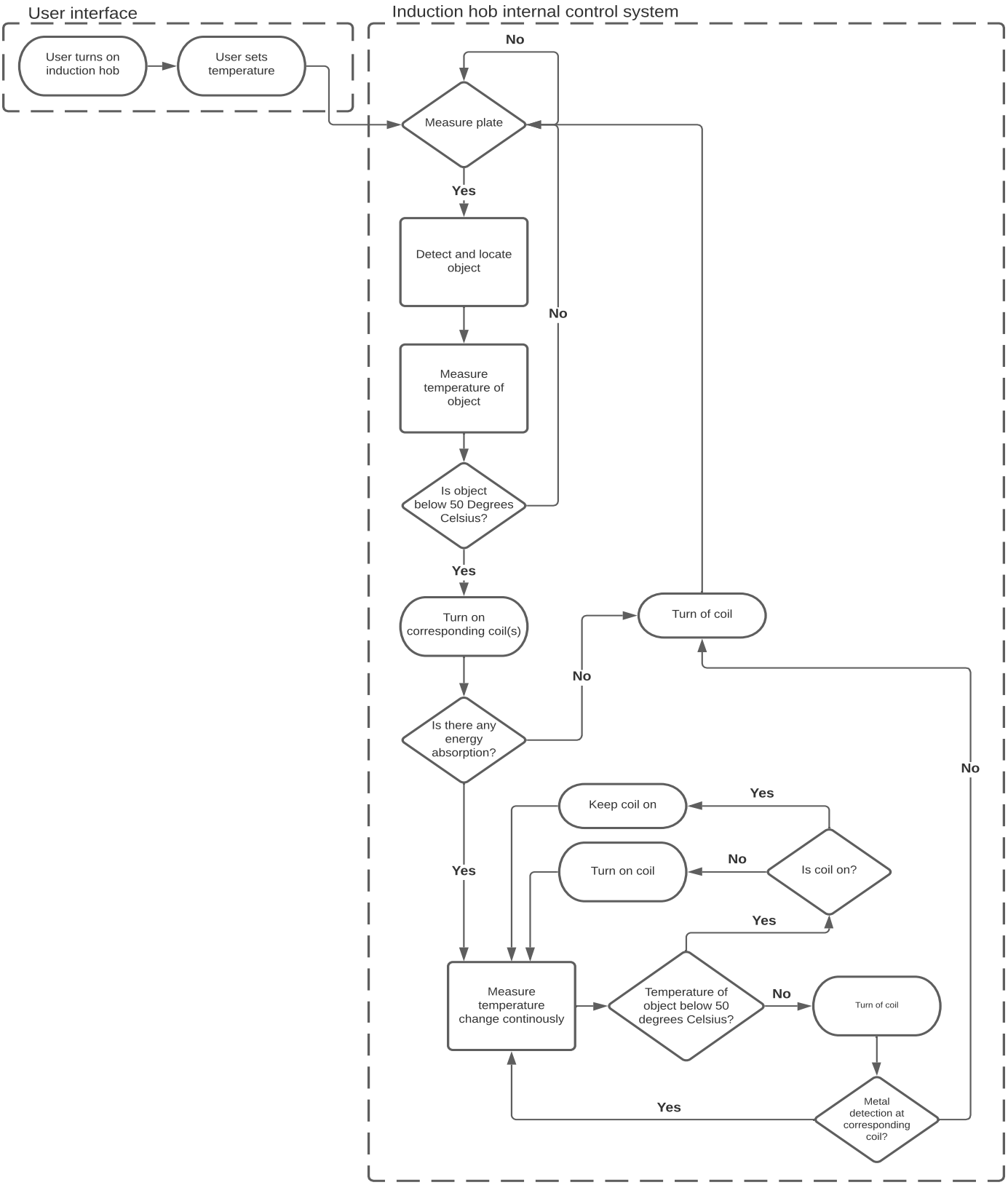


Image 61. Flowchart of the PIH

6.3

HOB DESIGN

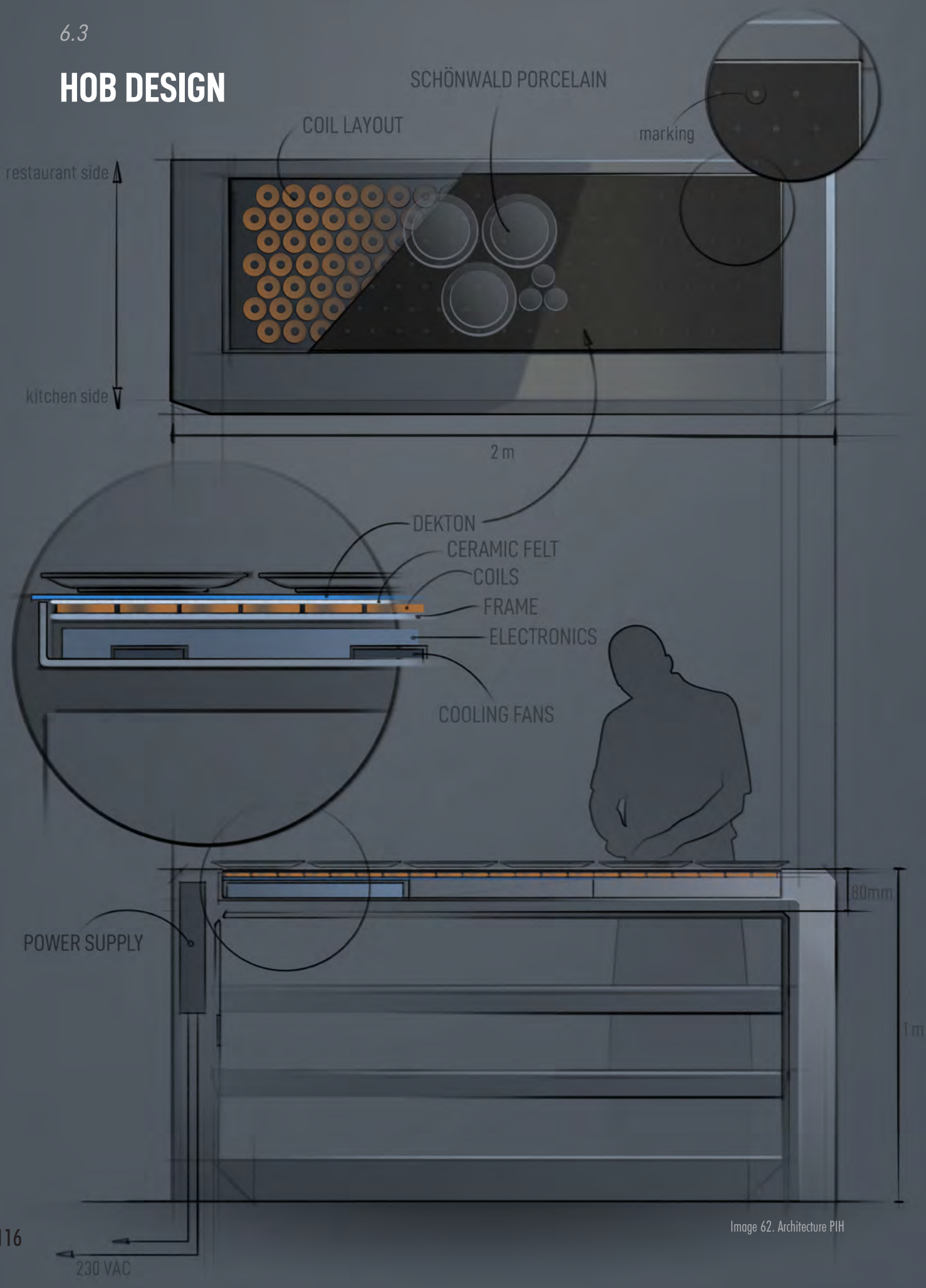


Image 62. Architecture PIH

6.3.1 COIL LAYOUT

Image 62 shows a front and top view of the suggested architecture of the PIH. The coils, shown in orange, are small and placed close to each other to give a full active heating surface. There are some brands that have an similar coil layout like Gaggenau and Thermador. See image 63. This coil layout offers the possibility to place a porcelain item, of any size equal or larger than the dimension of one coil, everywhere on the PIH.

6.3.2 ELECTRONICS

The actual electric components needed for the PIH are explained in the next chapter. The front view of image 62 shows a suggested architecture of the components.
Based on household induction hobs that can have a thickness of 60 mm (for a 1000W induction hob), it is assumed that it is possible to fit the PIH into a workbench thickness of 80 mm. Qook! uses a thickness of 80 mm on all their workbenches.

The top layer will consists of Dekton, a stone-like material, followed by a layer of ceramic felt that acts as an insulator.

The coils are placed underneath the ceramic felt on an aluminium frame. These coils and the sensors with it are connected to the electronic components underneath the coils. Within this electronic layer radial ventilators will cool the coils as well as the electronic components.

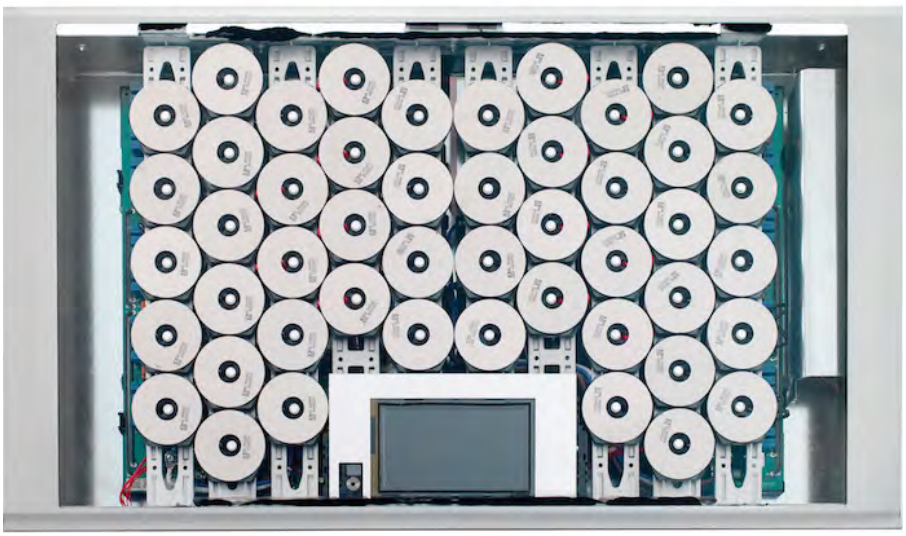


Image 63. Thermador coil lay out

6.4

ELECTRONICS

To validate the working principle of the PIH, parts of the required electronic system are developed. The electronic flow chart mentions a porcelain detection system and a temperature sensor. This project only includes the porcelain detection system.

6.4.1 PORCELAIN DETECTION

The porcelain detection system differs from conventional induction hobs due to the functionality of the PIH. Where a conventional hob is only active when used, the PIH is active for the full duration of the service. This can take up to 5 hours. Therefore, a low power detection system is designed together with the company M91200. This detection system is illustrated in image 64.

Simply put, this electronic system sends out a low power high frequency current to the coil and measures the in- and output of the coil. With no porcelain item above the coil there is no power absorption and no measurable difference between the in- and output. When there is a porcelain item on the coil, the low power current is partly absorbed by the porcelain and therefore a difference between in- and output is measurable.

Only if a porcelain item covers the coil for about 80% of its surface, the system sends a signal to the heating mechanism. This threshold value can be adjusted for the best functionality.

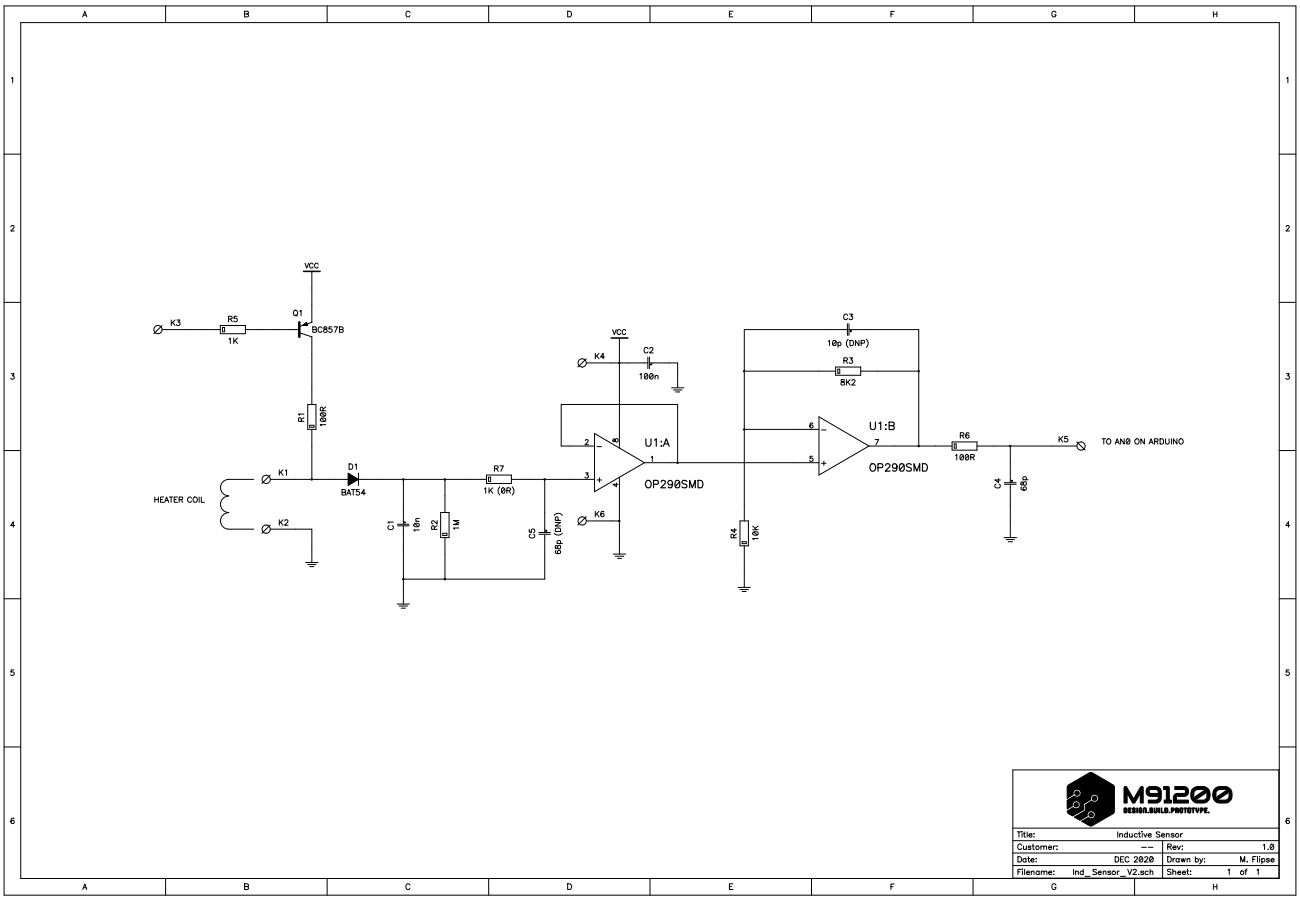


Image 64. Porcelain detecting circuit

6.4.2 COMPONENTS

The working mechanism of an induction hob can be simplified by the following steps.

1. 230V AC (alternating current) goes into the induction hob.
2. The 230V AC is converted to DC (direct current). Each coil needs a certain amount of power which is controlled by this DC converter.
3. The DC is fed to a half bridge circuit (see image 65) that converts the direct current to an AC with a high frequency. This frequency is dependent on the capacitor - inductor combination (LC combination).
4. The high frequency alternating current is fed to the induction coil which converts the high frequency alternating current to a high frequency alternating electromagnetic field.
5. The applicable object placed above this induction coil heats due to the Eddy current and Hysteresis.

This working mechanism needs the following components:

> AC - DC converter
> Half Bridge circuit
> Induction coil
> Control system

6.4.3 LC COMBINATION

Each coil will be equipped with its own Half Bridge circuit. This circuit converts the DC input to a high frequency AC output. The frequency is dependent on the LC combination.

The LC combination can be calculated by the following formula:

$$f = \frac{1}{2\prod\sqrt{L \cdot C}}$$

This formula describes the frequency (f) that is dependent on the inductor (L) and the capacitor (C). The coil design, described on page 120, gives a inductance L of 2,87 μH. The optimal frequency for the porcelain to heat up is between 18 and 24 kHz. The lower the frequency the smaller the Skin Effect and therefore a frequency of 18 kHz is desirable. With the frequency and inductance set, a capacitance of 27,3 μF is calculated.

This LC combination in the Half Bridge circuit of image 65 gives the required frequency to heat the porcelain.

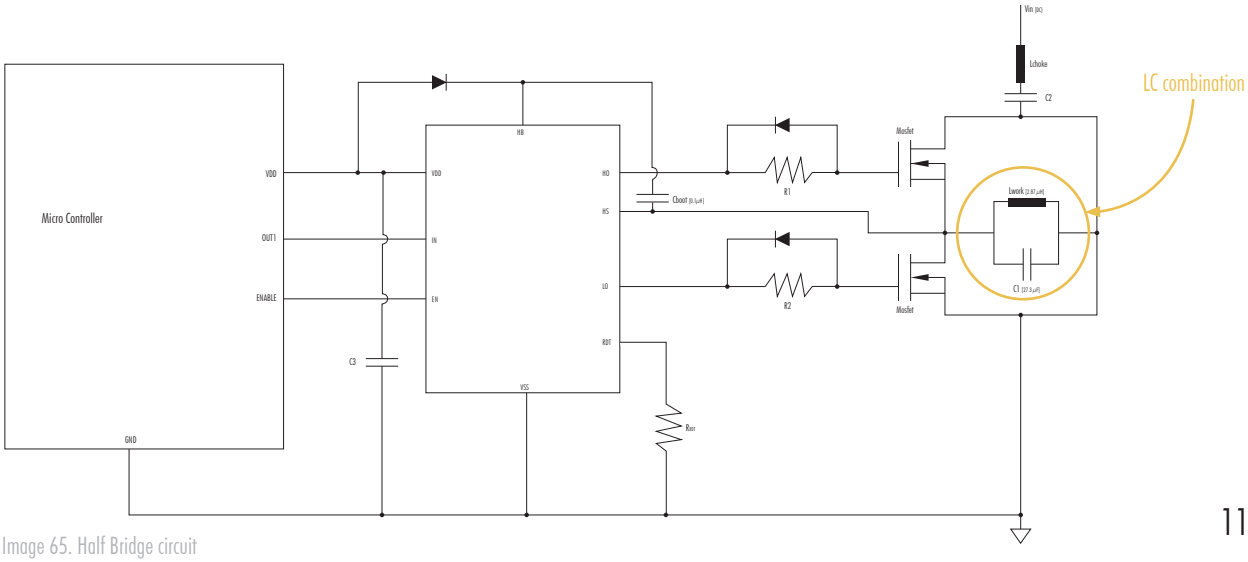


Image 65. Half Bridge circuit

6.4.4 COIL DESIGN

The coil, designed for the PIH, consists of 5 parts. Image 66 shows an exploded view with part names. The coil itself is made from 60 strands of lacquered copper wire with a diameter of 0,1 mm, giving a final diameter of 1,8 mm. Each strand is insulated by lacquer to reduce heat production due to the Skin Effect.

This wire bundle, also called Litze wire, is then pressed into the coil holder made of a high temperature resistant plastic. For example glass reinforced polycarbonate.

With a hot metal stamp the plastic is deformed and the Litze wire is secured in the coil holder.

The coil made of this Litze wire, in this shape and dimension gives an inductance of approximately 2,87 μH.

The centre of the coil holder holds the rubber temperature sensor housing that presses onto the bottom surface of the Dekton.

From underneath, the coil holder holds five ferrite blocks that absorb the electromagnetic field going downwards.

The thin mica sheet, that is clamped in, holds the ferrite and acts as insulator.

The coils will be secured to an aluminum frame with bolts.

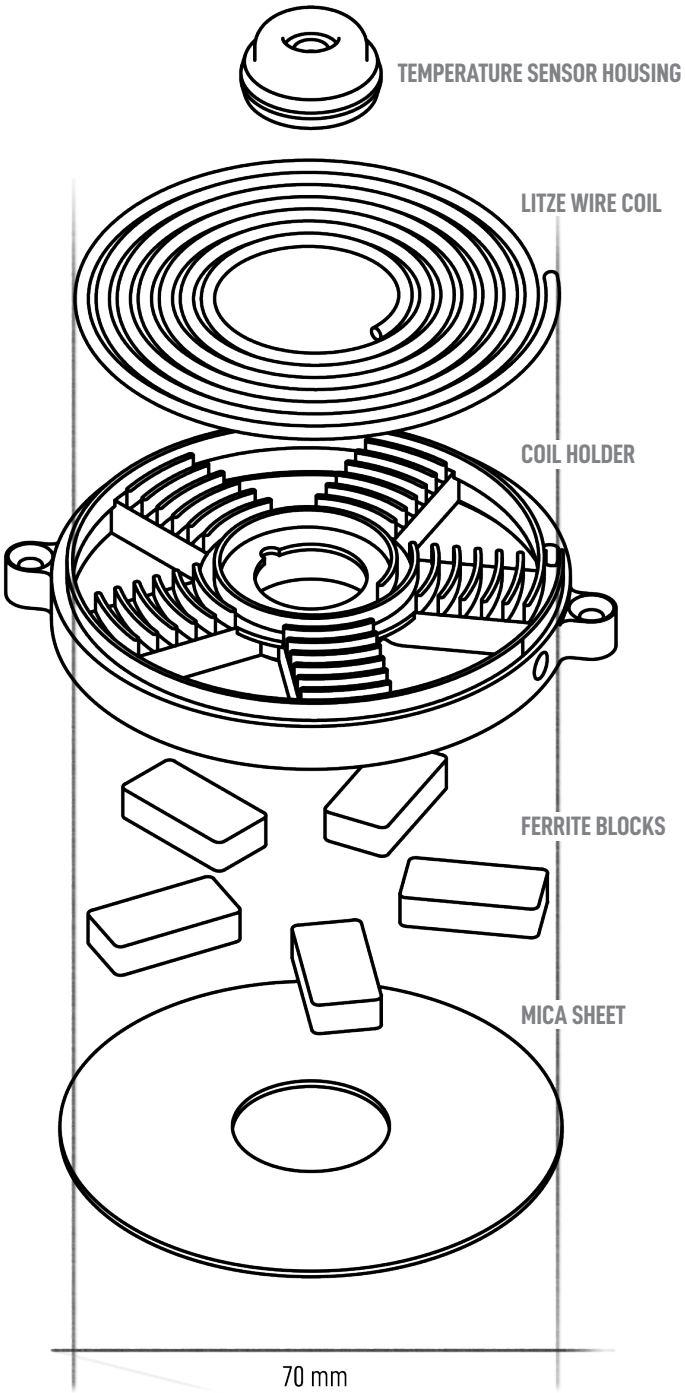


Image 66. Coil design

6.5

PROTOTYPING

This chapter presents the prototyping done throughout the concept phase. This project uses prototyping as a design tool. This Design-by-Doing approach is considered valuable.

Although prototypes are made throughout the project the final prototype is explained in this chapter.

6.5.1 GOAL

The final prototype is built as proof of concept and answers the following questions:

- Can coils with an outer diameter of 70 mm give enough inductance to heat porcelain items from 20°C to 50°C within 30 seconds?
- What power is needed per coil to achieve this heating time?
- What amount of capacitance is needed to achieve a frequency of 18kHz?
- Can the detecting mechanism detect through the covering surface of the hob?
- Do the designed coils keep a temperature below 80°C for the heating period of a porcelain plate?

6.5.2 PROCESS

The most critical aspect of the PIH is the coil design. Multiple iterations were made to achieve a coil with the right dimensions and inductance value. Image 67 to 69 show the process of making and testing the coils.

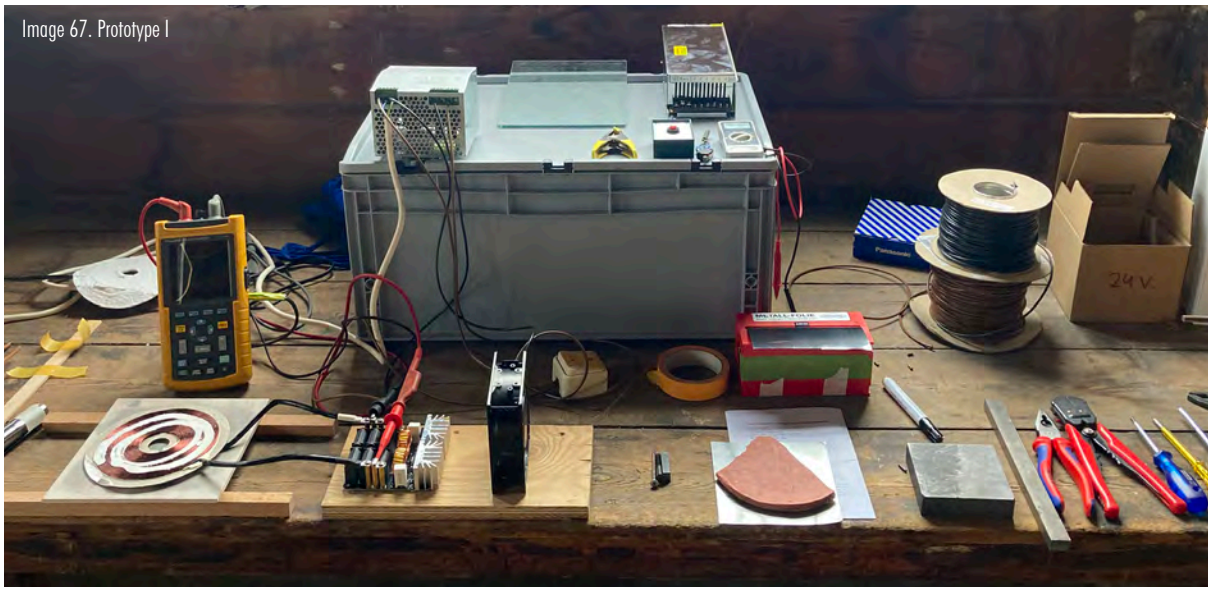


Image 67. Prototype I

Prototyping started with testing different coils to get an understanding of the working principle. Taking apart induction hobs and studying the components gave insights that are used for the development of the coils.

The top image shows the test setup.

The image to the right shows the fabrication of the Litze wire.

The images on the bottom show the first prototype of the coil and the test performed with it. This coil configuration did not heat effectively.

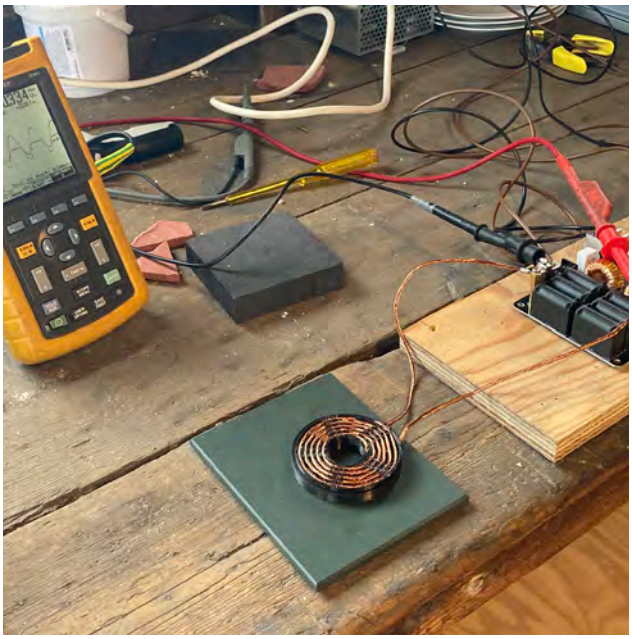
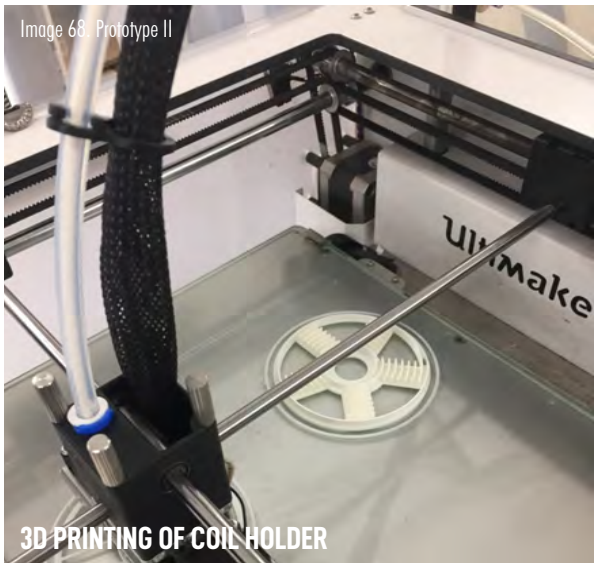
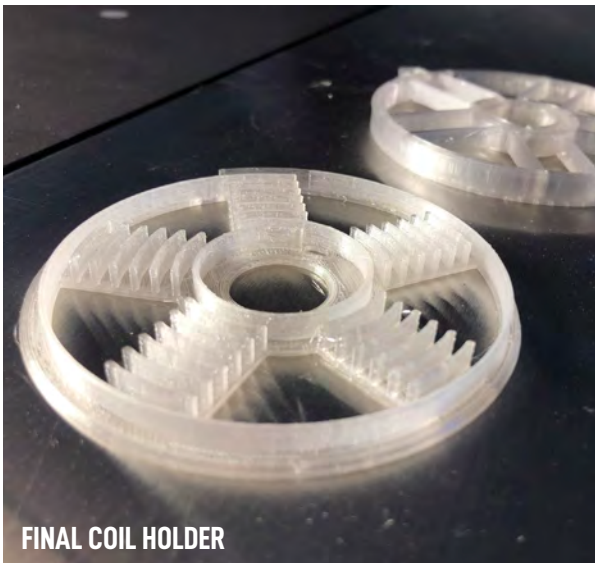


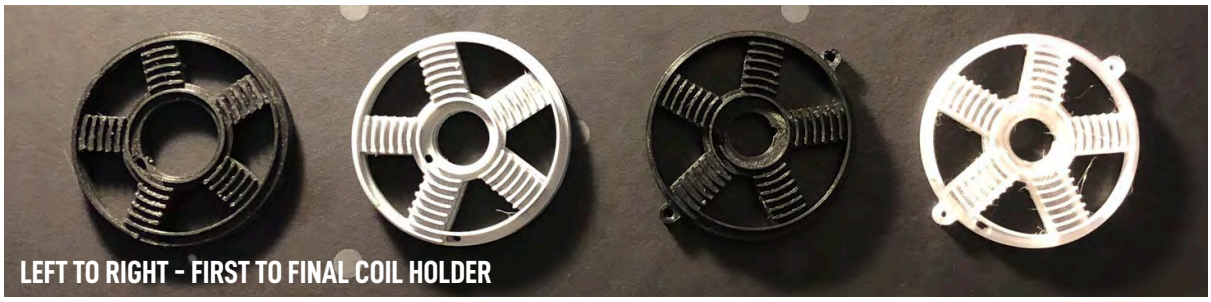
Image 68: Prototype II



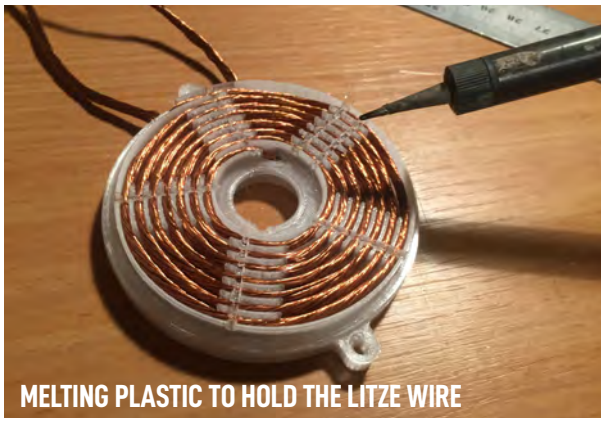
3D PRINTING OF COIL HOLDER



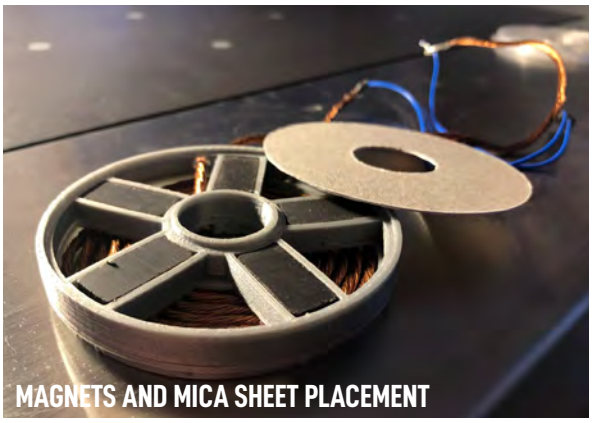
FINAL COIL HOLDER



LEFT TO RIGHT - FIRST TO FINAL COIL HOLDER



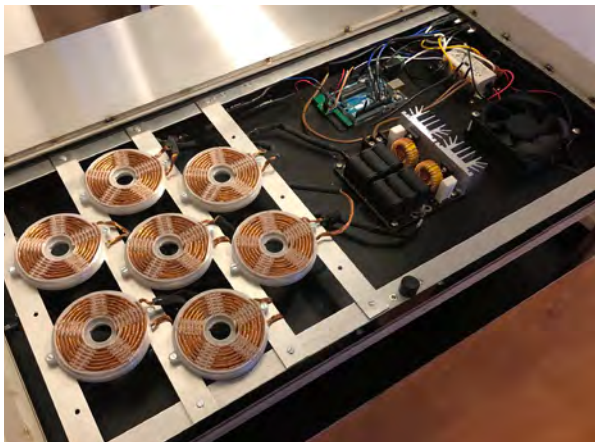
MELTING PLASTIC TO HOLD THE LITZE WIRE

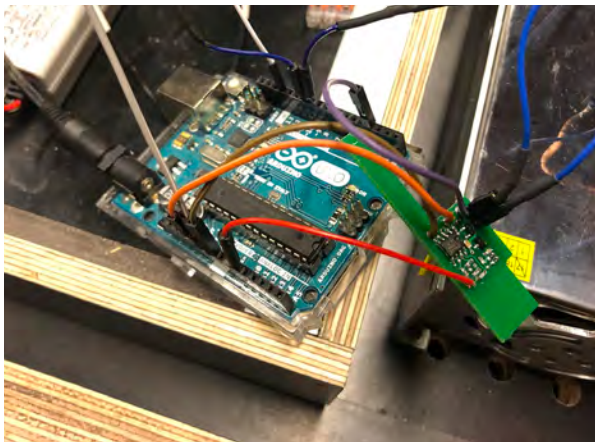


MAGNETS AND MICA SHEET PLACEMENT

TEST SETUP WITH A CLOSE COIL PLACEMENT

Image 69. Prototype III

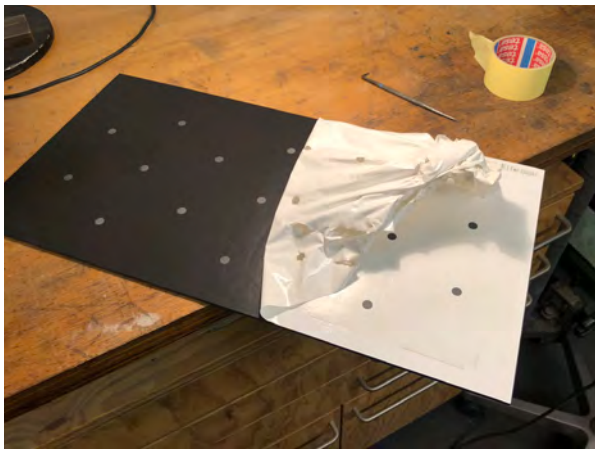


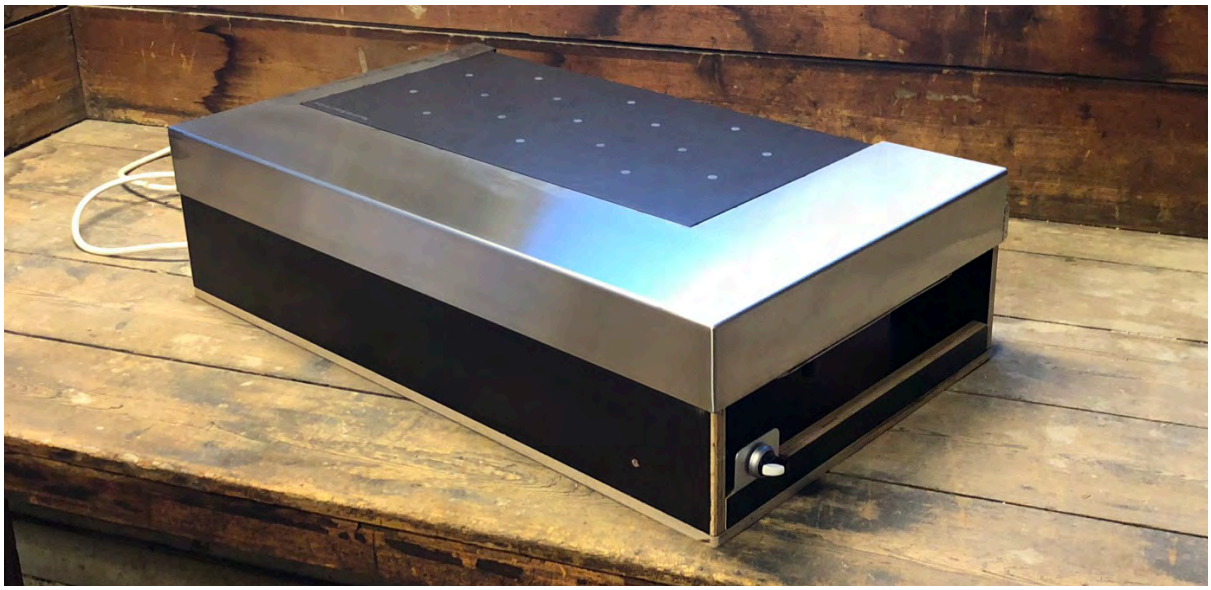


This page shows pictures of the final prototype with wooden frame. The two top images show the wooden frame (left) and electronics. The image left shows an Arduino with the PCB that detects the porcelain.

The images below show the wooden frame that holds the final stainless steel cover and the covering surface made of Dekton.

This embodiment shows how the final product could look like and it gives a sense of dimension and feel.





6.5.3 RESULTS

The prototyping phase, shown in previous pictures, resulted in a proof of concept and gave a list of recommendations that are described in the next sub chapter.

Most of the prototyping time is spent on the coil fabrication. The seven coils, attached to a frame, and connected to a Half Bridge circuit work sufficiently and the performance is tested. Image 70 shows a graph of the heating time with one, five, six and seven coils connected. As the coils are connected in series the power is divided by the amount of coils. A power source of 400W is used in the tests.

The graph shows that with 80W per coil a heating time of less than 30 seconds is needed to heat the porcelain from 10 °C to 50°C. If measuring from 20 °C, a coil, powered with 66,7W, can heat the porcelain within 30 seconds.

Moreover, measuring frequency of the coils connected to the Half Bridge circuit, with a capacitance of 2 μF, showed that the LC formula gives a close estimation of the actual frequency. A capacitance of 27,3 μF is therefore believed to be suitable with the coil design of this project.

Another interesting result was the coil placement. The first tested setup showed a distorted heat pattern with the IF (infrared) camera. It seems that with a close coil placement the coils interfere. Moving the coils further apart gives a more homogeneous heat pattern. See image 71.

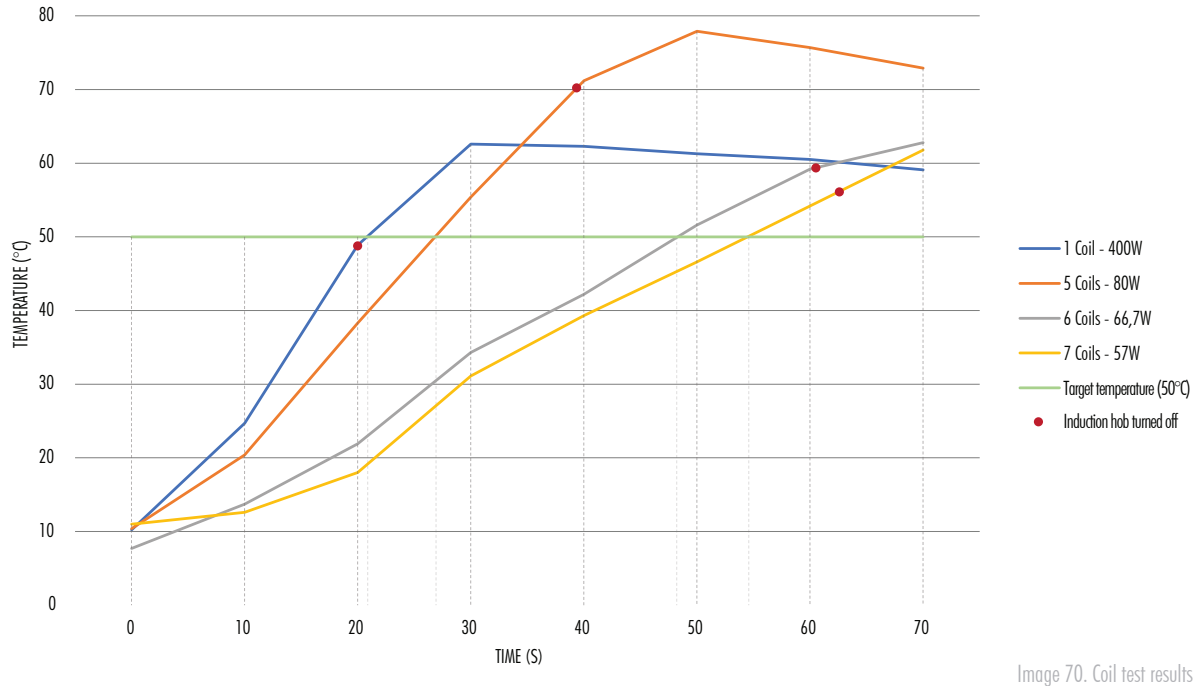


Image 70. Coil test results

This could be caused by the connection to the Half Bridge circuit. Preferably, each coil is connected to its own Half Bridge circuit. However, in the case of the prototype, the coils are connected in series to the same Half Bridge circuit. Therefore, each coil switches the same electromagnetic poles at the same time. This might influence the performance.

The porcelain detection system proved to be functional. With the sensitivity set to the right threshold value the detecting system works well. In the prototype, one coil is used as detecting system and cannot heat. However, based on the advice of the company M91200, intelligent coding and electronics can make it possible to detect and heat alternately.

The temperature of the coils does not rise above 35°C while heating a porcelain item to 50°C. However, in only 30 seconds there is a temperature rise of 20 °C.

6.5.4 RECOMMENDATIONS

The recommendations in this chapter are based on the results generated by testing the prototype.

The coil, designed in the project, works well. The inductance value is high enough. However, improvements are possible.

1. The coils should be optimised so that less heat is generated within the coils itself. This might be possible by taking a Litze wire consisting of more or bigger lacquered copper strands.
2. Secondly, the coil placement should be optimised. The desired heating profile can be obtained when the coils are placed as closely to each other as possible and do not interfere. This means that the powering should be changed and improved in a way that the coils work without interference.
3. Each coil should be equipped with its own detecting mechanism. To enable heating and detecting alternately smart coding and electronics are required.

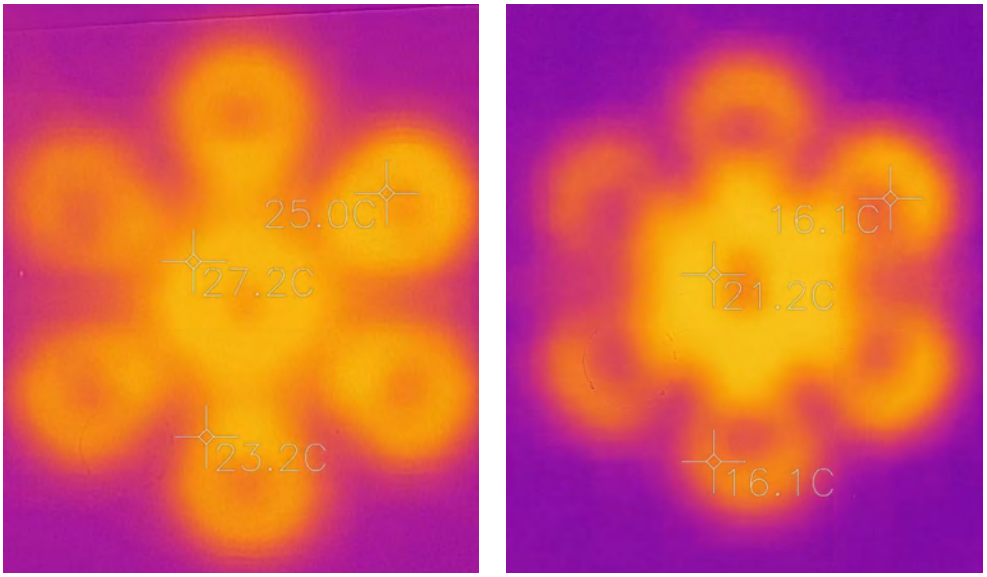


Image 71. IF Heating pattern

6.6

SUMMARY

This chapter, Concept Design, lays the foundation for a product that can improve the pass with a new heating method for porcelain.
It provides a proof of concept and shows the principles that are developed, that still need to be developed and the principles that need optimisation.

To conclude, this chapter shows that with more development and with the right expertise this concept can become a professional kitchen product which improves ergonomics.

Next chapter describes recommendations for further development of the product. It includes suggestions for the aesthetic part of the product as well as the functional components.

CHAPTER 7

RECOMMENDATIONS

Developing a concept and building a prototype in the previous chapter resulted in insights and recommendations needed for further development of this product concept.

This chapter gives recommendations concerning (7.1) aesthetics and (7.2) future development.

7.1

AESTHETICS

This Aesthetics chapter gives design suggestions with drawn illustrations. The design should evoke class and robustness which is a result of the analysis in chapter 2.1.3.4.

The drawings show the suggested architecture, embodiment and design details. These suggestions can be used by Qook! but are in no way bound to the functionality of the product. Only the electronics and markings on the covering surface are crucial for the functionality.

7.1.1 ARCHITECTURE

Image 72 shows the suggested architecture of the PIH. This architecture is also shown in previous chapter 6.3.

As most of the electronic components still need to be developed or optimised this is a suggestion. This suggestion is based on current household induction hobs, the prototype and the needed functionality.

Additionally, the top view of the PIH shows that there is a kitchen side and a restaurant side. The kitchen side has more space in front of the PIH. This space is needed to place pots and pans while plating. It also facilitates a quick and easy take away of plates by waiters.

7.1.2 OUTER EMBODIMENT

Another suggestion made in this architecture drawing is the use of the material Dekton.

DEKTON

Dekton is an extremely hard and durable material made of glass, porcelain and quartz. It is resistant to high temperatures, resistant to stains and scratches and a good cover of the induction coils since it does not contain any conductive materials. This material is selected instead of glass to give the product a distinctively different look than traditional induction hobs. Dekton is available in many different surface treatments and prints and therefore offers a highly customizable look. It additionally can be marked by sand blasting as is done for the prototype.

The marking, consisting of dots, suggested by the prototype and drawing, shows the centre of each coil. The cooks can roughly place a porcelain item on a dot to ensure a good heat transfer.

STAINLESS STEEL

The second material suggested for the outer embodiment is stainless steel type 304. This is a well know material for Qook! and the standard in the restaurant industry. All surfaces, apart from the Dekton cover, are made of stainless steel.

The Dekton surface is placed onto a stainless steel rim and glued to the steel with heat resistant and flexible black sealant, making the top surface water tight. This sealant is already used by Qook! on the conventional induction hobs.

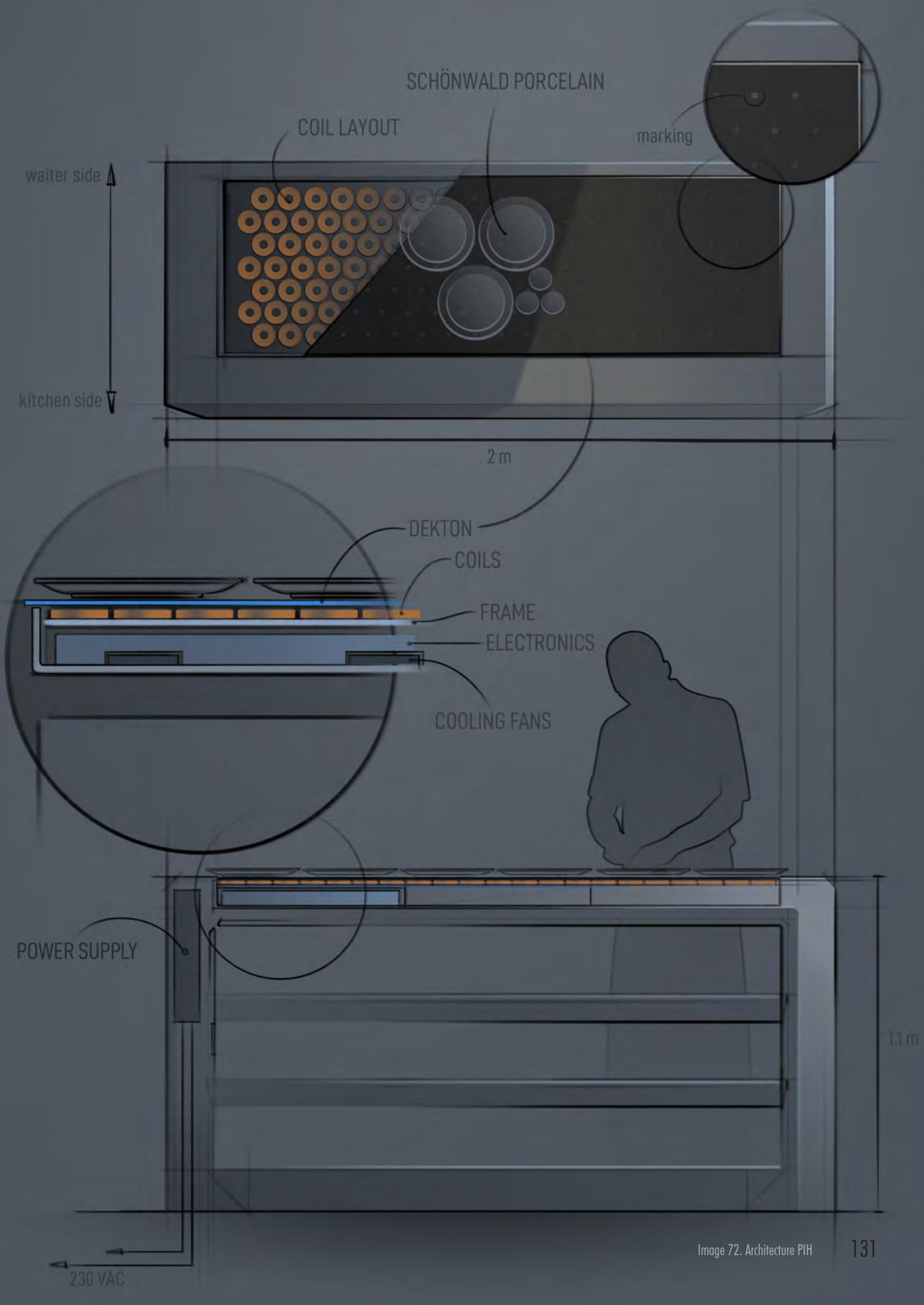


Image 72. Architecture PIH

The PIH is embedded into the stainless steal workbench of the pass. The PIH fits in the 80 mm thickness of the workbench as this is a standard in current workbenches of Qook!.

With new shape transitions and corner design the workbench has a distinctive look and should evoke robustness and class.

The workbench drawing below shows no shelves to give the suggestion that this space, now empty due to the new heating system, can have a new function and layout. It can just have shelves, other new systems for easy porcelain grabbing or new ergonomic improving features.

Image 74 shows design details and suggestions for the further development of the pass with the new heating system.

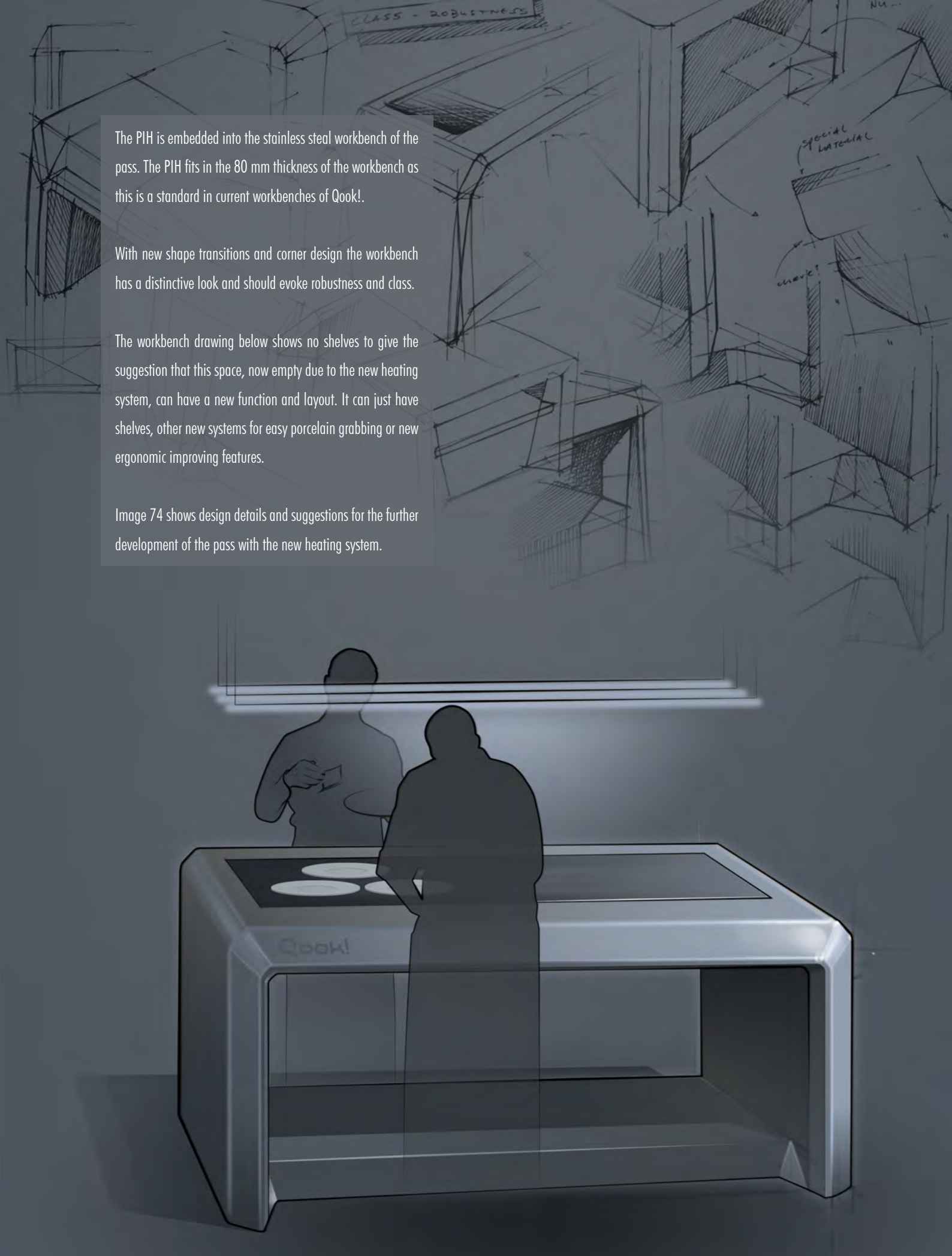


Image 73. Workbench design

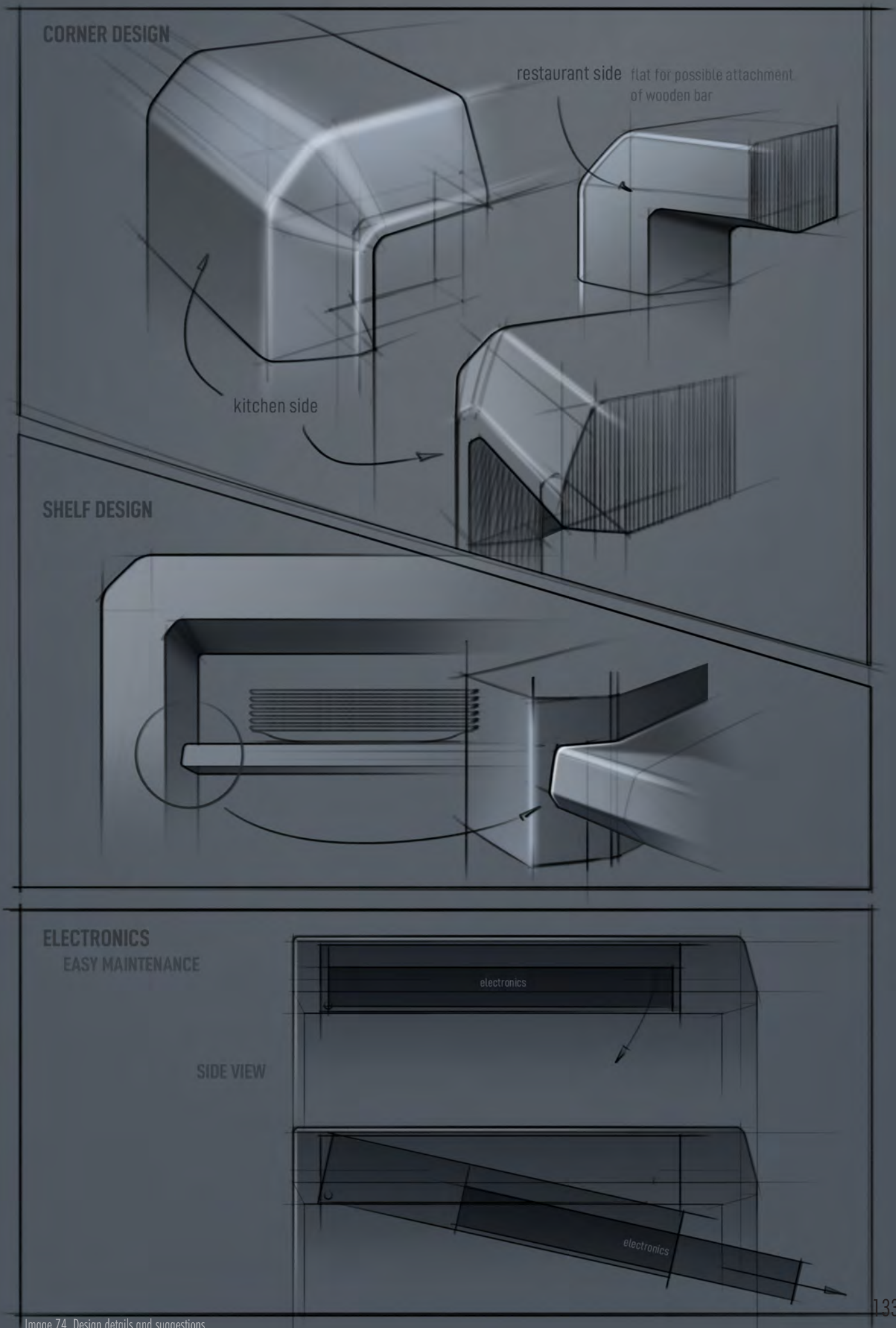


Image 74. Design details and suggestions

7.2

FUTURE DEVELOPMENT

This chapter gives recommendations concerning the functionality of the PIH. These recommendations are based on the built prototype and research which enabled building the prototype. These recommendations can be used as future steps to develop the PIH into a fully functional product.

7.2.1 TEMPERATURE CONTROL

The first future step is temperature control. A well functioning temperature control system is crucial for the envisioned functionality of the PIH.
As mentioned in chapter 6.2, a temperature sensor is placed in the centre of each coil and pressed to the Dekton covering surface. Tests should be done to get information regarding the heat transfer of the porcelain to the Dekton to the sensor. In the same duration that the porcelain is heated to 50 degrees Celsius the temperature sensor should have a measurable change in temperature.

Additonally, it will happen that already warm plates, due to the dishwasher, will be placed on the PIH. The danger with an already warm plate on the PIH is that it might heat up to a temperature above 50 degrees Celsius.

If a temperature sensor placed underneath the Dekton covering surface does not perform well, an alternative can be an infrared temperature sensing technology.

7.2.2 COIL ARRANGEMENT

Testing the coil layout gave the insight that multiple coils, connected in series to one Half Bridge circuit, give interference and therefore result in a poor heat pattern. The use of small coils, in a close arrangement, is a developed technology.
As it is an existing solution, the coil arrangement should be optimised with the help of an induction heating specialist.

7.2.3 COIL DESIGN

The coils heat up due to the Eddy Current. Although it is not a drastic temperature rise the coils should be optimised to stay cool, as the PIH will be used frequently for over five hours.

Another important part of the coil design are the ferrite block which ensure a one-directional electromagnetic field. As the coil is designed in such a way that no materials are glued or permanently bonded, it is advised to find a sustainable alternative of the ferrite blocks. The ferrite blocks are a composite of iron oxide and metal and can cause a negative environmental impact.

7.2.4 ELECTRONICS

Chapter 6.4 gives a suggestion on the electronic circuit and components needed for the PIH. Any further development of the electronics of the PIH should involve specialists in induction heating and electromechanics.

These specialists should optimize and build a fully functional prototype that can be tested in real life situations with cooks.

7.2.5 EMBODIMENT

The embodiment should be developed around the final electronic components needed for the PIH. This can be done by Qook!. It is advised to find a good solution for an easy access of the PIH for maintenance and placement.

7.2.6 SAFETY

Safety and regulations are important in the catering industry. All equipment used in the kitchen should be in line with these regulations and the PIH is no different. Therefore, some of the expected difficulties concerning safety are explained in the next alineas. Within the future development of the PIH these safety concerns should be taken into account.

7.2.6.1 ELECTROMAGNETIC FIELD

Induction heating works with an alternating electromagnetic field. When cooks are plating they move close to the porcelain in order to precisely place food elements. Most of the electromagnetic field is absorbed by the porcelain coating but it can happen that a porcelain item does not fully cover an induction coil while the coil emits a magnetic field. It is recommended to research the health effects of electromagnetic fields on humans.

7.2.6.2 UTENSILS

Multiple types of utensils are used during plating at the pass. The PIH needs implemented safety features so that these utensils cannot become hot.

7.2.6.3 PORCELAIN DESIGN

The specially coated porcelain used in combination with the PIH should specifically be designed for this purpose. A large coating surface underneath the porcelain with a shape that ensures full contact with the PIH improves the efficiency of the new heating system. A recommended safety feature that can be implemented with this porcelain is a non-coated area which the waiters can easily grab, without the risk of burns.

CHAPTER 8

DISCUSSION

Chapter 8 reviews this graduation project on a project level (8.1) and on a personal level (8.2).

It refers to the first chapter and gives new personal goals that I want to develop in my future as an industrial designer.

8.1

PROJECT EVALUATION

This graduation project is the most interesting and educational project done so far as an industrial design student. It concludes my time as a student and provides the basis for the start of my professional career.

The faculty of Industrial Design Engineering provides a set of rules that guides the student on a 20 week graduation project. This free topic graduation project did not fit these set of rules. The project did not start as a traditional IPD project and needed more time than the set 20 weeks. As the developed method is new, it is difficult to predict the challenges and problems that lie ahead. Therefore, it is difficult to create a specific planning.
A 20 week graduation project might work with a well defined project, however due to the open start and my personal desire to develop a working concept, I did not finish in the 20 weeks.

It did bring a lot of educational and personal gain. I became knowledgeable in fields I did not expect or desire to learn about. It showed the power of expertise and different perspectives. And it demonstrated that with the right contacts and the right motivation people genuinely want to help. For that I am grateful.

This graduation project also offered the opportunity to gain knowledge of a well functioning production company. It showed a very practical and quick working method that does not have similarities with the working method taught at the faculty of Industrial Design Engineering.

PROJECT GOAL

IMPROVING ERGONOMICS IN THE PROFESSIONAL KITCHEN

My graduation project started with this project goal. Interviewing cooks showed that a healthy work environment does not only depend on a well fitted work environment but also legislations, a good work-life balance and personal care.

Ergonomic improvements can lead to a higher efficiency, and if the product concept developed in this graduation project can have an attractive price it might encourage restaurant owners to invest in such a new product. For middle and high segmented fine dining restaurants the new porcelain heating method can be an ergonomic improvement. Moreover, the implementation of the PIH will replace the old fashioned plate heating cabinet which is not energy efficient and therefore can lead to a long term benefit.

To obtain some last opinions of cooks some of the previously interviewed participants are asked to react on the PIH. The result is explained on the next page.

VALIDATION COOK

This last validation provides the opinion of cooks on the functionality and use of the PIH. With photos and drawings the functionality and use of the PIH is explained to four cooks on different occasions. The cooks did not use the prototype.

The four cooks react positively. First, they mention that with this innovative system the pass can be improved. It increases freedom of movement, improves plating and it reduces residual heat.

Second, the PIH can be used for the temperature control of food items that are kept at the pass. Therefore, the PIH can serve more than one purpose.

Third, a cook makes a positive remark about the coating. The porcelain only heats where the coating is present and the rim of the porcelain can stay cool. This facilitates easy handling by cooks and waiting staff.

An a negative note, most of the cooks mention the financial side of the PIH and that it might be expensive. This is an aspect that is not covered in this graduation thesis. However, the PIH is meant to replace the current heating systems and give a lower energy consumption.

Although the PIH is meant to replace all heating systems, the majority of the cooks still believe in the necessity of a heat lamp. First, because of the vertical stacking of food on a plate. Second, because of the cold draft generated by the extraction system of the kitchen. The cooks mention that the heat lamp can be placed higher.

8.2

PERSONAL REFLECTION

The professional and personal ambitions set in chapter 1.2 are accomplished in this project. This project provided experience with a new design method; design by prototyping.
The method proved to be a good fit to my own personal skills and interests. The creation of a prototype shows to be more than a development on paper or in words. Additionally, it clears my head and makes space for new ideas and techniques.

The support of a professor, working with a similar method gave motivation and inspiration. I had the luck to spend most of my time at Studio Ninaber. At this studio people are like-minded and the tooling and knowledge available provides many opportunities.

The knowledge shared by Bruno is also something I perceived to be valuable to me as a designer. Bruno, being a industrial designer for many years has a lot of wisdom and knowledge and shows a way of designing that is interesting and enjoyable.

Gianni, my mentor, at the same time, showed valuable professional knowledge as well as a more relaxed approach of my study work and life. He showed me that moments of rest might not seem valuable at first but have a huge impact on your state of mind and motivation. The combination of Bruno and Gianni was gold.

Another valuable lesson learned concerned my personal profile. I have the tendency to work as an individual and not look around for advice or ideas.

Working as an individual showed that I have the determination of deciding on my own without the need of consultation. However, this did not always prove to be the best method.

I noticed that by asking other people, even if they are not specialists I obtained new and different perspectives on the matter. Different points of view that I'd never thought would give me new ideas. I experienced a specialist who could explain a theory in a few hours that by myself would have taken at least a week to figure out.

A future goal is to be more open to the perspective and knowledge others can give. Using knowledge of others can only improve my own design process.

CHAPTER 9

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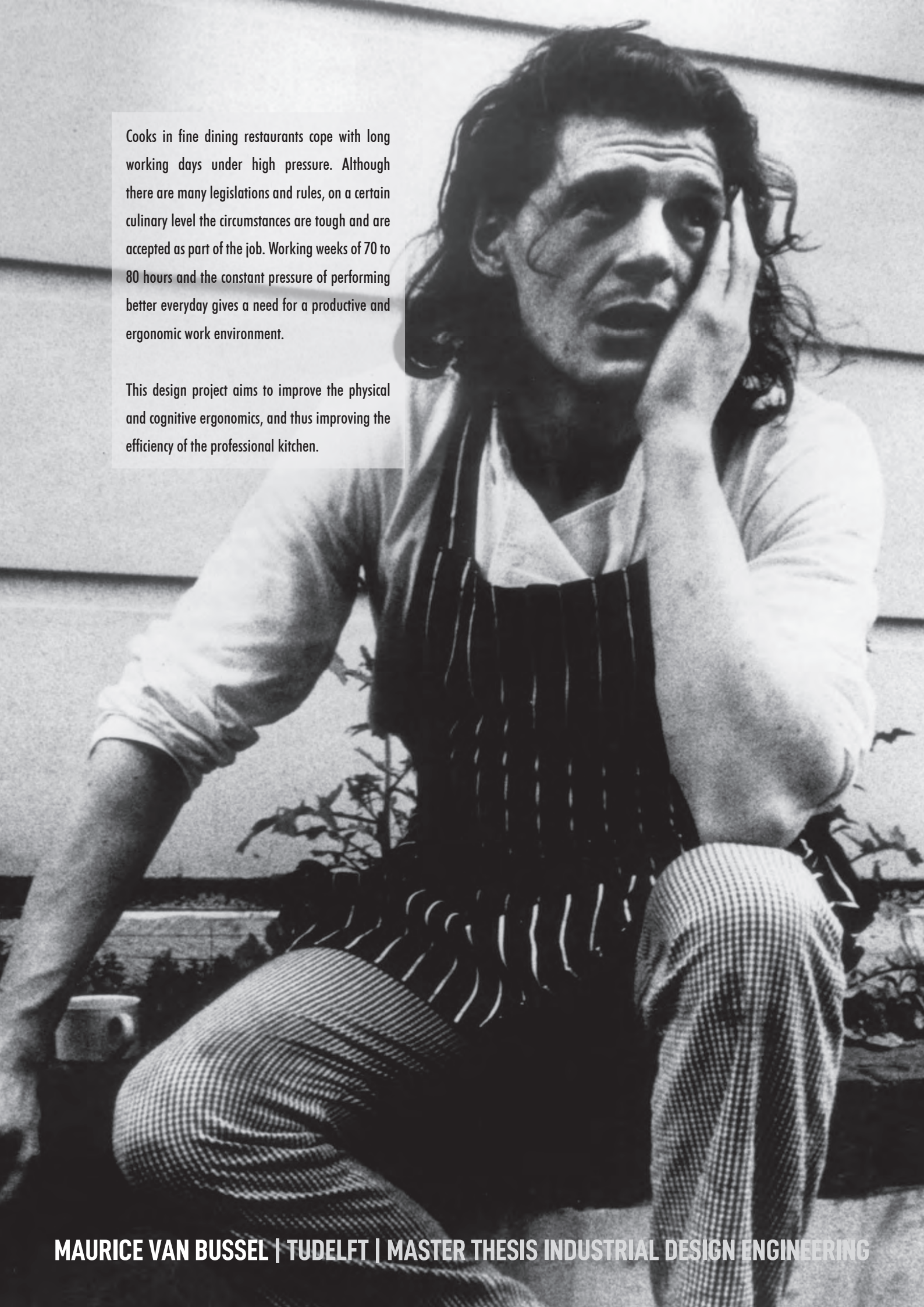

Cooks in fine dining restaurants cope with long working days under high pressure. Although there are many legislations and rules, on a certain culinary level the circumstances are tough and are accepted as part of the job. Working weeks of 70 to 80 hours and the constant pressure of performing better everyday gives a need for a productive and ergonomic work environment.

This design project aims to improve the physical and cognitive ergonomics, and thus improving the efficiency of the professional kitchen.

MAURICE VAN BUSSEL | TUDELFT | MASTER THESIS INDUSTRIAL DESIGN ENGINEERING

CHAPTER 10

APPENDICES

DESIGN FOR our future

TU Delft

IDE Master Graduation

Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT
Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME

Save this form according the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy".
Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 !

family name	van Bussel 4131
initials	M.J.F. given name Maurice
student number	4294610
street & no.	
zipcode & city	
country	the Netherlands
phone	
email	

Your master programme (only select the options that apply to you):

IDE master(s): ★ IPD ○ DfI ○ SPD

2nd non-IDE master:

individual programme: - - (give date of approval)

honours programme: ○ Honours Programme Master

specialisation / annotation: ○ Medisign ○ Tech. in Sustainable Design ○ Entrepeneurship

SUPERVISORY TEAM **

Fill in the required data for the supervisory team members. Please check the instructions on the right !

** chair	Bruno Ninaber	dept. / section:	Design Aesthetics
** mentor	Gianni Orsini	dept. / section:	HCD
2nd mentor	Bas van der Werf		
	organisation: QBTec		
	city: Woerden	country:	the Netherlands

comments (optional)

Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v..

Second mentor only applies in case the assignment is hosted by an external organisation.

Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

Procedural Checks - IDE Master Graduation

APPROVAL PROJECT BRIEF

To be filled in by the chair of the supervisory team.

chair Bruno Ninaber date 28 - 4 - 2020 signature

CHECK STUDY PROGRESS

To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair.
The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total: 31 EC

Of which, taking the conditional requirements into account, can be part of the exam programme 31 EC

List of electives obtained before the third semester without approval of the BoE

★ YES all 1st year master courses passed

NO missing 1st year master courses are:

name J. J. de Bruin, SPA-IO date 30 - 04 - 2020 signature J. J. de Bruin Digitally signed by J. J. de Bruin Date: 2020.04.30 15:07:23 +02'00'

FORMAL APPROVAL GRADUATION PROJECT

To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **.
Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: ★ APPROVED ○ NOT APPROVED

Procedure: ○ APPROVED ★ NOT APPROVED

- the Board of Examiners has yet to decide whether the mentor will be given exam qualification - end date is missing, the Board asks the chair to pay attention to that in the future. - adapt title at the exam application into New standard for professional kitchen

comments

name Monique von Morgen date 11 - 05 - 2020 signature

The new standard for the professional kitchen — project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 04 - 05 - 2020 — 11 - 11 - 2020 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

In this graduation project the ergonomics in professional restaurant kitchens will be addressed with the final goal to deliver an, ergonomic wise, improved kitchen. As the title says, The New Kitchen Standard. This graduation project is done for the company QBTec. QBTec is a Dutch company based in Woerden and is a manufacturer and supplier of professional kitchen interiors and cooking solutions. The subbrand Qook! focuses on the design and manufacturing of complete kitchen interiors (see image 1.). This graduation project will be done for the brand Qook!.

The professional kitchen in this project is described as a restaurant kitchen with a brigade (team) of at least three cooks that make at least 10 hour work days where the preparation, service and plating are part off. The focus in these kitchens should be on food preparation from start to finish.
The project is focused on this specific description to include the full specter of problems that may appear with cooking in a professional atmosphere. Kitchens with less than three cooks and without a start to finish production do not entail the same ergonomic challenges.

Included in this ergonomic challenges are five directions based on the Magazine for ergonomics (Tijdschrift voor Ergonomie, 2012)*.

1. Sensory ergonomics concerns the capabilities and limitations of the sensory system.
2. Physical ergonomics concerns the capabilities and limitations of the human anatomy and physiology in relation to its environment
3. Behavioral ergonomics concerns the motivation of behavior of humans and how this can be influenced
4. Cognitive ergonomics concerns the capabilities and limitations of the mental information processing.
5. Organizational ergonomics concerns the optimization of socio-technical systems. Applicable parts of this system are work design and work systems.

The kitchen tasks and interactions will be plotted within these five ergonomic directions and all have relevancy within the professional kitchen environment.

The work environment of the kitchen is a complex systems which cannot all be improved by a physical product. Regulations and laws are for example another way of improving health in this industry. Delivering a physical product therefore can offer a partly solution but cannot completely improve the ergonomics of the professional kitchen. Furthermore, after the research phase multiple problems and issues will be defined and a selection of these will be used as design directions. The other problems and issues are not addressed in this project but might offer a future opportunity for Qook!.

QBTec, together with Qook!, is a manufacturing company. The R&D department off the company with all its subbrands is equipped with two employees and are mainly developing User Interfaces for the deep frying products. Innovations that are implemented in Qook!'s kitchens are initiated by the client or salesman. The company is focused on production whereas this graduation project is more R&D oriented and in this way can bring insights and innovation to Qook!.

*Ergonomische Elementen. (2012). Tijdschrift

space available for images / figures on next page

introduction (continued): space for images

image / figure 1: Qook! kitchen

image / figure 2: White Heat (1990)

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

Cooks in Michellin starred and fine dining restaurants coop with long working days under high stress. It is an old fashion work environment with a work hard play hard stigma. Although there are many legislations and rules, on a certain culinary level the circumstances are tough and these circumstances are accepted as part of the job. With working weeks of 70 to 80 hours and the constant stress of performing better everyday gives a need of a productive work environment.
With this graduation project the goal is to improve the ergonomics, in the five ergonomic directions mentioned above, and with that improving the productivity of the professional kitchen. By making the work environment (kitchen) a better fit to the worker (cook) it can increase efficiency and reduce illness and dissatisfaction (Dul,2012)*.
According to Dul (2012) productivity is intertwined with well-being and therefore by fitting the work environment to the worker this project can contribute to the productivity as well as the well-being of the workers.

*Dul, J., Bruder, R., Buckle, P., Carayon, P., Falzon, P., Marras, W. S., … Doelen, B. van der. (2012, April 4). A strategy for human factors/ergonomics: developing the discipline and profession. Ergonomics, 55(4), 377–395. doi: 10.1080/00140139.2012.661087

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, … . In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

With this graduation project the work environment of high level restaurants in the culinary industry are observed to define genuine problems and issues. These problems and issues will lay foundation to the new kitchen standard that will be designed. This new standard should show Qook! multiple ergonomic improving solutions that can be implemented in the now designed and produced kitchens.

The product solution that is expected as outcome of this project is a product or series of products that fits Qook!'s portfolio and improve the kitchen ergonomics. Qook!'s portfolio consist of full kitchen interiors that can be from two square meters to more than 50 square meters. Therefore the product, that is a result of this project, is most likely to be of big dimensions. However, this large product will consist of small sub solutions that in itself can be seen as products. Since the final work should fit the portfolio of Qook! the ambition to realize a matching product is there and it is likely to be a combination of product/sub solutions.

A goal of this project is prototyping the final concept with production detailing so that Qook! can implement this new product, or parts of it, effortless. Additionally, this final concept will be used for validation with the end user.

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 4 - 5 - 2020 - - end date

Approach

A professional kitchen environment is -or should be- extremely functional and practical. The aim is to maximize the practicality of the final design by continually prototyping and testing solutions with the end user. In other words, using prototyping as a design tool and a testing methodology very similar to the LEAN-method, where the aim is to test small, smart and fast to optimize the functional utility of the eventual design. This LEAN's build-measure-learn framework and the prototyping as a design tool method could be extremely useful to optimize the process and ultimately the design.

MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... Stick to no more than five ambitions.

The last six years of studying and cooking showed me that cooking and designing share multiple characteristics even though the atmosphere in which they are practiced is vastly different. During my time as a cook, working in a one Michellin starred restaurant and other fine dining restaurants, I noticed that the life of a cook, especially on this level, can be quite harsh. I only have worked in less than ten different kitchens, however, in every kitchen there was room for improvement. After experienced this I started to think of the improvement possible in a professional kitchen.

Completely apart from this, the past half year I did an internship at the design bureau WAACs. At WAAcs, I was mainly deployed as visualizer and designer of products. This meant five days a week of computer drawing. I learned a lot about this real life process of product design but I realized that working only behind a computer does not give all the satisfaction. Prototyping is something I enjoy and I am good at. This made me come up with this project. It is a combination of designing and prototyping all concerning a, for me, interesting subject.
Whereas all the products designed at WAACs are focused on aesthetics, this project has a focus on functionality and practicality. Also something I want to master.

Additionally, with all project of IDE, the bachelor and master together, I did not yet make use of the method prototyping as a design tool. I want to familiarize myself with this and learn and perceive how and why this is a useful method.

Finally, my ambition is to use this graduation project as the basis of a startup business. A business that will focus on products for the professional kitchen. Through this project I can connect with production companies and other stakeholders in the catering industry and create a launchpad for this business with a design that has tested real-world application potential.

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.

Initials & Name M.J.F. van Bussel Student number 4294610

Title of Project The New Kitchen Standard