DESIGNING AN ELECTRIC COOK TOP

On basis of an existing heating element

Bachelor Assignment
Bas Jan Kylstra
University of Twente
Industrial Design Engineering
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INFORMATION PAGE

TITLE OF THE BACHELOR ASSIGNMENT
Designing an electric cook top on basis of an existing heating element

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PRELUDE

This is the Bachelor assignment of Bas Jan Kylstra, student in Industrial Design Engineering on the University of Twente. The Bachelor assignment is the final assignment of the course. The knowledge and skills gathered from subjects of the course should be put into practice.

The assignment was formulated by a Brazilian company named ABINFO and was partially fulfilled in Campinas, Brazil and completed back in Holland. The gathered experience in a foreign country combined with the first big solitary fulfilled design assignment taught me much in a lot of ways. The intense working experience gained from the assignment was very instructive. Working in another country with a different (work) culture was interesting as well. Dealing with different ways of communication and with different habits was a great experience and gave me new insights on many issues.

I am very grateful for having had this fantastic opportunity and for the received help.
A special thanks to: Prof. C.I.Z. Mammana, Prof. A. Pellegrini Mammana, Dr. D. Den Engelsen and Mr. R. Martini from ABINFO for the great cooperation, for supporting me in the work in Brazil and for being great hosts, Elmer Lise for being a great coworker and friend during the process and Ing. T.G.M Krone and Ing. M. Mulder-Nijkamp from University of Twente for the help and consultations concerning the assignment.

If it is not fun, why do it? - C.I.Z. Mammana

Left to right: Elmer Lise, Prof. A. Pelegrini Mammana, Prof. C.I.Z. Mammana, Bas Jan Kylstra, Dr. D. Den Engelsen, Mr. R. Martini.

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MANAGEMENT SUMMARY

ABINFO is a small non-profit organization in Campinas, Brazil. Their main focus lies on performing research and improving technology in Brazilian companies. Part of their activities is the development of a new kind of high efficient heating element. At this moment the heating element is still a prototype. ABINFO decided to call in the help of a Dutch bachelor student of Industrial Design Engineering to do research in the integration of the heating element in a cook top.

ABINFO set several sub goals to achieve the main goal: Integrating the ABINFO heating element in an electric cook top design. Displaying the design possibilities is important for ABINFO to see different possible directions. An electric cook top will be designed to communicate the possibilities with companies and to show the steps needed to complete the whole product.

The Brazilian market is divided into a large quantity of gas cook tops and a smaller part of electric cook tops. The use of electricity in Brazil is better for the environment because of the large amount of waterpower. This gives a good position for a new kind of efficient cook top on the market. The market can be split into three large consumer groups: The lower class, the middle class and the green class. These groups differ in income and in consumer wishes.

The cook top is divided into different aspects to show ABINFO the possible design frames of the new product. These design aspects are developed into new ideas. Three different design frames are composed on the basis of the three consumer groups. The design frame for the middle class consumer group is chosen to form the basis for the concepts. The main properties of the design frame are: Innovating design, high efficiency, computer aided cooking and a competing price.

The three concepts were created with this vision with different qualities. The final concept is a cook top with a custom design top. The enamel layer on the top can be printed in any design. The Cook top is equipped with a computer and can be operated through a touch screen. This system enhances the efficiency in a number of ways and enables programmed cooking. This program copies the cooking behavior of the consumer and can reproduce it.

The production and assembly are worked out to give an idea of the steps to produce the total product. The costs of these steps are estimated and an overhead cost is added. These all add up to a total cost of € 492,-. This is within the range of the competing prices.

The product suits the core wishes of the consumer described in the vision. However there is a need of thorough testing on multiple levels.

- Material stress caused by heat or by heavy objects has to be researched more thoroughly.
- The new layer system and its sensors have to be tested.
- The usability of the newly developed computer system has to be tested.

The goals of the assignment are reached as after extensive research the heating element is integrated into a cook top. ABINFO has an idea of the different possible design directions and can use the developed concept to show companies the possibilities of this product.

INTRODUCTION

CAUSE

The Brazilian non-profit organization ABINFO is doing research in a wide range of different technologies. ABINFO has some contracts with companies to help them improve their technologies. Part of their activities lead them to the development of a new kind of high efficient heating element. The main research done by ABINFO on this topic was focused on attaching conductive materials on a circular metal plate. The method used is called silk screening. The created heating elements are tested thoroughly for effects and corrosion created by high temperatures. The result of the research has given parameters for the heating element and insulation.
At this moment the heating element is still a prototype and is not integrated into a product idea. To see the possibilities ABINFO decided to do research in the integration of the product and called in the help of a Dutch bachelor student of Industrial Design Engineering.

GOAL

The main goal of the assignment is to integrate their new developed heating element into a cook top. The options of what kinds of consumer groups could be interested and what products are possible have to be clarified. A few possible product frames will be the result of the research. One of the options should be developed into a detailed concept. The requirements, functions, design, production and costs should be researched and determined. This way a clear example of a product can communicate the possibilities of their technology. Questions about future possibilities for this product and about possible solutions for the spherical bottom of aluminum pans caused by expansion gave reason for some side researches.

STRUCTURE OF THE REPORT

The project frame exists out of multiple aspects like the company, the assignment, the country and the side activities. These are discussed in chapter 1. The research phase, which forms the basis of the assignment, will be discussed in Chapter 2. A set of requirements will be the conclusion of this chapter. Chapter 3 shows the different design aspects of the cook top and their possibilities. A clear direction of the product design is chosen in this chapter. Different concepts on basis of the chosen direction are elaborated in chapter 4. The detailing of the concept in design, production and estimated costs is explained in Chapter 5. The final product is presented and evaluated in Chapter 6. In Chapter 7 a conclusion of the total project is shown.

1. PROJECT FRAME

In this chapter the assignment, the company and the reasons for going abroad are elaborated to give a view on the start of the project.

ASSOCIAÇÃO BRASILEIRA DE INFORMÁTICA (ABINFO)

This non-profit organization is started by two ex-professors of UNICAMP, a university in Campinas. The field of work of this organization has a focus on improving technology within Brazil. This improvement is reached by doing research in the laboratory they built and by forming a platform to communicate with different researchers. The research is done in different areas like: an interactive computer table for schools, heating elements or new production methods like etching on a thin film layer. The idea of the research platform comes to life in the development of a research website and the organization of LatinDisplay. LatinDisplay is an annual international display congress with approximately 300 visitors of all levels of the Display industry which was held this year from 26 until 30 November 2012. The work is positioned in two different places in Campinas. The research part is mainly positioned at the house of the professors, which includes a laboratory with homemade low-cost, high quality equipment. There are two interns working at this office, two voluntary researchers who work there besides their daytime job. The work on the LatinDisplay congress was mainly done in an office at a University called UNISAL. At this moment they have one employee working there and a voluntary student helping as well. The office at this university is also where the work of this Bachelor assignment is positioned. This is the motto of ABINFO:

Office at the University

"Our work is to unite efforts in research, development and innovation, aiming to strengthen and enhance the vitality and competitiveness of Brazilian industry in the manufacture of finished goods and materials, devices, instruments, equipment and assets for production resulting in a positive contribution to the areas of life, energy, education and environment"

Labaratory

ASSIGNMENT GOALS

The assignment was addressed briefly the Introduction. ABINFO has designed a new kind of heating element. The main goal of the project is integrating this heating element into an electric cook top. The heating element is a prototype at this moment. Displaying the many possibilities is very important for ABINFO. A final product will be created to communicate the possibilities with companies and to show the steps needed to complete the whole product. The (sub) goals are shown in the schedule below:

- **Integrating the ABINFO heating element in an electric cook top.**
    - Exploring the multiple possible directions of the design
    - Researching a solution to loss of efficiency due to pans with a bend bottom
    - Choose a good design frame with ABINFO
    - Creating the product
        - Setting requirements
        - Determine functions
        - Creating a design
        - Create a production plan
        - Create a cost calculation

SIDE ACTIVITIES

Besides the work around this project a couple of side projects were also created during the internship. As our office is positioned in UNISAL, it gave an opportunity to use the available knowledge at this school and show them some of the possibilities of the University of Twente. This idea resulted in two introducing presentations for the (around 40) professors, one for the students (around 1000), a final presentation for the professors and ABINFO staff and attending some meetings and events of this University.

Another side activity was helping with the oncoming event of the congress. This work included making phone calls to organizations, designing posters and helping at the event itself. Besides these ABINFO projects, another side project was asked for the minor International Management. An international questionnaire had to be created and answered by Brazilians. These side projects taught other things than the internship itself and were very interesting.

Side Acitivities

MOTIVATION TO GO ABROAD

Some of my friends told me stories about going abroad. They spoke about the experience and knowledge they got from this choice. This inspired me to look beyond our borders for a Bachelor Assignment. The safest way was to go with another student, Elmer Lise, so we were looking together. To narrow down the search we decided to look for options in South America. Looking for options was done through own contacts, by contacting embassies, by contacting companies directly and by using University contacts. Eventually there were three options, one in Mexico, one in Colombia and one in Brazil. The assignment in Brazil had the most potential for us.

BRAZIL

Brazil is the 5th biggest country in the world and has approximately 200 million citizens[1]. The country has many materials gained from the ground and a lot of hydro-electric power[2]. These natural resources give Brazil a good market position and are the power behind the current economical growth. Brazil is one of the emerging economies and its own market gives possibilities for the development of new innovating products.

The culture of Brazil is different from the Dutch culture in many ways. Some of the ways of working and thinking differ from those in the Netherlands. Adapting and working with these small differences is interesting. Regarding the project this differed on the subject of making plans and appointments. These were sometimes organized and changed at the day itself. This gives a very flexible working environment.

A different language and culture also creates a communication barrier in multiple levels. English was communication language. Although everybody spoke proper English, delivering a message is always easier in your own language (Dutch versus Portuguese). Explaining Dutch ideas in English was sometimes challenging. This added a great learning value to the whole experience.

Foz do Iguaçu waterfalls

2. RESEARCH PHASE

In this chapter the research will be described, which forms the basis of this report.

2.1 COOKING SITUATION IN BRAZIL

This paragraph will show the current Brazilian cooking situation.

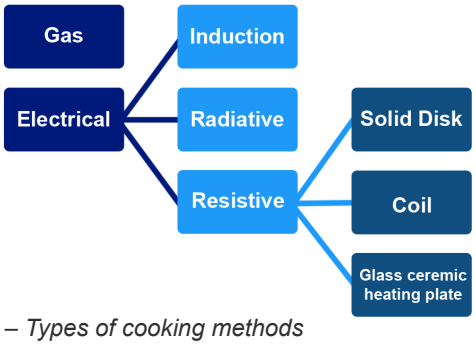


Figure 1 – Types of cooking methods

Current cooking solutions

In Brazil there are two main ways of cooking: with gas and electricity. In Brazil the most popular way of cooking is done on gas stoves similar to those in Europe.[3] Gas at the houses is mainly provided by gas bottles which can be bought at the store or at gas salesmen who drive avvround at standard times in neighborhoods.

Environmental situation

The environment is a growing issue globally. Brazil has a relatively good position CO2 emission. The emission is growing instead of decreasing because of the growing population and economy(1,1% growth of population, 199 million Brazilians in 2012)[4]. The Brazilian government has started multiple projects to implement initiatives to help change this global situation.[5]

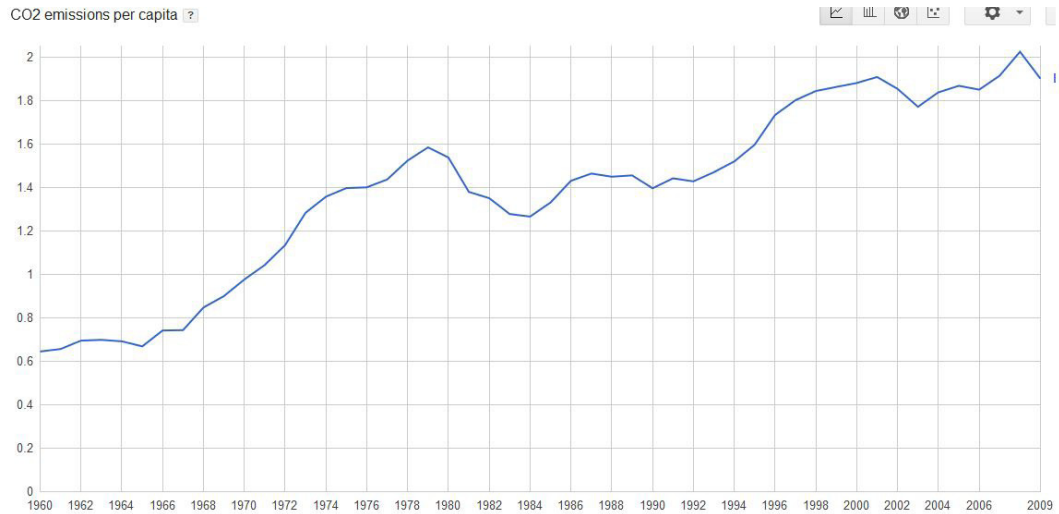


Figure 2 – Table of CO2 emissions per capita of Brazil 2008[6]

Cooking is one of the highest energy consuming activities in a household. This activity is mostly done on gas cook tops in Brazil with a direct emission of CO2. Although electrical cooking is more efficient during cooking than gas cooking (MAX-TECH, maximum efficiency levels of 77% electrical vs. 42% gas energy)[6], this does not directly mean electricity is more energy efficient in total. This depends on the way of generating electricity. Some of the gas power plants have an efficiency of 40 - 45%, in this situation the gas is more efficient. 70% electricity in Brazil is generated by hydroelectric power stations, which do not generate CO2. This gives Brazil the opportunity use electrical cooking to decrease the CO2 emission.

The use of gas for cooking is still available at a price less than electricity; this might prevent the change from gas to electricity to happen in large numbers.[7] The new vision of the government could help change this situation in the future.

Cookware and Habits

The pots and pans in Brazil are sometimes made of aluminum. This material and the way of producing these products combined with the heat of cooking, causes the bottom of the pan to become round as the time passes. This causes a gap of air between the bottom and the surface of an electric cook top. Although current cook tops use 70% IR-radiation and 30% conduction[20], less direct contact surface will cause more heat to be lost and a less efficient process. This is a problem for the current electric cook tops. ABINFO has made this a side project to explore the possibilities.

At this moment also other materials are used for pans like: stainless steel, enamel coated steel, starflon coated steel and coated aluminum. The diameters of current pans on the market differ between “16 to 32 cm” and pans can contain a volume up to 6000 ml.[9,10] A filled pan of 6000ml will have estimated weight of 10 kilos.

Figure 3 – Pans on the Brazilian market

Figure 4 – Cooking in Brazil

2.2 THE COOK TOP MAIN PARTS

A cook top can be separated in to a few basic parts: the frame, the heating element, the insulation and the user interface. In this sub paragraph these parts are explained shortly.

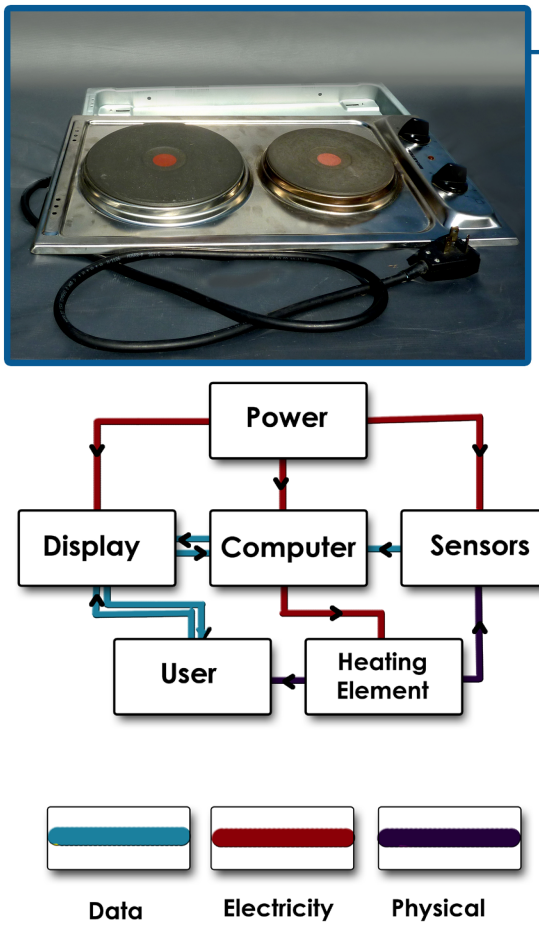


Figure 5 – Data en energie schema

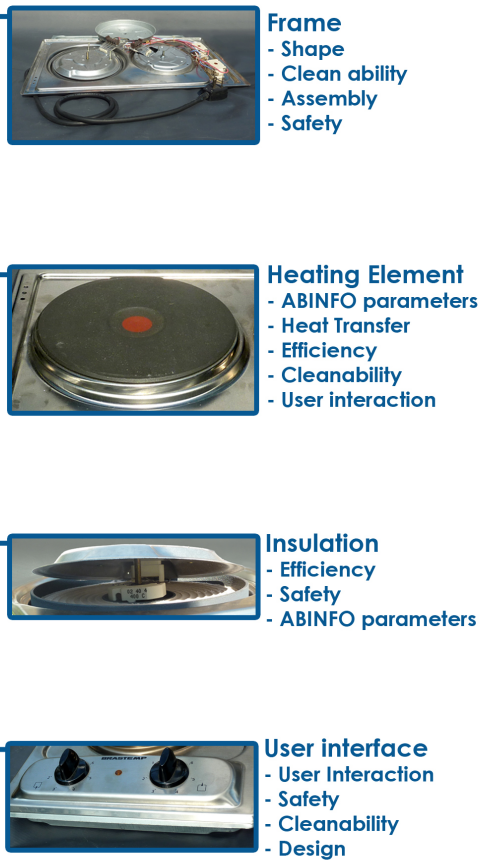


Figure 6 – Parts of a cook top displayed

Pictures of a simple model cook top are used to show these parts. In short the most important qualities the part are explained.

Important User Apsects	Important Producer Aspects
Cooking interaction (usability)	Assembly
Safety	Production costs
Efficiency	Safety
Cleaning	
Durability	
Design	

Figure 7 – Table of cook top aspects

Besides the aspects per part, the different aspects of the whole products are also mentioned in figure 7.

2.3 COOK TOP MARKET

The Brazilian cook market is researched in this paragraph.

Prices

The gas stoves have the biggest range of products on the market as well as a wide price range which makes them available for most groups in society. The proportion of search results is around 15 gas stoves to 1 electric cook top. A table of price differences is categorized into cook tops with 1-2 heating elements, 4-5 heating elements without oven and 4-5 heating elements with an oven. This table is shown below:[11,12,13,14,15,16,17]

	1-2 Heating elements(HE)	**4-5 HE without oven**	**4-5 HE with oven**
Gas	30 R$ to 600 R$	300 R$ to 3500 R$	250 R$ to 6.000 R$
Electric	30 R$ to 1.000 R$	1.000 R$ to 4.000 R$	2.000 R$ to 6.500 R$

Figure 8 – prices of cook tops in current market. Currency: 1 R$ = € 0,3801[18]

The competition of the gas stoves is now obvious, this will be a good comparing factor as it contains the biggest part of the competition. The electrical competition should be regarded as well.

Electronic Cook tops[19,20]

At this moment there are three types of technology used to cook food with an electronic cook top: Inductive, Radiative and Resistive heating elements. The way of creating heat is different in all these technologies. Inductive cook tops use magnetism to create heat. The magnetic waves create heat through a reaction of the atoms of the metal pan. Radiative elements use halogen lamps beneath a glass ceramic plate. A reflector helps to distribute the heat upwards to the pan. The resistive cook top uses resistive characteristics of a material to create heat. This heat is brought to the pan by conduction and IR-radiation. Three types of these resistive cook tops are most popular on the market: Coil elements, solid metal plate and glass ceramic cook tops. These types are explained in more detail in Appendix III on page 53.

Depending on the area of Brazil the voltage is 127 V or 220 V. This difference can be countered by a voltage converter.

Type	Inches/Centimeters	Watt
Small	6 / 15	1050
Small/medium	8 / 20	1500
Medium	9 / 22	2200
Medium/Large	10 / 25	2500
Large	12 / 30	2700
Combination elements	6-9-12 / 12-22-30 6-8-10 / 12-20-25	1050-2200-2700 1050-2000-2500

Figure 9 – Heating element sizes[11,12,13,14,15,16,17]

The size of the cook tops differs. The ergonomic norm of 600mm for a kitchen top dept can be used to determine the size of the cook top. This size is often used for cook tops. The size of the heating elements also differ as shown in figure 9.

Comparison of methods[20]

ABINFO compared all methods on a few different aspects. These are shown in the table of figure 10. The construction, production, the different prices and costs are also investigated to determine which method would fit the best in attending the application in households.

The resistive heater method was chosen to work with for a number of reasons. This method has a simpler construction, which also causes it to have fewer parts. These two facts conclude in a simple production plan and a cheap design to make. As is shown in their research, energy efficiency of this method is good. These reasons make this an interesting direction to follow.

	Conduction	IR-light	Induction
Energy efficiency	~70	~75	84
Cooking surface	flat	flat	flat
Ease of cleaning	easy	easy	easy
Scratch resistance	low	low	high
Instant heat	medium	fast	fast
Retain heat after cooking	yes	yes	some
Utensils/cookware	All	All	Iron/steel
Temperature limiter	yes	yes	???
Hot surface warning	yes	yes	n.a.

Figure 10 - Table with the comparison between the electric cooking methods

Thin Film Heater[20]

Another type of resistive heating was developed by ABINFO using a thin film. This will be used in the new cook top. A thin film heater (4) is based on a material which is deposited on an insulated iron plate (2) by a physical process called silk screening. The material of the film heater will be made of graphite. A current will be put on the layer by the conductive track and pressure contact. The material has resistive properties which turn it into a heat element. This heat will be transferred by induction of the top layer and the pan. The iron plate is added to ensure a balanced transfer and reduces dynamic temperature differences; its isolating layer protects the iron plate from corrosion and damage. The insulator (6) will assure an efficient heat transfer by keeping the heat to escape in other directions than up, this insulator can be supported by a reflector. The thin layer reduces, in comparison with the other resistive methods, the height, weight of the cook top, the components used, and so gives reduction in the production process and reduction in costs. The method should also be able to reduce the power needed to heat the surface.

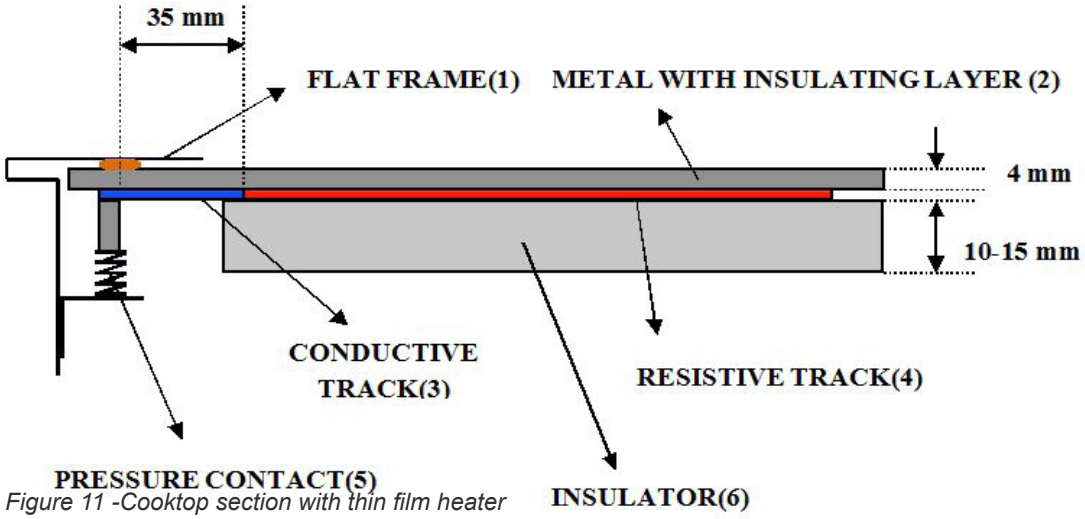


Figure 11 -Cooktop section with thin film heater

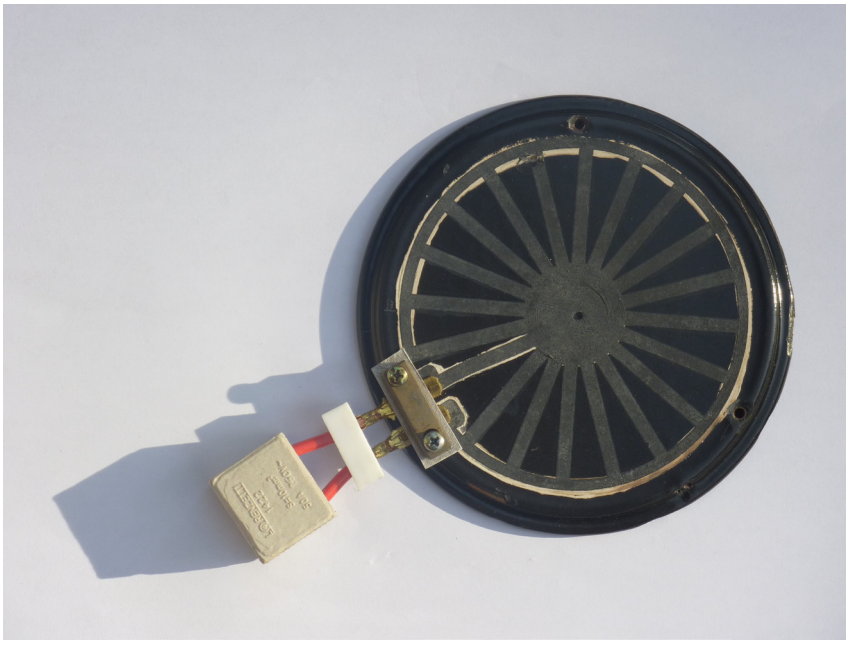


Figure 12 - Prototype of the heating element

2.4 FUTURE GROUPS OF CONSUMERS

The group of consumers has to be chosen in order to make design decisions. This group is not yet chosen by ABINFO. Three different options of these consumers and their properties are explained in this paragraph.

Low Class Consumers

These consumers are focused on the price of the product and the efficiency will be seen more as a way to save money rather than a way to save the environment. The costs of this product should therefore be as cheap as possible. This group is also a group who mostly is cooking on gas and will have to make the change to electric cooking. The income of this class is until 3 times minimum wage and lower and represents more than 50% of the society.
Target of the product: As cheap as possible to create a good alternative for gas cook tops.

Middle Class Consumers

These consumers have enough money to consider buying a nice product with extra abilities. This is a long term investment for them and the product has to fit in the style of their kitchen. Efficiency will be received as a good property of a cook top. This group has an income of 2 times to 10 times minimum wage and represents 20% of the society (table X).
Target of the product: provide a cook top with style, efficiency and is still affordable.

Green Consumers

This group will be found in the section of consumers who care about the environment. This consumer will be much like the supporters and users at 'green' organizations like Akatu (Appendix I).
Sustainable materials and new technologies cause similar 'green' products so be often more expensive.). They use the products to show their ideals to other members of society. Efficiency and design will be the main focus points of this consumer. This group has an income of 5 times minimum wage or higher and represents 6% of the society (table X).
Target of the product: The product should be efficient, look efficient and use new technologies.

Futuristic Consumers

A group for in the far future has been explored and new cooking methods and the influence of the development of technologies is discussed. As this is not a realistic group to consider in this report, these ideas can be found in the Appendix I and II on pages 50-52.

Category	%	People (1.000)
Toral	100	166.987
Up to 1 minimum wage	23.6	39 448
More than 1 until 2 minimum wages	22.4	37 471
More than 2 until 3 minimum wages	9	15 111
More than 3 until 5 minimum wages	5.9	9 921
More than 5 until 10 minimum wages	4.1	6 810
More than 10 until 20 minimum wages	1.4	2 301
More than 20 minimum wages	0.5	818
Without income	30.5	50 850

Figure 13 -The table of the income in Brazil, in minimum wages ($R 622,- /€ 240,- per month)

2.5 REQUIREMENTS OF A COOK TOP

The cook top should have certain requirements to be a successful product and to be able to compete with the other cook tops on the market.

Technical Requirements

The cook top should be sustainable and strong enough to withhold the events of the environment. The technical requirements form the material performance of the cook top.

- The cook top should have scratch proof cooking surface with at least 100 HV(HV of Stainless steel)
- The cook top should hold/withstand the pressure of a sitting human of 100 kg
- The cook top should be water proof
- The cook top should not have sharp edges
- The cook top should not distort by the temperatures in reached during cooking
- The display should be waterproof
- The display should be able to handle a temperature of 150 Celsius

Functional Requirements

The user product relation is very important. These requirements will be the basis of the functionality of the design.

- The cook top should be able to be cleaned within 2 minutes with a towel and detergent
- The cook top should provide a stable surface for the pan
- The cook top should be able to heat multiple pans
- The cook top should be able to heat pans of different sizes up to 300mm Ø
- The cook top should not be deeper than 600 mm (Due to the kitchen top)
- The consumer should be able to use the touch screen with wet hands
- The buttons on the screen should be no smaller than 20 mm[22]
- The cook top should indicate when its warm
- No more than 3 steps should be taken to start cooking
- The system should be able to monitor the cook time
- The system should be able to calculate the power used
- The display should show the temperature
- The computer has to have the option to cook manually
- The user should be able to program cooking
- The user should be able to manually determine heat levels of the cook top

Heating element Requirements

The performance of the heating element will determine a big part of the efficiency. These requirements are formed on basis of the new technologies of ABINFO.

- The technology of ABINFO should be incorporated in the design
  - o 5 cm of Rock wool as insulation
  - o The use of the heating element and technologies
- The possible contact with current should not exceed 40 V
- The cook top should be able to maintain different temperature levels
- The cook top should have a temperature range of 25 a 400 °C
- The cook top should cool down to 30 °C in 5 minutes
- Energy efficiency of more than 90 %

3. DESIGN ASPECTS OF THE COOK TOP

This chapter will show ABINFO the different design aspects and possibilities. These ideas and new designs give a basis of the concepts. The bend pan problem will be researched as part of these ideas. The chapter will conclude in the choice of a design frame.

3.1 NUMBER OF HEATING ELEMENTS AND INTEGRATION

The number of heating elements directly influences a lot of aspects of the cook top. This number will increase or decrease the use of materials and components. This will determine the weight and the costs, affect the use and application of the cook top. The most common numbers of elements are two and four. In some cases integration with a furnace or kitchen top is possible. The oven is not the main focus of the project. So when integrated only the kitchen top will be considered and the oven will be regarded as a black box.

Two elements	**Four elements**
Separate element best option (movable)	Integration best option (not movable)
Low weight and size	High weight and size
Lower material costs	Higher material costs
Easy to stock and move	Kitchen element
Short term investment	Long term investment
Camping, small kitchen	Bigger kitchens

Figure 14 - Table of advantages

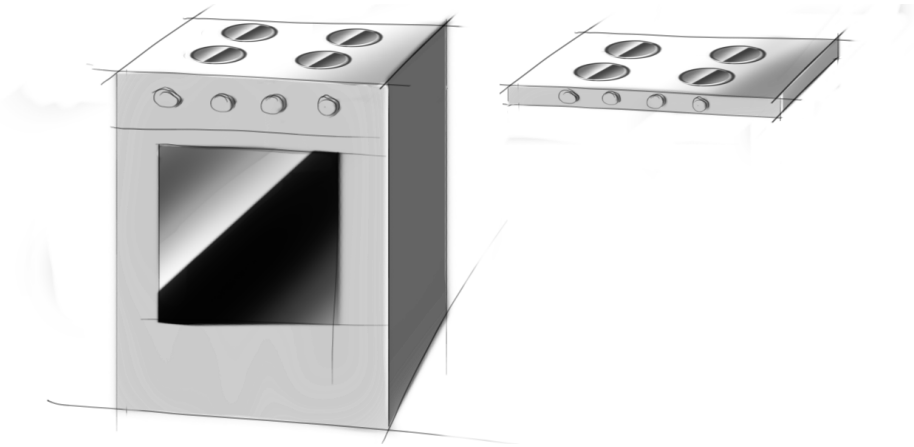


Figure 15 - Cook top with 4 heating elements and 2 heating elements

3.2 SHAPE OF THE COOK TOP

The shape of the cook top determines a big part of the design. To explore the different possibilities some sketches were made. Some possible shapes of the cook top are presented in the figures below.

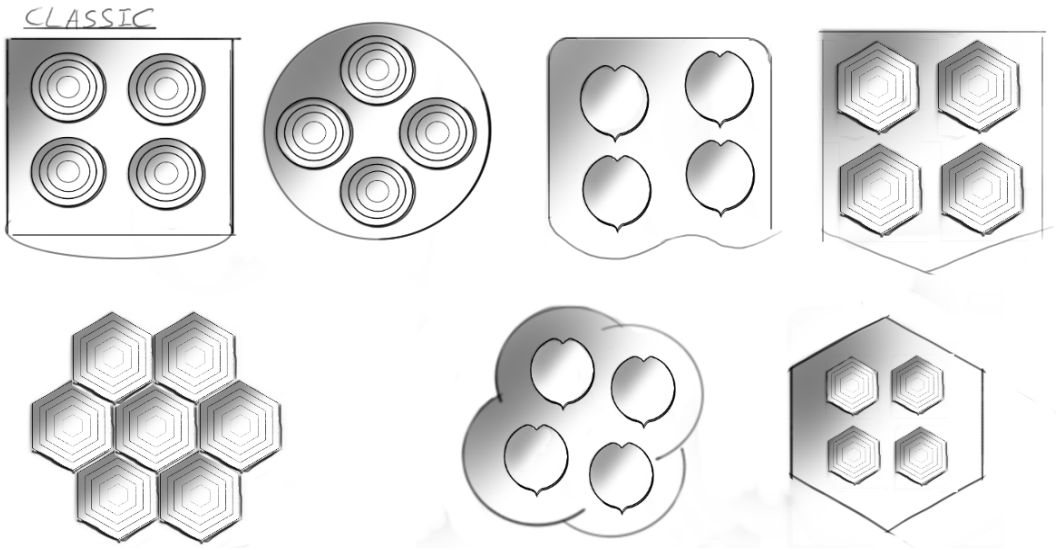


Figure 16 - Cook Top designs with two heating elements

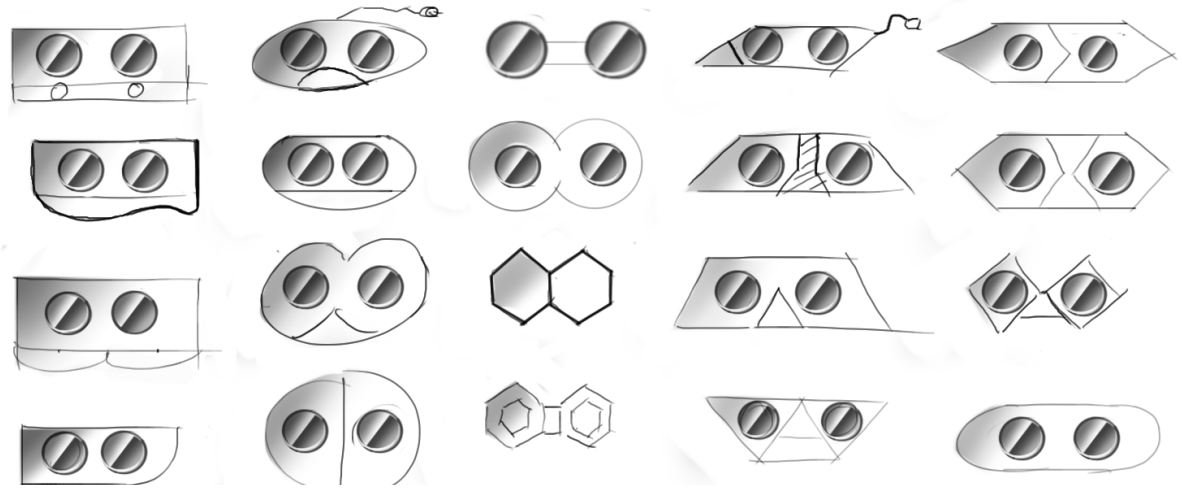


Figure 17 - Cook Top designs with four heating elements

3.3 SHAPE OF THE HEATING ELEMENT

In this sub paragraphdifferent possible shapes are discussed.

Basic shapes

The classic shape of the heating element is a circle, because of the similar shape of pans. To get an idea of possibilities some shapes are sketched based on circular shapes which can be found in nature.

The shape of the heating element can also be used to control heat distribution. By building layers in the heat element the heat inside of the pan can be controlled better. This can avoid heat loss in case of a smaller pan than the heat element. This idea will be explored more thoroughly later in this project.

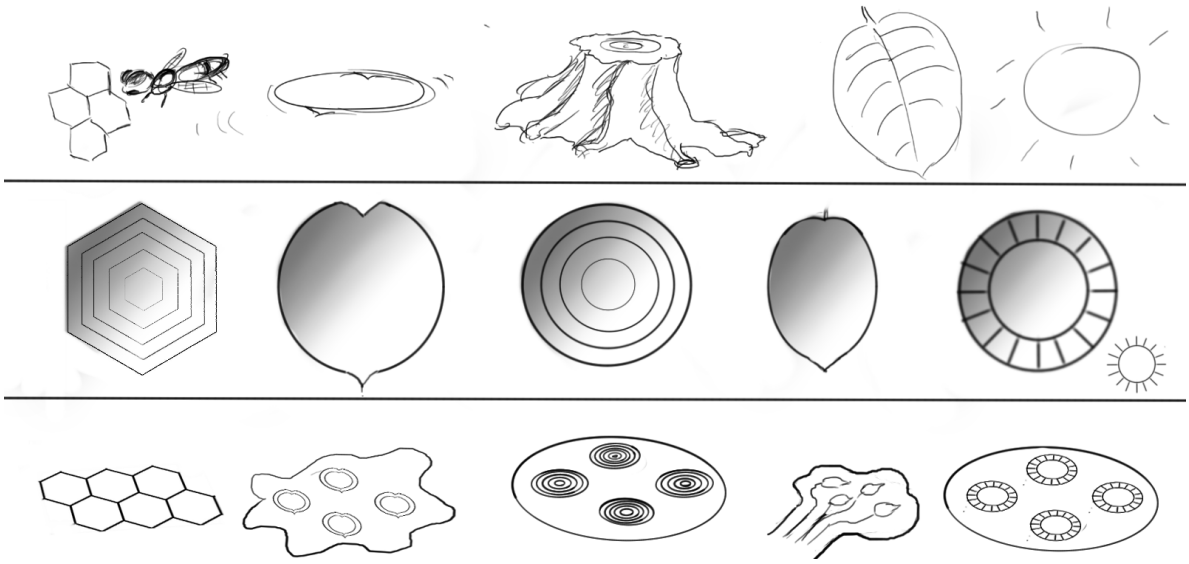


Figure 18 - Possible shapes of the heating elements

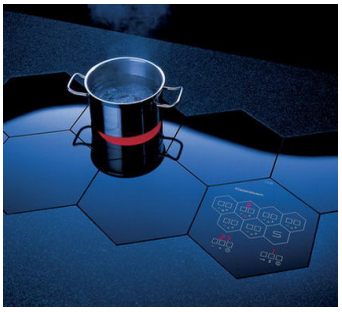


Figure 19 - Honey comb system

It could also be possible to make the whole cooking surface a heating element. The heat can be distributed where ever you place a pan. A possible negative side effect might result in heat loss due to the moving of the pan from heated surface to a cold part. Modularity is also an interesting aspect. The system of the honey cone[24] (figure 19) is an example of a possible modular system. In this system any number of heating elements can be placed in multiple places. This is possible without a frame.

The height of the element determines if the element sticks out of the cook top or be on the same level as the rest of the cooking surface. The big differences between the possibilities lie in the way of insulation and design.

3.4 USER DISPLAY

The choice of a user display will have a big influence on the design and the cognitive way to use the cook top. The options differ between the analog to the digital user display.

Figure 20 - Different kind of displays (left to right: Analog, digital with buttons, touch screen).

Analog displays are popular in the current cooking solutions. This is the simplest of the solutions because of the parts used in the system. The digital display can be controlled by buttons, static touch screen (a touch screen with buttons on a fixed position) or a dynamic touch screen (a touch screen which can change from form and use). Digital displays can give more opportunities for a more advanced display and thereby a smarter product. Options like internet access for recipes and new cooking methods could be possible. The price of the touch screens is not very high. This makes it an interesting option.

3.5 TEMPERATURE CONTROL

Controlling the temperature is a cognitive action. A higher level of control can increase and decrease the usability of a product. This will be shown in this paragraph.

There are a lot of ways to indicate the level of heat from zero to the maximum temperature. These different ways are shown in the figure below.

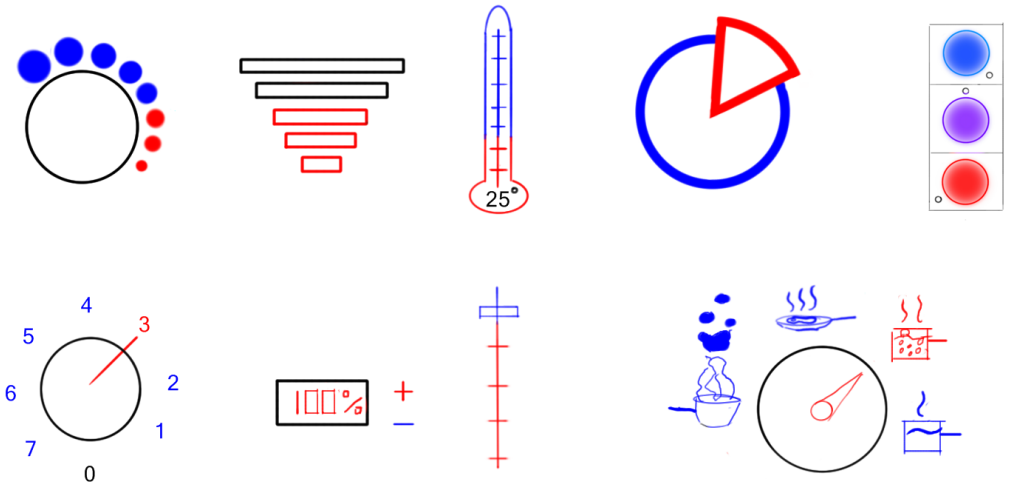


Figure 21 - Cognitive methods to control temperature.

3.6 LEVEL OF CONTROL

The level of control influences the way of cooking and the efficiency of the cook top. This influence is described in this paragraph.

Guided cooking

There are a few ways where technology can guide the consumer to cook more efficiently. By gathering more information about the cooking plan, an intelligent cook top could anticipate and work to be more efficient.

Heat is lost in the cooling down of the heating element. The computer can avoid this by turning of the heater near the end of cooking.

Using to much heat for some cooking actions is also a cause for heat loss. When the maximum temperature of the food is reached(for example 100 degrees by water), the temperature should be maintained and not increased by adding more heat. This control is possible automatically.

Other computer controlled features could be a great addition. For example: Maintaining the temperature of food before eating, programming a heating time, etc. Weight sensors can help the features of the system. The display can be used to guide the process manually. The system can use additional information about the cook plans to work optimal.

Adding a recipe or programming a cooking action can result in more efficient and effortless cooking. This is a whole other way of cooking where the temperature is regulated on beforehand and only the ingredients have to be added. This is an option to give all control

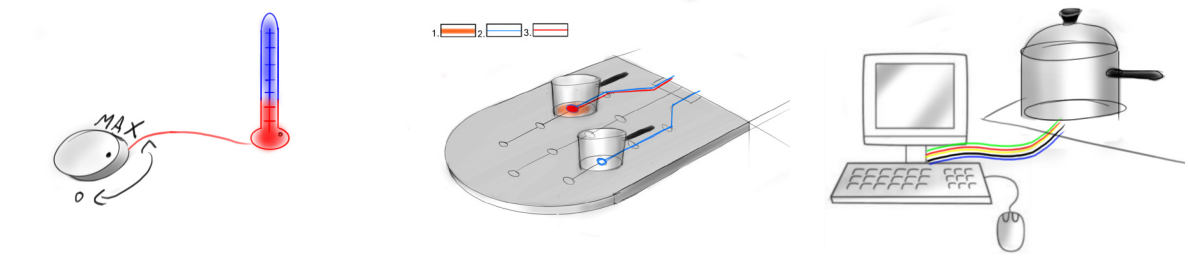


Figure 22 - Control systems: left to right: Classic method, Hybrid method, Automatic method.

to the cook top.

The level of control is divided into three different styles:

- Classic method: Temperature control without guidance of a computer.
- Hybrid method: Cooking with guidance by the sensors to create a better power plan.
- Automatic method: The power plan will be solely controlled by a computer.

3.7 BOTTOM OF THE PAN

The new cook top will transfer heat through conduction; this means the surface contact has to be optimal to create the best efficiency. This could create a problem with the current pans which are available at the Brazilian market. Bottoms of some older pans tend to bow or warp when used frequently in combination of high heat. This causes gaps of air between the pan and the surface which lets the heat escape because of the contact with the air. (Figure below) The different solutions are explained in this paragraph.

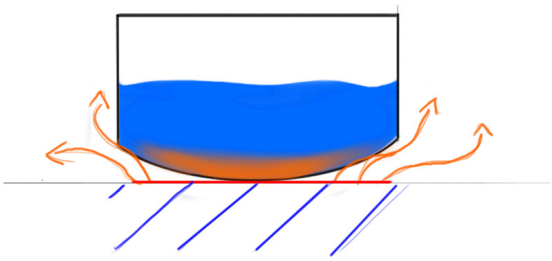


Figure 23 - Problem of the bend bottom of the pan

Figure 24 - Bend pan

Au bain-marie

This method is invented in France; the main principle is that the pan is not heated through heated water. This method can be used to adapt all irregularities of the pan. A sponge like material with a waterproof layer can be used to keep the fluid together and prevent the liquid from splashing.

Like in this method a liquid can be used to adapt the shapes of the pan. There are some disadvantages:

- The buffer of the liquid could take more time to heat.
- Cooling down the buffer of the liquid can cause a big heat loss after cooking.
- The boiling temperature of the liquid affects the maximum heat of the cook top.
- The expansion of the liquid must be adapted.

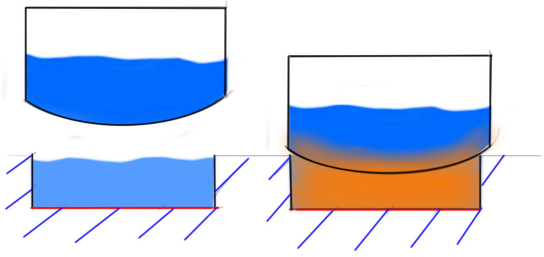


Figure 25 - Au bain-marie

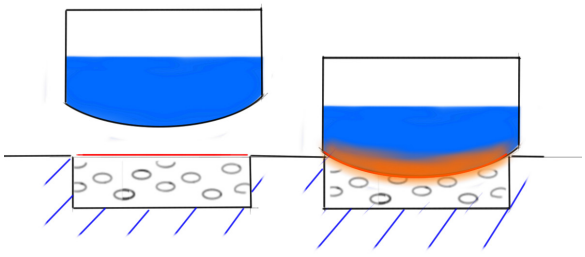


Figure 26 - Sponge idea

A possible solution for these disadvantages could be to use a low conductive liquid and use it both as an insulator and to adapt to the shape of the pan. The heating element can be mounted on top of the liquid. The iron plate has to be subsidized by a flexible component.

Perfect fit

The bottom of the pan will fit in the shape of the heated surface and the heat transfer will happen through radiation and conduction on the side of the pan. The success of this method will be determined on the connection between the sides of the pan and the surrounding contact area. The loss of energy normally produced by the gaps showed in figure 26 will be avoided. This connection can be created in different ways.

One of the ways is a static solution. Where most pans have a round bottom a parabolic shape could be used to create a contact on the sides of the pan (figure 26). The air trapped between the bottom of the pan and the heating element cannot escape.

The disadvantage is that the air has to be heated first and direct conduction is not optimal.

Another way is to enclose the sides of the pan by a dynamic system. This system has an adjustable contact area and can adjust to the size of the pan. This solution will avoid hot air from escaping and still causes for enough surface area. This system is more complicated than the static one. This might cause for more elements and more costs.

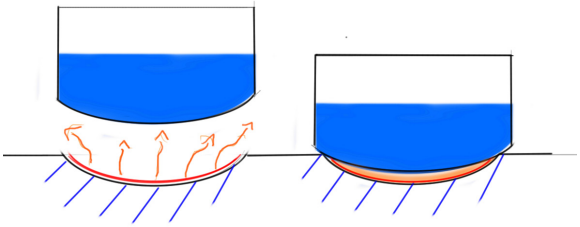


Figure 26 - Parabolic shape

Avoid problem

The problem could be avoided in a number of ways. This could save costs in comparison with other solutions or create a new concept.

A possible way to avoid the surface area problem is by substituting the pans by special pans. This could be used to get an even more efficient cooking method. The pan could fit by form into the heating element which eliminates the possible heat loss and the heat loss on the sides of the pan.

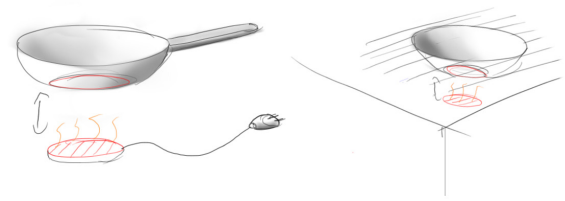


Figure 27 - Heating element integrated.

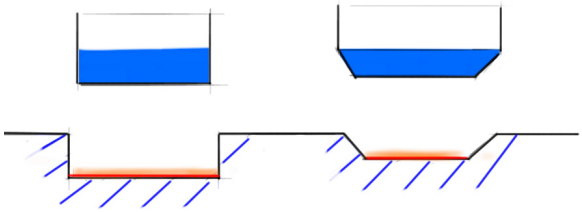


Figure 28 - Form fit idea.

The concept of a cook top can also be adjusted to create a solution. The pan can be integrated into the system. This way the food can be directly cooked at the cooking surface and the heat loss may be reduced. The way to transport the cooked food to the plate can cause a problem. The other way around is possible too. The heating element can be added to the pan. This is already an existing concept and has many forms (rice cookers, electric heating pans, etc.)[25] . These two methods are shown in the figure above.

The last way is just to ignore the whole problem and let it be. The investment in a new cook top can be followed by an investment in new pans.

3.8 MORPHOLOGIC DIAGRAM

To give ABINFO a clear view of the possibilities a systematic scheme has been created. The different possibilities are gathered in this morphologic diagram. In this diagram the different combinations can be found. The chosen combinations are indicated with the colored lines and explained on the next paragraph.

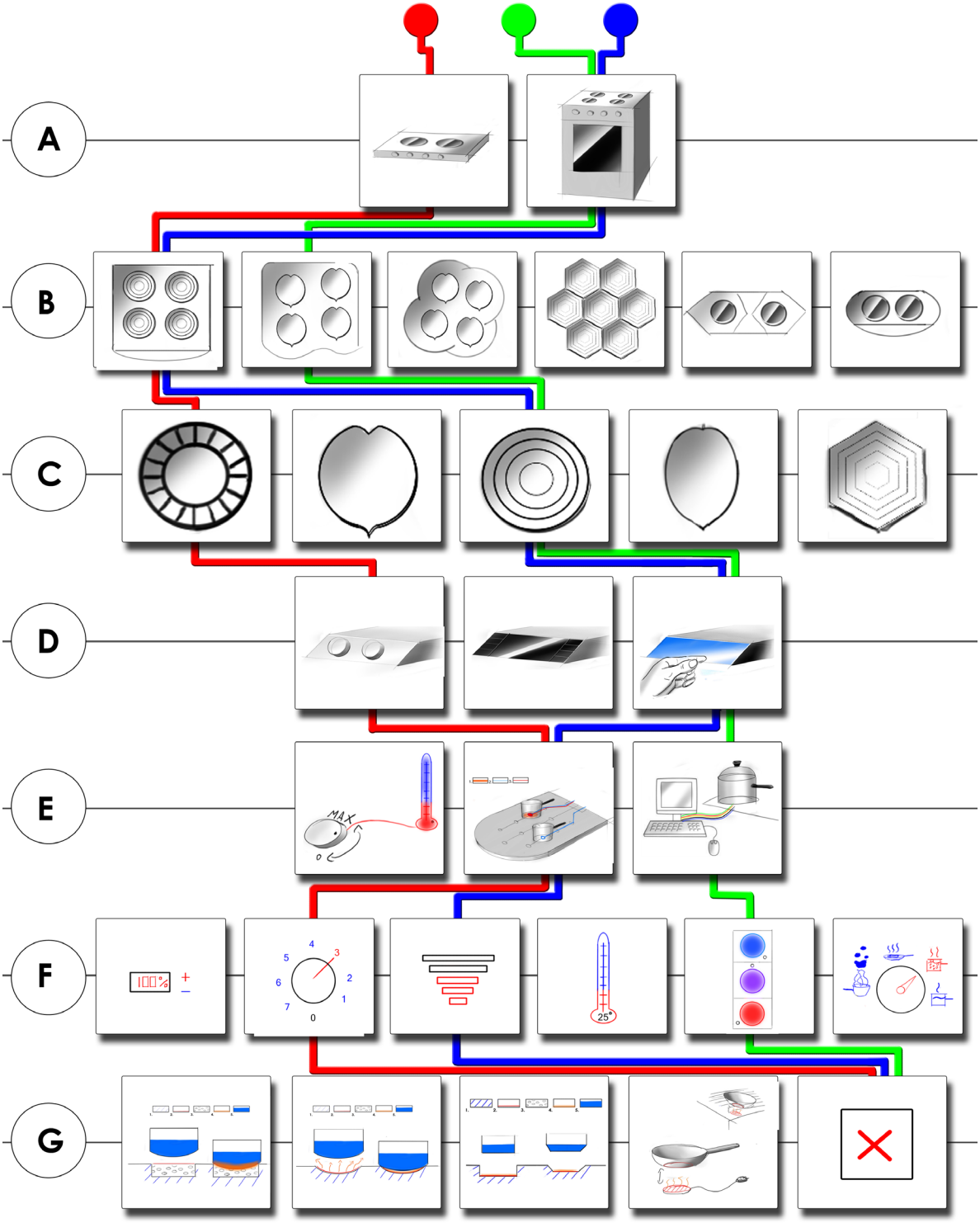


Figure 29 - Morphologic Diagram:

A. Number of Heating Elements and Integration, B. Shape of Cook Top, C. Shape of Heating Elements

D. Display, E. Level of Control, F. Temperature Control, G. Pan solution

3.9 THREE VISIONS:

As cheap as possible

This design frame will be for the low class consumer group. The basic vision is make it as cheap as possible, less cost is a better product. This is why in the chart, the simplest of solutions are chosen. Two simple heating elements is chosen to reduce the material costs. The element does not use the layer idea and will not be integrated in an oven or kitchen top. The control of the cheap product is not aided by the special electronic aiding system.

- Simple design
- Simple technologies
- Less materials
- More control of the user

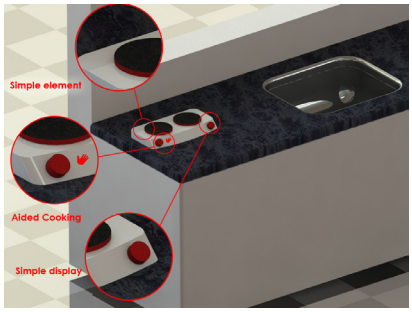


Figure 30 - Cheap vision

As efficient as possible

The green consumer group is the basis of this design frame. The main focus points of the product will be efficiency and 'green design'. The high end and best solutions are chosen in the scheme because of the high income of the consumer group. The layer idea and high computerized cooking will ensure the efficient cooking solution.

- Environmental design
- Use technology for an efficient cooking method
- Less control of the user, intelligent product
- Price/materials is not an issue

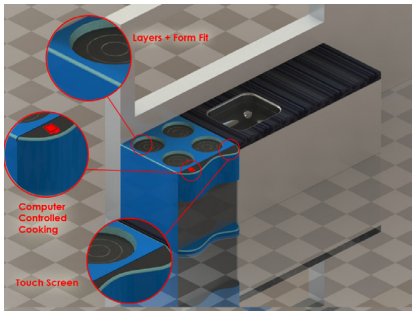


Figure 31 - Efficitent vision

As accessible as possible

This design frame is created for the middle class consumer group. The main focus will be making efficient cooking and new technologies available for a big group of consumers. An innovative design is needed to stand out in this market. The layer method incorporated and an aided system controlled by a touch screen will be added.

- Innovating design
- Use the high efficiency for USP
- Aided control
- Competing price

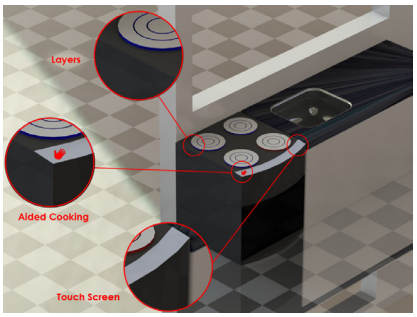


Figure 32 - Accessible vision

Choice

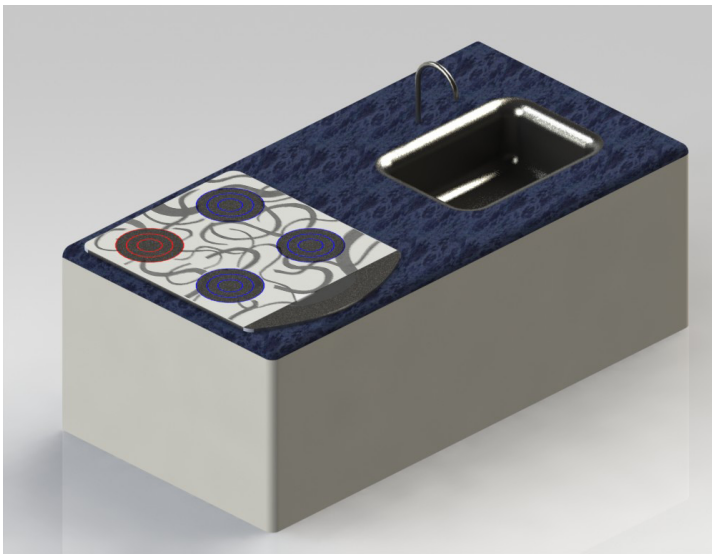
The three options were discussed and considered and a choice was made on basis of the thoughts and ideas of ABINFO. The 'cheap' consumers product have a big market, but the design possibilities are limited. The 'green vision' has a small consumer group and might not be realistic. The 'Accessible vision' is the final choice because of its promising market and design possibilities. A new efficient product would be an addition to this part of the market.

4. CONCEPTS

This chapter will describe three concepts based on the ‘accessible vision’. One of these will be chosen to be developed into a more detailed design in Chapter 4.

PERSONALIZED COOK TOP:

The idea of the personalized Cook top is creating your own design and preferences for the cook top. Coating a metal surface with enamel is a frequently used method in older cook tops and pans. This is used to make the cook top customizable. The system of programming the cook top can enhance the personal cooking experience.



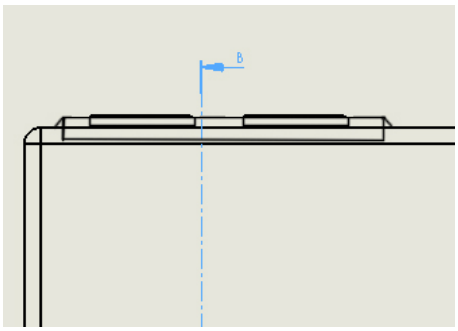


Figure 33 - Personalized Cook top

- Designing your own cook top style by silk screening enamel on cook top
- Aided cooking
    - Programming cooking style
    - Pre programmed cooking
    - Higher efficiency
- Layer system
- New cooking element
- Cut out in kitchen top

This cook top is in basic shape similar to some cook tops on the current market. These similarities can be found in the cut out, placement and shape. The customized design and technology on the other hand make it an innovating product.

MODULAR COOKING SYSTEM

The cook top will be integrated in your kitchen top with the modular cooking system. The consumer can choose the amount, size and position of the elements. These elements will be integrated in the cook top by cut outs. The display will also be added as cut out. The elements and display are connected by wires which run over the kitchen top. The elements can be connected and placed in an original and creative way.

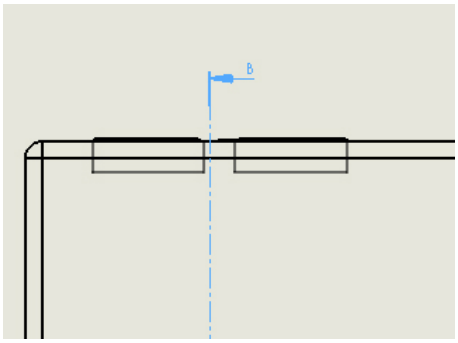


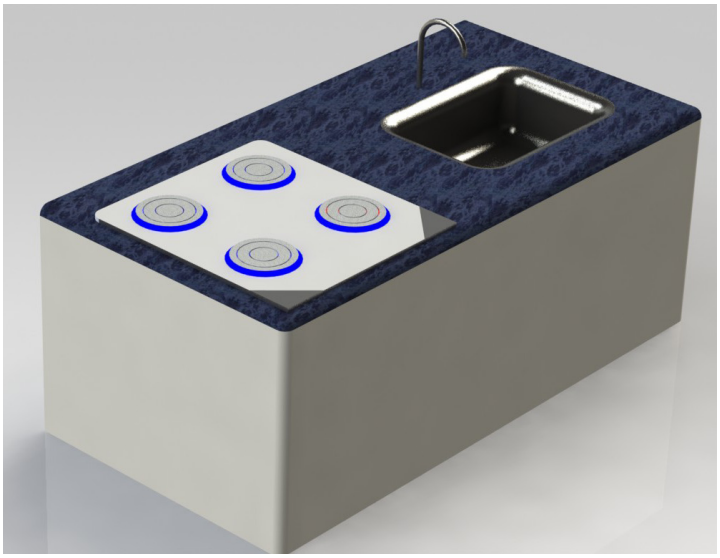
Figure 34 - Modular Cooking System

- Placing cooking elements in the kitchen top
  - Amount can be adjusted
  - Placement can be determined creatively
- Aided cooking
  - Pre programmed cooking
  - Higher efficiency
- Connections of the different elements are made on top of the kitchen top
  - Personal design of the connections can be added and enhanced by adding light.
- Layer system
- New cooking element
- Cut outs in kitchen top

The whole concept is very innovating and new. This gives the product a great innovating and futuristic appearance and an advantage on the market as unique product. The disadvantages of this concept lie in the technologic difficulties. The expansion of the elements and the reaction of the kitchen top to the heat can combine into a problem. The way of placing these elements, display and the wires could create further problems and will require a lot of research.

EASY PLACE COOK TOP:

Where the other cook tops have cut outs in the kitchen top, this idea is created to avoid it. Through the higher positioned elements, the cook top frame can be lower. The system is easy to install in any environment as it does not require any special assistance of the kitchen top material.



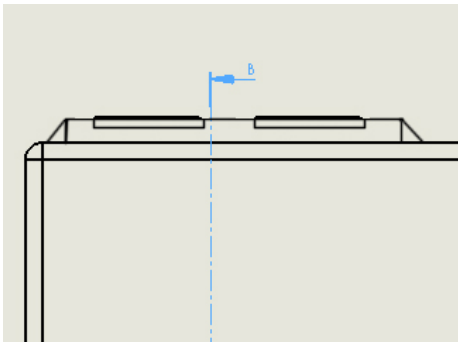


Figure 35 - Easy Place Cook top

- (Relatively) Cheap
- No Cut-out
- Aided cooking
    - o Pre programmed cooking
    - o Higher efficiency
- Layer system
- New cooking element
- Cut out in kitchen top

This concept is very similar to the first and these concepts could be combined. The main difference is the way of placing the cook tops on or in the kitchen top. Because it is a long term investment people should not have a big problem with a cut out and a bigger problem with a height difference with the cook top. The product might be interesting for customers who often change their living environment.

CHOICE

The personalized cook top is chosen for further development. This is the most realistic and innovating design. In the development the final measurements and materials, method of production and final design will be discussed in detail.

5. DETAILING PHASE

The chosen concept will be developed and described in detail in this chapter. In paragraph 1, 2 and 3 the production, assembly and costs will be described. In paragraph 4,5 and 6 the layer system, the enamel design surface and the programmed cooking will be explained.

5.1 PRODUCTION

In this paragraph a method of production will be described for each of these parts and how they will be assembled as one product.

The production number per year of the cook top is chosen at 35.000 units. This choice is based on the size of the middle class consumer group and the possibility of foreign sales. This group represents around 30 million Brazilians. The concept of the product can also be applicable on foreign markets in South America, North America and Europe. The possibilities in these countries are not researched yet.

The production of most of the main components is described. The electric compartment and the detailed production of the heating element are considered as black box. These are too complicated for this project and require expertise and research. Dimensions and possible methods of connection are described to give an idea of the place in the product. Disassembly of these parts is important for maintenance, in case of one of these parts is malfunctioning.

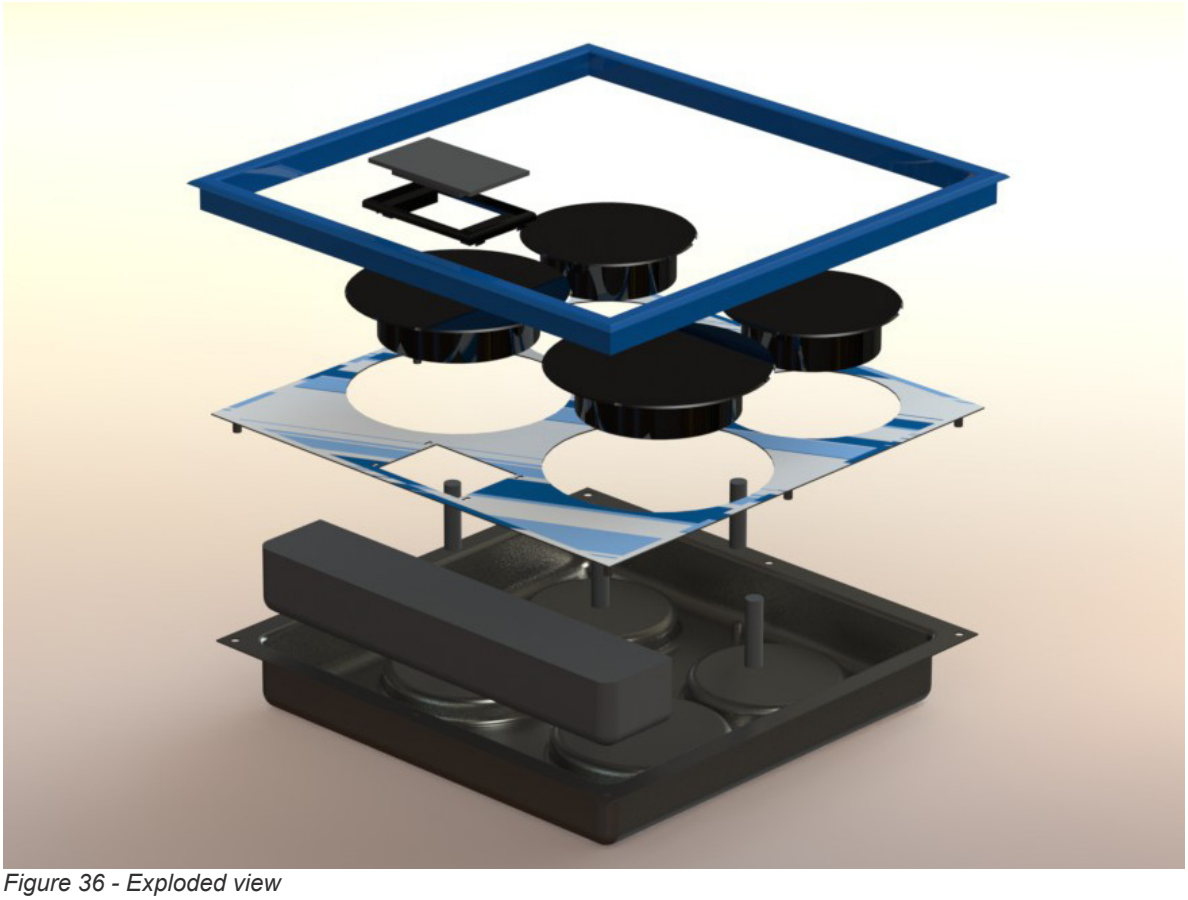
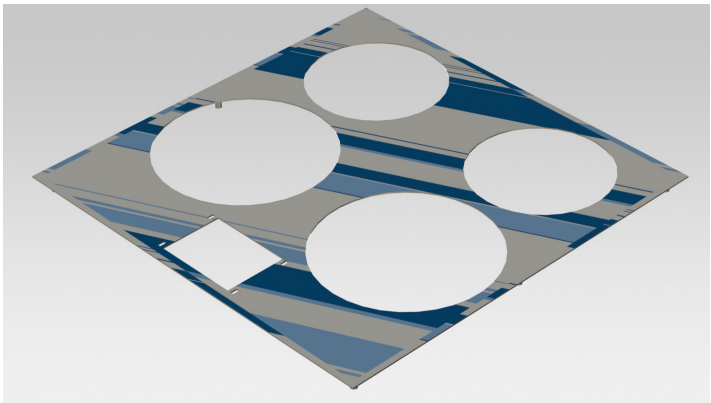
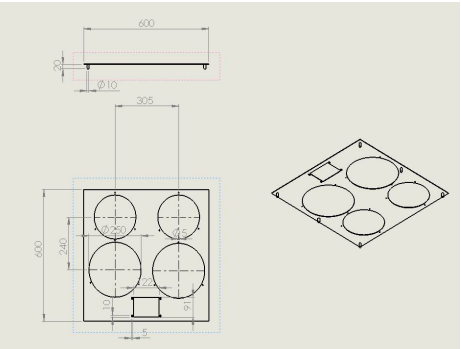


Figure 36 - Exploded view

STEEL TOP PART





Drawings - Larger in Appendix IV

Figure 37 - Toppart

Geometry:

The top piece is kept flat for design reasons. The strength in vertical direction is not high because of the geometry and especially the thickness of 2 mm. This problem will be solved by redirecting forces to other parts. Holes will be added to provide room to fit the heating elements and the display. On the top of the part an enamel layer will be added to create a design and give the cook top a protective and cleanable layer.

Materials:

The main material is a flat piece of 2 mm DC07EK steel plate, this is a material from a specialized steel enamel company. According to their charts this particular kind of steel is the best option. This material is suitable for the combination with enamel because a low carbon content is necessary. This material can also be deep drawn which is important for the bottom part. The enamel used is called Easy To Clean (ETC) enamel. This ECT enamel layer is a coating which is resistive to chemicals, high temperatures, scratching and is easy to clean. The studs (M5) used for the connection and matching bolts are bought as separate parts.

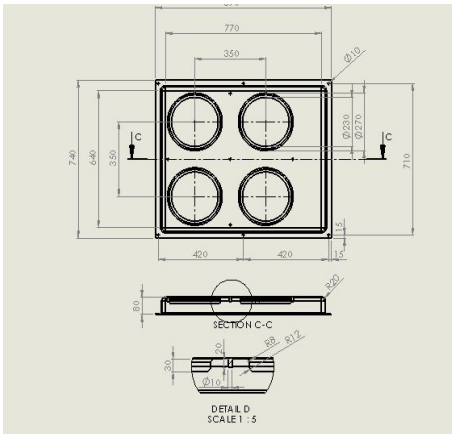
Production steps:

The described holes will be punched in the plate using a punching machine. To connect the top part to the bottom part, threaded studs will be added by stud welding them on the bottom of the plate. As disassembly still has to be possible, stud welding is an easy and cheap solution. After these processes are finished, the surface is prepared in a two steps: Degreasing and light pickling. After this a ground coat of enamel is applied by firing the enamel. After these steps a thin homogenous (180-500 µm[26]) top layer of enamel is applied by the method by firing the enamel. The edges of the part are trimmed as they might create a problem fitting the plastic frame and other components.

Top part	Machine costs	Price	Material	Price		Total:
	Punch	0,42	Steel	9,1		
	Stud weld	0,50	Studs +	1,6		
	Enameling	15,00	bolts			
	Steel coating	1,67				**28,28**

BOTTOM PART

Figure 38 - Bottom Part



Drawings - Larger in Appendix IV

Geometry:

The bottom part is drawn deep to create room for the insulation and electronic system. This geometry also creates vertical strength to the bottom. This is important as the force on the top part is guided to this bottom part. Holes are added on the sides to make room for the studs. Studs are added to the bottom part to create a connection with the spacer tubes. A hole in the back of the part makes room for the electrical connection.

Materials

The bottom part of the cook top is made of the same 1 mm coated steel plates as the top parts. 1 mm steel is suitable for deep drawing and buying higher quantities of a certain material might lead to an economic advantage.

Production steps

The first step is to punch the holes for the studs. After this the plate is drawn deep by a deep drawing machine. Later the studs for the spacer tubes are welded to the plate. The last step will be surface treatment.

Bottom part	Machine costs	Price	Material	Price		Total:
	Punch	0,42	Steel	6,19		
	Deep draw	8,33	Studs + bolts	1,6		
	Stud weld	0,50				
	Steel coating	1,67				**18,71**

PLASTIC TOP FRAME

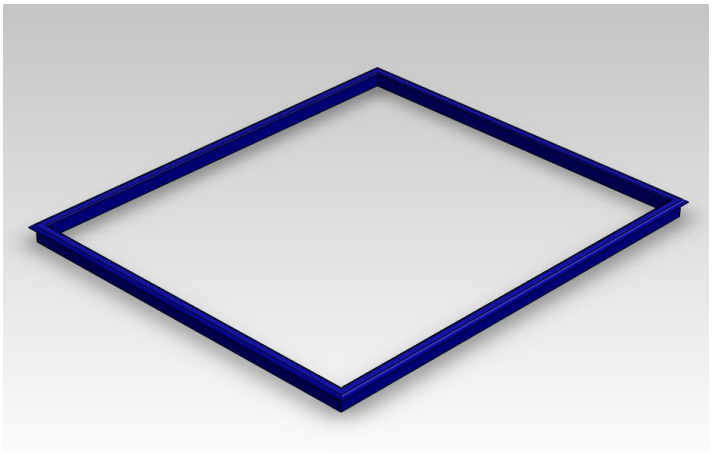
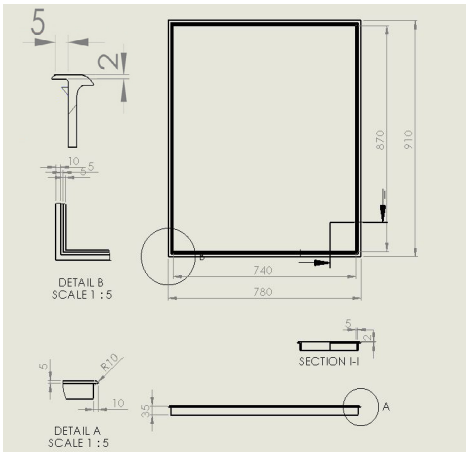


Figure 39 - Plastic Top Frame



Drawings - Larger in Appendix IV

Geometry:

This part is shaped to fill the gap between the top part and the kitchen top by overlapping both parts. The geometry of the part is shown in the drawing above and the technical drawings in the Appendix IV Page 54-56. As the geometry suggests the part will be joined with the other parts by 'click assembly'.

Materials

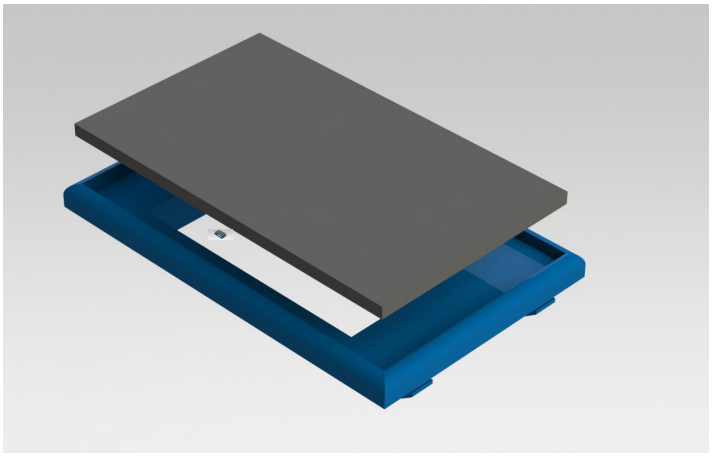
The material is Polyamide which can be sold in multiple colors to adjust to the design choices of the enamel. The selection was made by comparing popular injection molding materials on material properties like melting temperature and hardness[29]. The selected materials were Acrylonitrile-Butadiene-Styrene (ABS), Polyamide (PA), Polycarbonate (PC), Polypropylene (PP), Polystyrene (GPPS) and PEEK. PEEK had the pest properties. A decision was made on basis of the price of the material, which was too high. Polyamide was second best. A negative side of this plastic is its melting temperature of 210 degrees Celsius.

Production

Injection molding is a cheap way to produce this part as the production is 100.000 units. The click system will be released out of the mold due to the material elasticity. Possible problems will occur in the corners of the frame because of uneven material thickness which can cause stress when shrinking. This should be examined by an expert.

Plastic top frame	Machine costs	Price	Material	Price		Total:
	Injection molding	6	Polyamide	1,95		**7,95**

DISPLAY AND PLASTIC FRAME



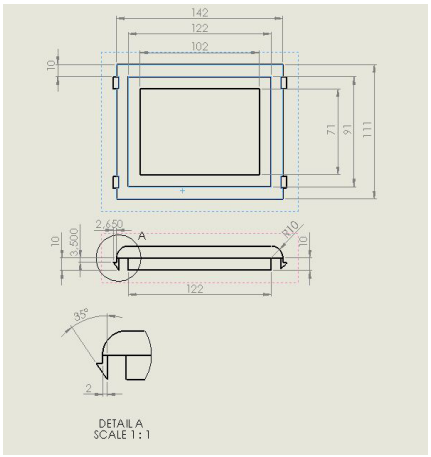


Figure 40 - Display and Plastic Display Frame *Drawings - Larger in Appendix IV*

Geometry:

A 7 inch resistive waterproof touch screen will be bought directly from a display producer. The resistive technology is chosen due to its high resistance to liquids and contaminants. The display is fitted into the product with a plastic frame. The connection with the plastic frame will be made with the use of a waterproof adhesive. This plastic frame is fitted into the top part by using the elasticity of the plastic for a ‘click fit’.

Materials

The same material choices were made at this part as the plastic top frame. Adhesive is used to fit the display in the frame.

Production

The frame is made by injection molding, this is a cheap way to produce this part as the production is 100.000 units. The click system will be released out of the mold due to the material elasticity.

Plastic Display frame	Machine costs	Price	Material	Price		Total:
	Injection molding	6	Polyamide	0,44		
			Adhesive	2		**8,44**

HEATING ELEMENT

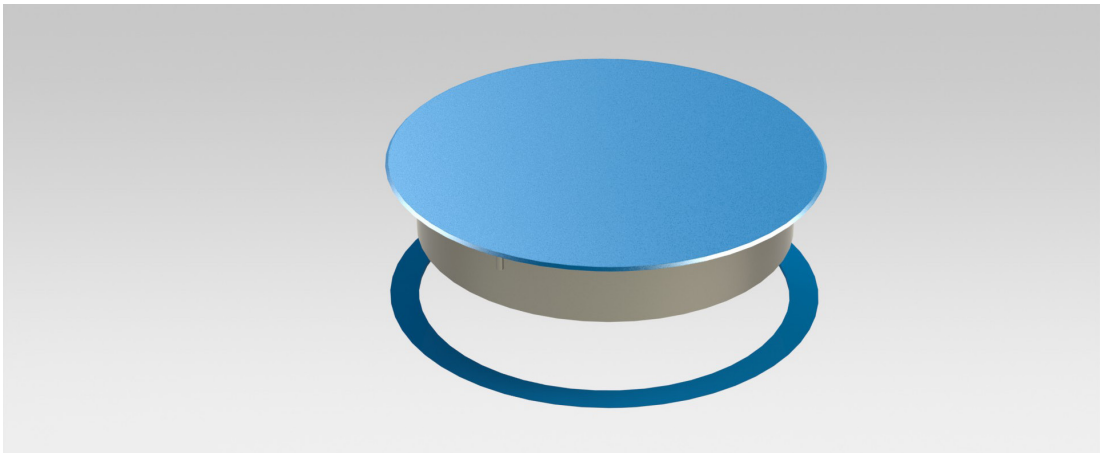


Figure 41 - Heating Elements

Geometry:

The geometry of the heating element is shaped like a short cylinder with a flat top. The insulation and sensors are positioned inside the cylinder, this choice is made on the basis of the geometry of other comparable products. The size of the flat top is determined by the requirements set by the layer system. Studs protected by insulating rings could be a way to assemble the heating element to the top part. The requirement of 300 mm Ø will be ignored in order to keep the size of the cook top less than 600mm in depth. The pans of this size can also be heated by smaller heating elements.

The sizes of the elements differ in size. The two biggest elements have a three layer system incorporated where the smaller elements only have a two layer system. The sizes in the analysis fase are considered in the sizing of the elements.

A ring of Isoplan 1000[30] is added between the heating element and his connecting parts. This should insulate the element and avoid possible heat transfer.

Materials:

The specific materials of the heating element are decided by ABINFO and described in Paragraph XX. Isoplan ® LOW EMISSION will be the chosen insulation between the element, studs and top part.

Production:

The precise production of the heating element depends on the production choices of ABINFO.

Costs:

The costs of the four elements are estimated as a total of € 150,-.

ELECTRONICS

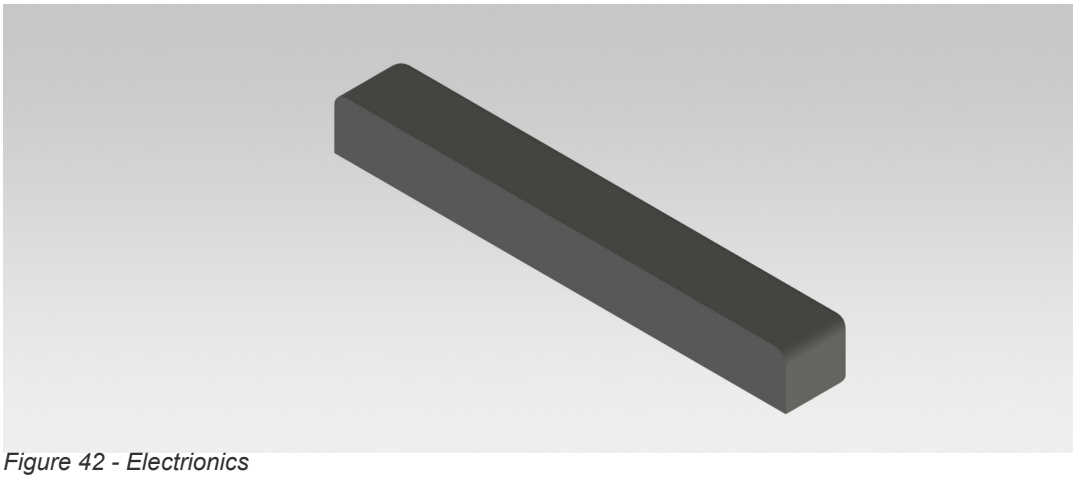


Figure 42 - Electrionics

Geometry:

The electronic system inside the cook top is shaped like a box to create room for this component. The sizes chosen for this black box should enable an electrical engineer to fit all components. The wiring and box will be connected to the top part to ensure easy access for maintenance work.

Materials:

The materials will be chosen by the electrical engineer.

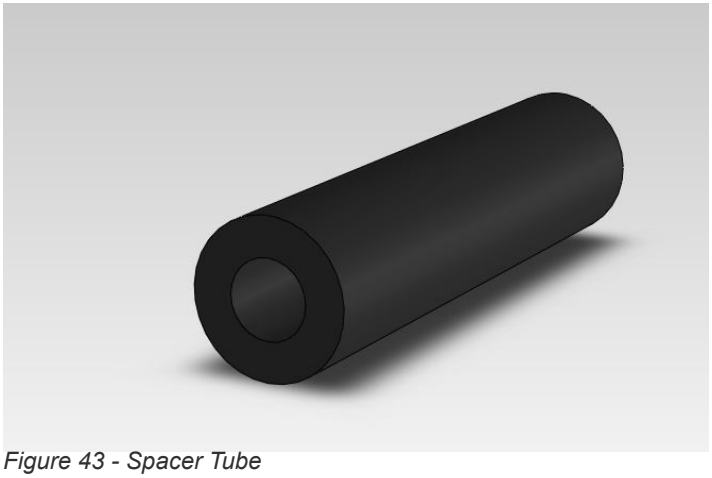
Production:

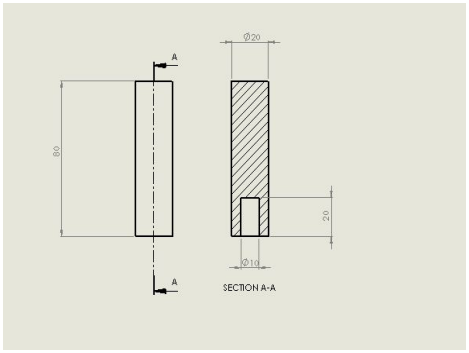
Production will be chosen by the electrical engineer.

Costs:

The costs of the electronics and programming will be estimated at € 100,-.

SUPPORT PARTS





Drawings - Larger in Appendix IV

Figure 43 - Spacer Tube

Parts:

To support the top part, spacer tubes should be added. These will be positioned at five points on the bottom part to support the top part. These spacer tubes will be bought as separate components and connected to the bottom frame by studs.

The cook top has to be connected to the kitchen top in a way the weight of the cook top could be supported. Connecting clamps to the bottom part and the cook top is chosen as a solution. The connection will be made by welding. These clamps fixates the system and stops movement in both up and down direction. The clamp should be able to hold the weight of the system. These components can be bought as separate components. As the clamps facilitate the last transfer to the kitchen top and should be able to handle the force requirements.

	Amount	Price		Total:
Insulating ring	4	2		**8**
Display	1	20		**20**
Spacer tubes	5	0,2		**1**
Clamps	4	1,25		**5**
Total				**34**

5.2 ASSEMBLY

The assembly will be shown in this paragraph.

As already stated in some of the descriptions of the parts in the assembly a few different connections are used. These ways and the different connections are displayed below:

Connecting Part 1	Connecting Part 2	Connection
Top plate	Bottom plate	Studs and bolts
	Heating element	Studs and bolts
	Plastic Frame	Click fit
	Wiring	??
	Display Frame	Click fit
	Electronic compartment	???
Bottom plate	Support pillars	Studs
	Clamp	Welds
	Kitchentop	Clamp
Display Frame	Display	Adhesive
Heating element	Isolation Ring	Form fit

Assembly step	Action	Start time	Time(min)	Workers
1	Heating element to rings	0:00	0,5	1
2	Heating elements to top part	0:30	3	1
3	Display to display frame	0:00	2	1
4	Display to top part	3:30	0,5	1
5	Electronics to top part	4:00	15	2
6	Spacer tubes to bottom part	0:00	3	1
7	Clamps to bottom part	3:00	4	1
8	Top part to bottom part	19:00	4	2
9	Plastic frame to top part	23:00	0,5	1
Total:		**23:30**		**11**

The total time of assembly is 23 minutes and 30 seconds with an assembly crew of 10 workers. Equipment used and the labor costs will give a man machine price for the time of € 80,-/hr. The total assembly cost will be €31,33.

5.3 TOTAL COSTS:

The total costs are calculated in this paragraph.

The total estimated costs are a summation of the costs per part and the assembly. The batch size is set at 35.000 pieces a year with a goal of 100.000 pieces. The overhead costs are estimated by a percentage of 20% of these costs and added to the summation. The costs of the Heating elements and electronics are roughly estimated as the production and assembly are not researched in this project. Further development and testing of the design is estimated at 10% of the total costs.
The total estimated costs will be € **492,33**. The total excel sheet can be found in Appendix VI on page 57.

Assumptions:			
Batch size	35000	/year	
	Man/machine costs:	**Material costs:**	**Price:**
Top part:	17,58	10,7	28,28
Bottom part:	10,92	7,79	18,71
Top frame:	6	1,95	7,95
Display frame:	6	2,44	8,44
Electronics			100
Heating elements:		150	150
Insulating rings	8	8	8
Display:		20	20
Spacer tubes:		1	1
Clamps:		5	5
Assembly:			31,33
Overhead:			75,34
Development:			37,87
TOTAL			**492,33**

5.4 LAYER SYSTEM

The layer system will be explained in this paragraph.

The idea is to create multiple heating layers in the heating element to adjust to the size of the pan. The element on top is still one plate. But the inductive layers will be split into three components with separate power input. These are placed in circles under the heating element. This way of heating a solid steel plate can give problems because of the badly spread expansion. The option of separating the steel plate into three elements was also an option. This option was ignored as the gaps between the elements could cause for cleaning problems.

Sensors in the heating element will detect the size of the pan and how many should be used. The system makes a decision based on the information, but can be overruled by a manual order. The sensors used in this system can be using a few different techniques. The sensor can use light, weight and electrical conduction.

The light sensor will work according to the reflection of light of the surface. Locating the sensor can be a problem because the steel plate is not transparent. Another problem is a dirty surface; this could block the signal and wrongly indicate a pan.

Electrical conduction can also detect a steel pan by two points on the surface. Connection points can be added in the multiple layers. A pan with a coating with a different level of conducting like enamel can cause a confusing signal. Other possible problems can be caused by non conducting material pans and conducting dirt on the cook top.

Pressure sensors are the best solution for the problem. They can be placed underneath the metal plate and surface conditions do not affect the signal. A high sensitivity might be needed. The sensor is closer to the heating element; the effect of the heath on the sensor has to be explored.

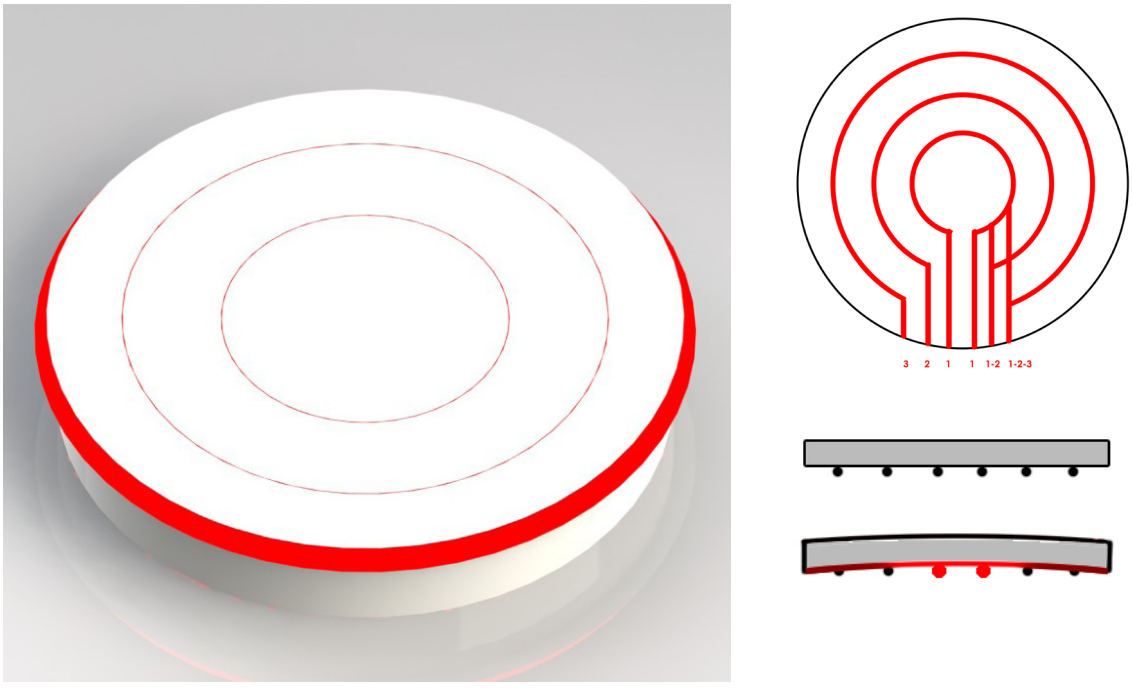


Figure 44 - Heating element illustrated

5.5 AIDED COOKING

The main point of aided cooking is helping the consumer cook more efficient. The main gaining points are heat loss by cooling of heating element, energy loss by overheating. Besides this main function, other functions are added to improve usability. these will be described in this paragraph.

Figure 45 - Home screen

Programmed cooking

The programmed cooking makes cooking some regular dishes easier. People eat certain dishes frequently, for example: If you always bake an egg in the same way, you can manually program this. The next time, you only have to select the program, shuffle when necessary (shuffle-warning could be used) and wait for the alarm.

Figure 46 - Programmed cooking

Copy Cat

Another way of programming can be used. To make it easier for the user, the computer can record your cooking behavior and create a program. By doing all the actions like changing temperature during cooking and putting your food on standby will be registered.

Cooking information:

During the process of cooking it is important to have access to the current processes of the system. The color of the icon (i) gives the hot surface warning. Red = HOT, Blue = COLD. When you open the menu, you will see which of the elements is HOT and what is scheduled.

Element control

This enables the user to manually control the heating element.

Other functions:

- Timer + Time indicated cooking (cook in XX minutes)
- Display lock mode (during heavy cooking/cleaning)
- Stand by function (maintains food temperature before eating)

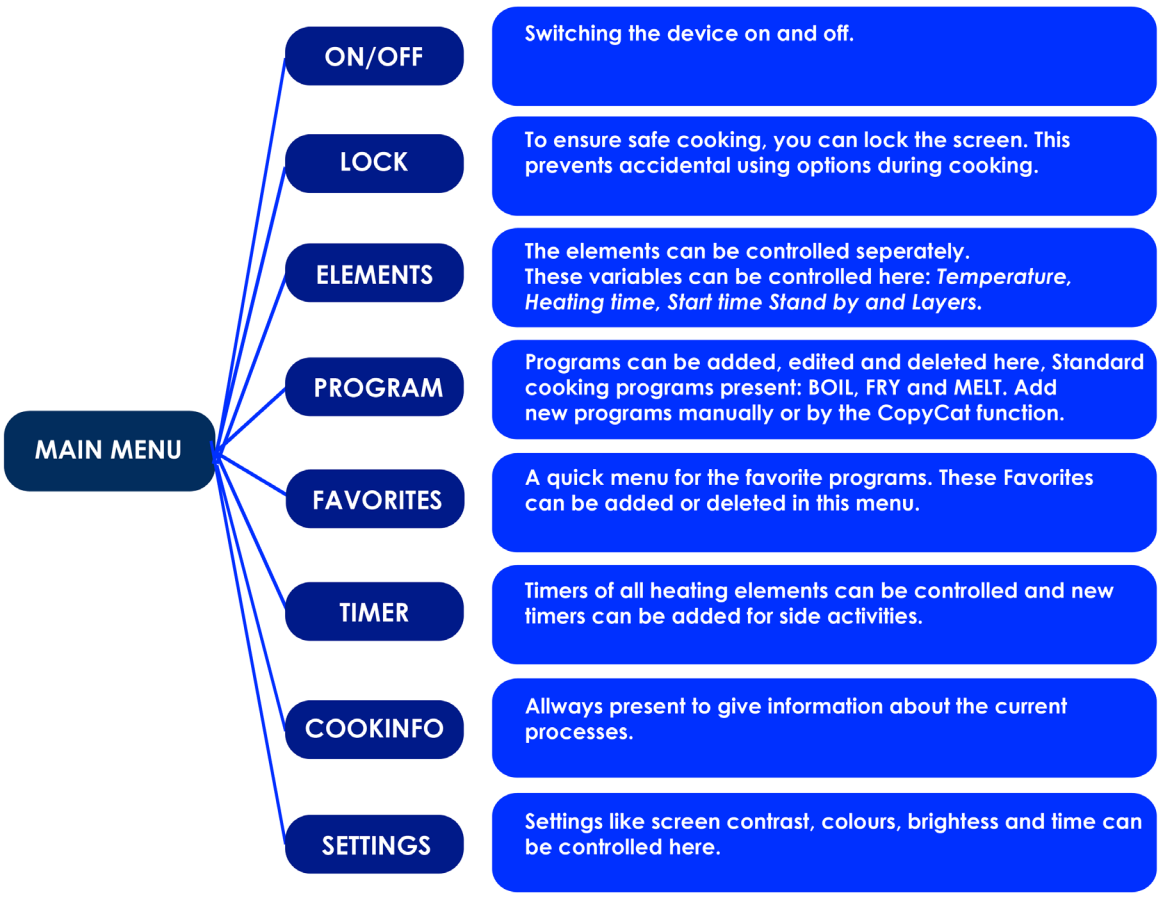
Input:

The chosen functions will need input of sensors and the user:

- The temperature should be measured
- The weight of the pan should be measured
- The time should be determined by the user

Figure 47 - Manual Element Control

Figure 48 - Menu chart



5.6 PERSONAL DESIGN OF THE TOP

One of the great aspects of this cook top is the ability to customize the design of the top. This design will be made by using enamel. This will be described in this paragraph.

Enamel

The material enamel is used in many household products. This material is smooth, hard, scratch resistant (5-6 on the Mohs scale), chemically resistant, long-lasting color fastness, easy-to-clean and cannot burn. It also has a similar thermal expansion rate as many metals. It is applied as coating on copper, aluminum, iron and steel. These properties make enamel a suitable material for kitchen equipment. The use of enamel can be found in many different kinds of products. For example: cooking pots, ovens, clothes washers, dryers, iron bath tubs.

Figure 49 - Enamel pot[27]

Design

In the past there have been many products with an enamel design. At this moment the design in enamel can be found regularly in advertising signs, cooking pots, jewelry and metal boxes (used for sweets and cookies).

This designing technique in enamel can be used in the cook top. The flat top surface is suitable for this kind of surface treatment. This means the consumer can choose to create his own design or choose one of the designs made by the company. The heating elements have a enamel coating as well and can be adjusted to the design. The color of the plastic frame parts of the cook top and display could make the design complete. Some possible designs are shown below.

Figure 50 - Enamel advertisement sign[28]

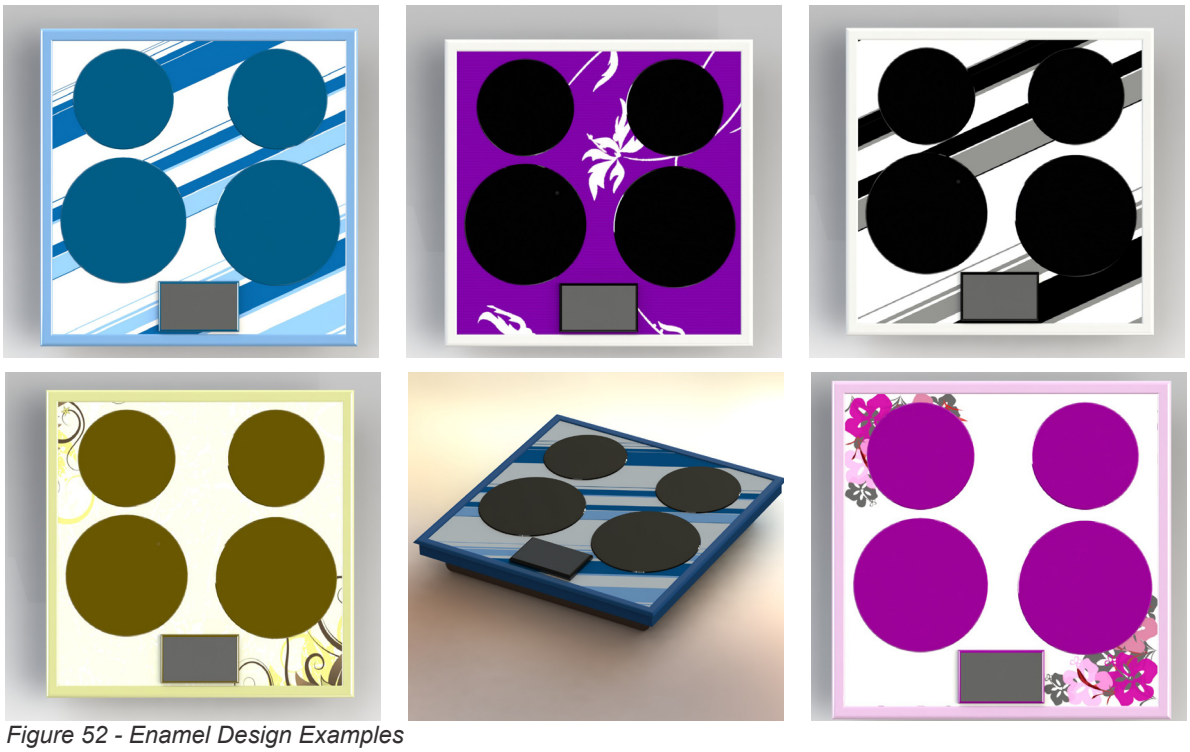
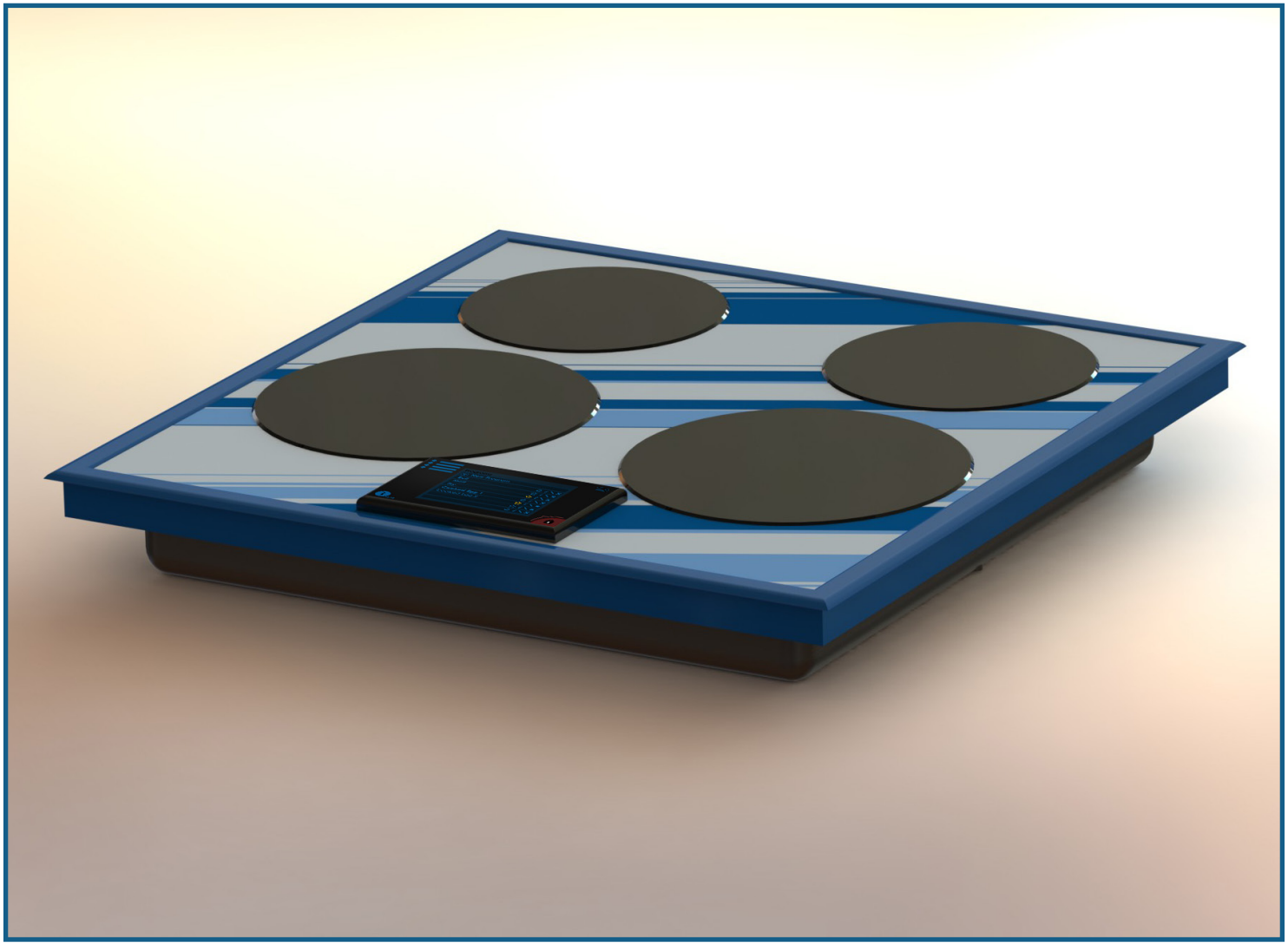
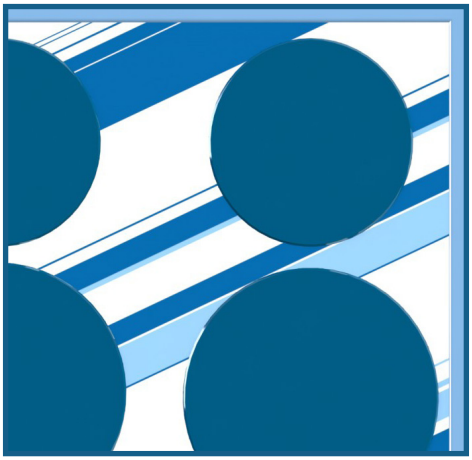


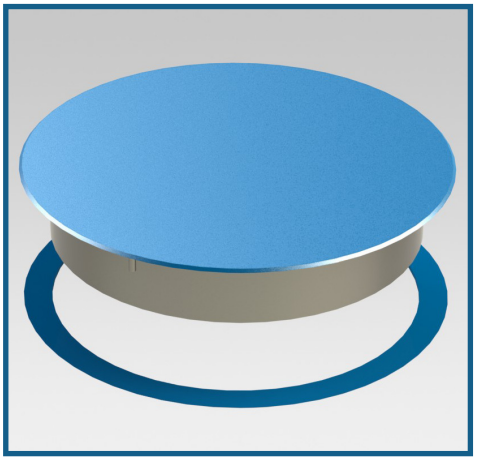
Figure 52 - Enamel Design Examples

6. PRESENTATION DESIGN

Figure 53 - Cook top render







DESIGN **USABILITY** **EFFICIENCY**

Figure 54 - Cook top

7. CONCLUSION AND RECOMMENDATIONS

In this chapter recommendations for future research and conclusions of the project will be made.

General goals

The main goal: 'design a cook top which incorporates the technologies of ABINFO regarding the heating element' is met by completing the sub goals. The multiple possible design directions are displayed and a choice of direction and product frame was made with ABINFO. The problem of 'the efficiency loss when using old pans with a bend bottom' was researched but no usable solution was found. The steps in creating a product were executed as planned. All parts are designed on a basic level. To continue with the development of the product these parts have to be reviewed by peers and redesigned on some levels. The execution of this design will probably change some of the now given specifications.

Technical aspects

No prototype is made for testing and no calculations have been made of stress on the system. Tests should be conducted and some parts have to be developed into further detail. However, the techniques and materials used are similar to other comparable products. This similarity and the material properties make it very likely the technical requirements are met. Although it is likely, these requirements should all be tested before going into production.

The degree of how waterproof the system is, is very hard to predict. This is a very critical point in the testing where possible problems may rise. This requirement should be tested more thoroughly.

The distortion because of heat shall probably not be a problem because of the material properties. A heated pan could be the biggest problem for the display and the plastic parts. Adding carbon to the plastic mix could enhance the conduction level. This will avoid melting because the energy can be quickly distributed throughout the plastic[32]. Displays with properties of withstanding over 150 degrees Celsius are common.

The HV of above 200 of enamel will give the cook top a scratch proof quality. The sharpness of the edges in contact with the user should be safe after surface treatment.

Heating element

Although the Heating element is regarded as a black box in this project a new aspect is are added to the existing element: the layer system. As mentioned in the report the different radius of heating could cause some stress in the element. The production and final design with the new aspect integrated should be researched and finally tested. ABINFO could look into the possibilities on this level.

Functional aspects

The first five of the functional requirements are physical requirements of the cook top. The only one of these requirements which is not entirely met is the requirement about the different sizes. The biggest element of the cook top has a 250 mm Ø, this is smaller than the given 300 mm Ø of the pans. These pans can be heated, but not as efficient as possible.

The last ten requirements are all about controlling the cook top. The resistive touch screen is regularly used in cooking and medical appliances. Therefore the assumption can be made that a wet display surface should not trouble the user.

The program layout developed should cause the requirements of the functional control of the cook top all to be met. Only functions are shown in this report. The electrical and program part of the system have to be further developed by experts and integrated in the final product. A user test should indicate the usability if the system.

Result

The result of this assignment is a concept design of a cook top with many new attributes and new possibilities. The combination with a price which fits in the Brazilian market and new techniques give the cook top a good future perspective.

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APPENDIX I - FUTURE CONSUMERS

A vision of a future consumer group will be described in this Appendix.

The reserves fossil fuels are decreasing and a lot of new methods to generate new kinds of energy are explored. One of these fuels is gas. It is speculated that in the future these fuels will not be easily available and will be more expensive than new energy. Gas, which is used for heat and cooking, is one of these fuels. Being economic with energy could be a new cultural aspect which influences everyday live decisions and purchases. An efficient way of cooking is one of the many aspects in this new culture which may become important.

This new consumer will have a whole other vision than is usual in the current culture. This new vision can only be fantasized by trying to make a futuristic design. As said the efficiency will be important in this product and the new methods of cooking can be incorporated as idea for the future. The costs, materials and production processes cannot be predicted as the technology will evolve in time. This also means that the budget of the consumer and the size of the consumer group will become irrelevant.

As this group will require a futuristic design and functions, the futuristic aspects will be non-realistic when looked at the current possibilities in production process and technologies.

AKATU

AKATU is an organization who influences this consumer group.

Not only the government is working on helping the environment in actions which try to affect on a daily basis. There are also many NGO's (non-governmental organizations) planning actions to protect the environment. One of those organizations is called 'Akatu'. This is an organization that encourages people to change their lifestyle and consuming behavior to spare the environment in any way possible. This helps the consumer group who care about the environment to make good decisions regarding their consuming behavior.

'It is your lifestyle that will tip the balance to a better and more sustainable or waste, pollution, decreased quality of life, social inequality, destructive growth, global warming and the risk to the continuity of human life on the planet.'

[Direct translation using translate.google.com: http://www.akatu.org.br/Temas, Retrieved at 17-09-2012]

APPENDIX II - NEW COOK METHOD

In this appendix a new cooking method based on an American research will be described.

An American research group started a research to see what energy was necessary to cook food. To see where energy can be won, first the temperatures needed to cook food and kill the bacteria are researched. This temperature is a lot lower than the current temperature used to cook food. It lays around 74 degrees Celsius. The lower temperatures used to cook will give a more efficient use of energy than current methods.

An English research shows another way to reduce the use of energy. They tested the use of an electric cook top on energy use influenced by human factors. The results show that because of the way of cooking (tested by instructing a specific task) the use of energy was 3 times more than necessary. The differences were found in time management, temperature management and use of materials.

This insight can create a new type of healthy and environmental friendly cooking. This way of cooking might have a different cook time, preparation of the food and taste of the food. The methods can be used in the new cook top and to create a new design.

This new cook top will need other properties than the current cook tops. The temperature needed is far less, which means other materials and techniques can be used. A timer function will be needed to help the new user to get acquainted with the new cooking style. A new display could be added incorporated with new recipes of the new cook style and access to an online database. This way the user can be guided while cooking and it would be much easier to get the best food preparation.

It is hard to predict what might happen in the future regarding this new style of cooking. A short list of possible effects is added below.

Effects, consequences and possibilities

Neutral effects:

- People will have to get acquainted with a new system
- Cook rules
- Ways of preparing food
- Timing of cooking and dinner
- Tastes of food
- Structure of food
- Appearance and color of food
- Recipes altered (in shops as well)
- Health issue
- Research

Negative effects:
- Fear of the new style
- Leaving traditional ways of cooking
- Traditional food cannot be replicated (tastes)
- Some food might be impossible to prepare

Positive effects
- New line of food
- New hype
- Support by the government(like electrical cars)
- Environmental advantage
- New is better?
- Cookware will be spared(less heat)
- Less burning food/stuck on pan

This idea can be translated into functions of the cook top programming. A few examples are given below.

New combined functions for the cook top
- The display has to be used for recipes and for cook programs
- The display should be able to scan a product/barcode to find a recipe
- The display/computer should be able to communicate with multiple devices(like laptop/tablet/phone)

L.Oliveira, V. Mitchell, K. Badni, Cooking behaviours: a user observation study to understand energy use and motivate savings, Loughborough University, 2012

APPENDIX III – ELECTRICAL COOKING METHODS

Different ways of Electrical cooking will be explained in this Appendix.[13,14]

Inductive

Inductive heating cook tops use the method of magnetic induction. Electricity is used to produce a magnetic field that sends currents into iron atoms that react by movement which causes friction and heat in a metal vessel. The electro-magnetic elements are housed under a ceramic-glass surface. Disadvantages are: the limited materials of the cookware which can be used and the costs which can be 3-5 times higher.

Radiative

A radiative cook top uses the radiation of a halogen heating element for cooking. This heating element is created by halogen lamps beneath a glass ceramic plate, below the lamps a reflector is positioned to direct the heat upward.

Conductive

The resistive cooking technique is based on resistive wires. These wires are made into a spiral and create heat by putting a current on these wires. This is a relatively simple system to create and produce. There are three different cook tops which control this segment of the market.

Conventional Coil

The most common of the three methods is the conventional coil. The method is based on a resistant wire which is leading through a metallic casing filled with an insulating material. The tube is made into a spiral and flattened to create an optimal surface for the heat transfer with cookware.

Solid Disk

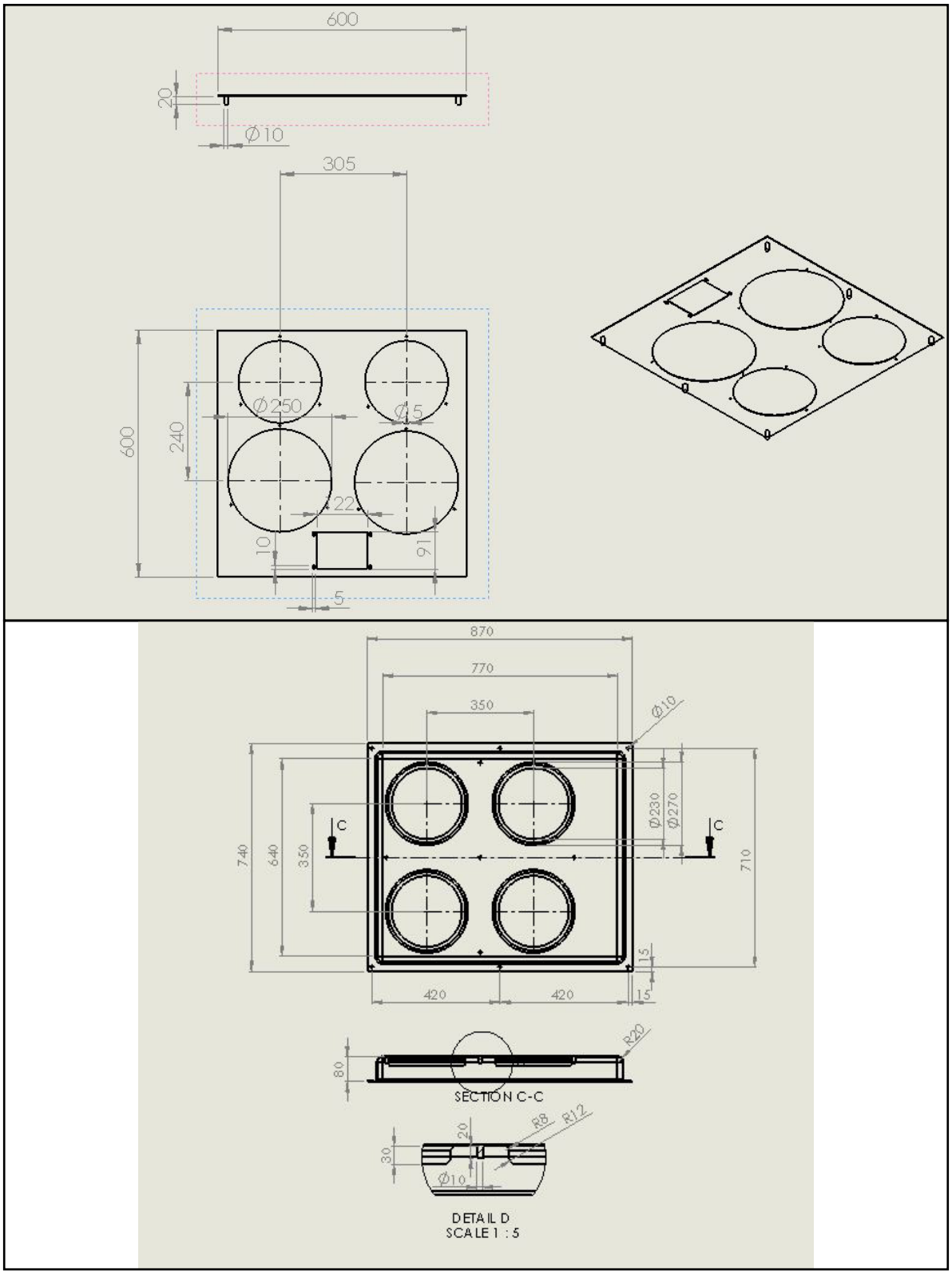
This method also uses the resistant wires in its system. These wires are embedded in an insulation layer and covered with a solid disk. This disk spreads the created heat and transfers the heat to the cookware through conduction.

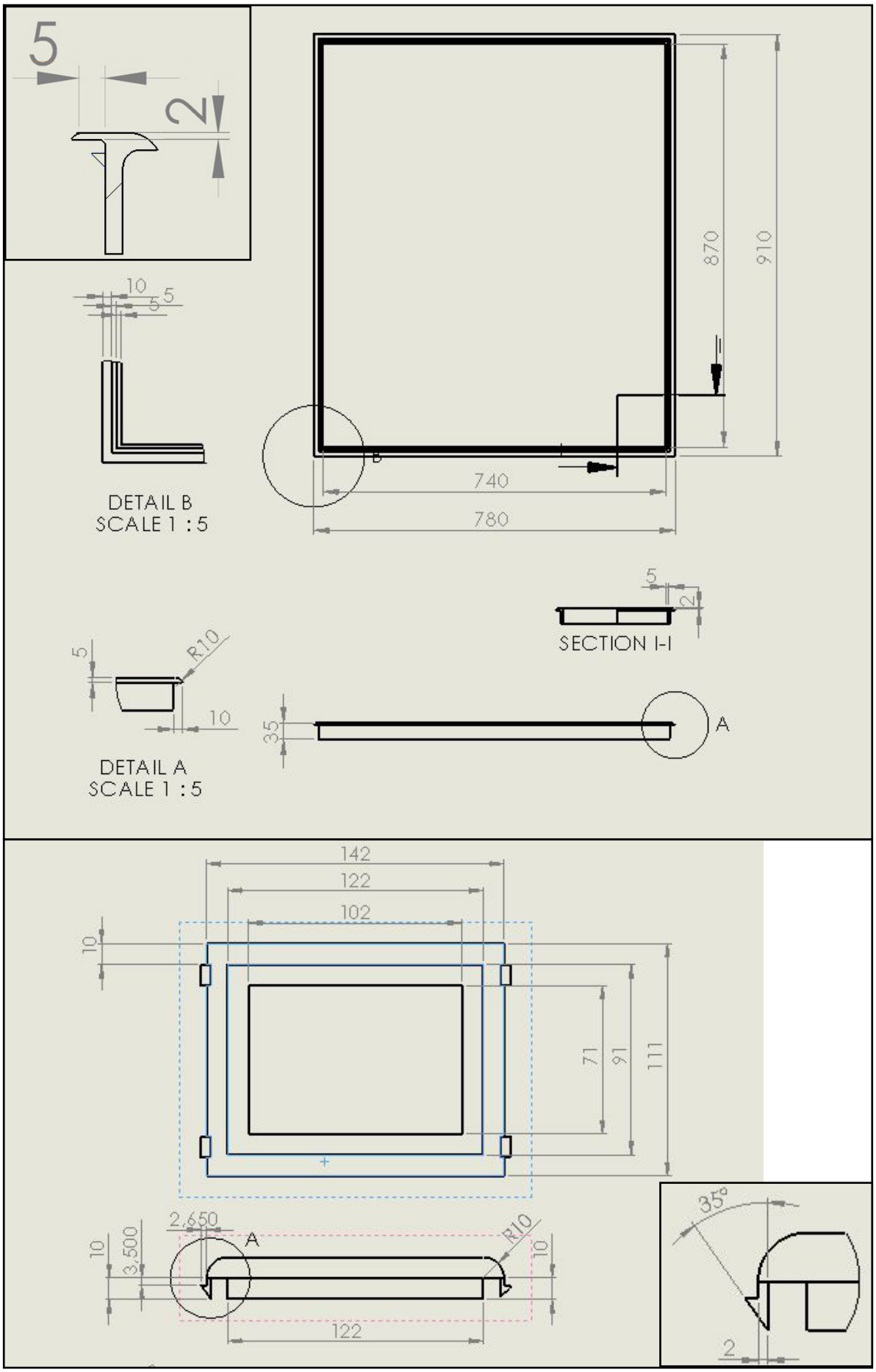
Glass Ceramic plate

Some glass-ceramic cook tops have thermostatically controlled elements. The units turn off and on to maintain a precise temperature. Glass-ceramic cooking surfaces tend to be slower than the other cooking systems, except the solid disk. Glass ceramic is transparent to IR radiation which is responsible for heating the pan; only 30 % of the generated heat is transferred by thermal conduction.

APPENDIX IV – DRAWINGS

Simple Solid Works Drawings of the part ar shown in this Appendix.

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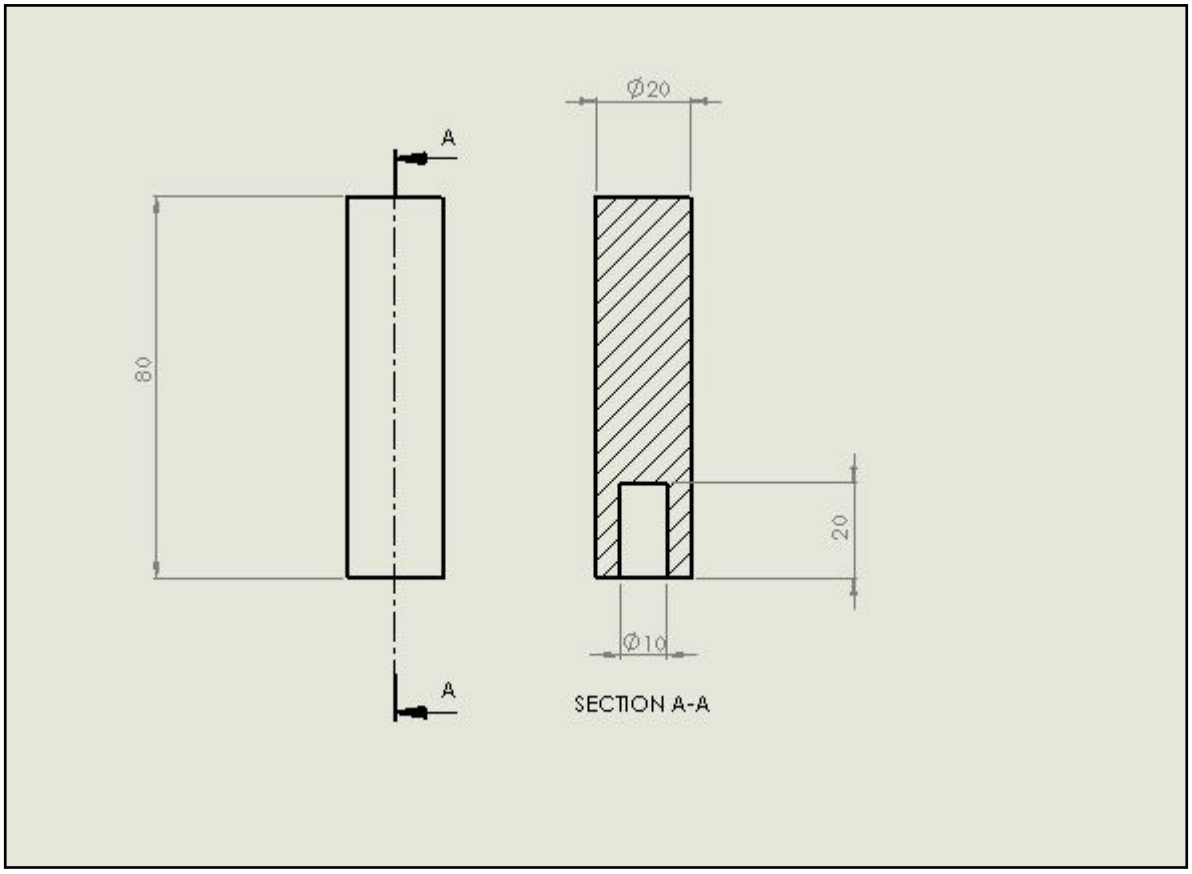
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SECTION A-A

APPENDIX V - COSTS

Assumptions:									
Batch size	**35000**	**/year**							
Cost for complete stamp*	15000	euro			Steelprice	1,4	euro/kg		
Punch Man/machinekosten pers (inc. stamp)	50	euro/hr			Plate volume (600*600*2)	0,00072	m3		
Stiftlasmachine *	10000	euro			Steel density	7850	kg/m3		
Stiftlasmachine man/machine	30	euro/hr			Trimming waste plate	15	percent		
Emailleren	15	euro/stuk			Studs	0,1	euro/stuk		
Coating steel parts	100	euro/hr			Bolts	0,1	euro/stuk		
Toppart	**Machine costs**	**time/hr**	**Price**		**Material**	**Weight/kg**	**Price**	**Total:**	
	Punch	0,01	0,42		Steel	6,5	9,1		
	Stud weld	0,02	0,50		Studs and bolts		1,6		
	Enameling and surface treatment		15,00						
	Steel coating	0,02	1,67						28,28
Assumptions									
Batch size	**35000**	**/jaar**							
Deep drawing mold	30000	euro			Steelprice	1,4	euro/kg		
Deep drawing man/machine	50	euro/hr			Plate volume (600*600*2)	0,00049	m3		
Punch drawing man/machine	50	euro/hr			Steel density	7850	kg/m3		
Trimming drawing man/machine	20	euro/hr			Trimming waste	15	Percent		
Stiftlasmachine *	10000	euro			Studs	0,1	euro/stuk		
Stiftlasmachine man/machine (inc machine)	30	euro/hr			Bolts	0,1	euro/stuk		
Stiftlastijd	1	minuten							
Coating steel parts	100	euro/hr							
Coating steel time	1	minuten							
Bottom Part	Punch	0,01	0,42		Steel	4,42	6,19		
	Deep draw	0,17	8,33		Studs		1,60		
	Stud weld	0,02	0,50						
	Coating	0,02	1,67						18,71
Plastic mold	30000	euro			Price polyamide	3	euro/kg		
Plastic injection molding man/machine	360	euro/hr			Part volume	0,00057	m3		
					Polyamide Density	1140	kg/m3		
		Time/hr	Price			Kg	Price		
Plastic top frame	Injection molding	0,017	6		Polyamide	0,6498	1,95		7,95
Small size element	25	euro/piece			Big size element	50	euro/piece		
		Pieces	Price			Pieces	Price		
Heating element x 4	Small size element	2	50		Big size element	2	100		150,00
Electronics and programming									100,00
Plastic mold	30000	euro			Price polyamide	3	euro/kg		
Plastic injection molding man/machine	360	euro/hr			Part volume	0,00013	m3		
					Polyamide Density	1140	kg/m3		
		Time/hr	Price			kg	price		
Plastic display frame	Injection molding	0,017	6		Polyamide	0,1482	0,44		
					Adhesive		2		8,44
Insulating rings	2	Euro/piece							
Insulating ring x 4					Insulating ring 4x		8		8,00
Display									20,00
							Price		
Spacer tubes x 5					Spacer tubes 5x		1		1,00
							Price		
Clamps x 4					Clamps 4x		5		5,00
					10 man assembly + 9 assembly stappen				
					Assembly man/machine	80	euro/hr		
					Assembly time	23,5	min		
Assembly					**Assembly**				31,33
Subtotal									378,72
					Development:				37,87
					Overhead	20%	van het totaal		75,74
Total									492,34

APPENDIX VI - FORCE DISTRIBUTION

The forces of the system all have to be distributed to the kitchen top. A simple schedule of the forces will be shown in this Appendix. This hierarchy shows how the forces are expected to be distributed.