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An approach for the generation of target product specifications in the development of home appliances

Marcel Morosini, Milton Borsato
Universidade Tecnológica Federal do Paraná – UTFPR
e-mails: marcel_morosini@hotmail.com; borsato@utfpr.edu.br

Abstract: Product designers need to conduct product development projects based on detailed and complete technical specs that mirror consumer requirements. Target product specifications poorly met or assumed incorrectly may potentially cause serious problems for companies such as excessive cost, low quality and long time-to-market. The main objective of the present work was to propose and validate an integrated solution (method and tool) for facilitating the generation of target specifications applicable to home appliance products. The proposed method is able to automatically generate target specifications for each sub-system of the product starting with customer needs as identified by Marketing teams. Information obtained in a systematic and assertive manner can then be used in the Conceptual Design stage of the product development process, when design solutions are generated. Results were validated through a comparative study of three products designed and manufactured by a large transnational home appliance manufacturer enterprise located in Brazil. Target specifications resulting from the application of the proposed tool were compared to actual characteristics of the products studied.

Keywords: home appliance; target specifications; product development.

1. Introduction

Surviving in the current fierce competitive market requires companies not only to develop new products which meet the needs of customers, but also to strive constantly for improving the quality perceived by the consumer, as well as reducing costs and development time (JIAO; CHEN, 2006). Therefore, it is necessary for designers to conduct product development projects based on detailed and complete technical specs that mirror the needs of consumers.

The process of determining target product specifications is critical and of utmost importance for launching products with high quality and low cost (NELLORE; SÖDERQUIST; ERIKSSON, 1999; ROZENFELD et al., 2006). Such specifications should consist of objectively described and structured data, clearly derived from the survey, analysis and understanding of customer needs, and deployed throughout the product development process. It is essential that this list of requirements be drafted properly for avoiding misinterpretations that would otherwise lead to mistaken conceptual alternatives.

Target product specifications poorly met or assumed incorrectly may potentially cause serious problems for companies such as excessive cost, low quality and long time-to-market. Without proper tools to produce product specifications, the qualified information withdrawn from the consumer market may be wasted, in the form of products that do not meet customer needs.

According to Cooper (2001), new products with clear and refined definition of target specifications have 85.4% chance of being successful, i.e. 3.3 times more than a product with poorly formulated specifications. Mckay, De Pennington and Baxter (2001) claim that target specifications are of better quality regarding completeness and consistency with the voice of the customer, when generated from methods and techniques specific to certain types of product. According to Baxter (1995), a few factors may determine the success or failure of a new product. In addition to aspects related to market orientation and internal factors to the company, prior planning of specifications increases by three times the odds of a product to be successful. For this, target specifications must be clearly defined before development is to be commenced.

Rozenfeld et al. (2006) and Cristiano, Liker and White (2000) suggest that QFD Quality Function Deployment is the most common method for converting the customer's voice into product specifications, mainly in the automotive industry. However, in other industries that require shorter time-to-market, such as the household appliance industry, methods for generating specifications are generally ignored. Slowness of existing methods, long time for completing tools and spreadsheets, and the need to bring together experts from different areas are the main obstacles for using QFD, which supposedly facilitate the development of product specifications (CHENG, 2002; JIAO; CHEN, 2006).

Household appliances are developed from target specifications that may not properly cover all the important features and aspects appointed by customers. This may create some problems in product development, such as delayed discussion of product specifications in the development process, frequent changes in specifications that impact time and cost of project, and excessively broad or overly strict requirements when there is no need.

Wei, Liu and Chen (2000) developed a system to automate the product development process. Through a software tool one can manage the product planning stages, survey of customer needs, product design to modeling virtual 3D prototypes. Product specifications are automatically generated by the software after the collection of customer needs. For Wei, Liu and Chen (2000), this system is able to structure and improve the conversion of customer needs in concrete product specifications and unambiguous and reduce changes throughout the project. Thus, the main benefits to the process of product development are: reduction of development time, reduction of costs and improvement of product quality. The system was developed for a shower nozzle, and further work should be undertaken to develop a generic system able to design different products. In this approach, a large number of geometric parameters for the automatic generation of 3D models from the specifications are required. This automated system has its application restricted to well-defined products. In this particular case, a shower nozzle was used, for which significant changes in the concept of the product are not intended.

Yu, Wang and Yu (2008) proposed yet another method for generating target product specifications of customizable products using neural networks. In this case, the specifications are treated as variables in the process and represented by mathematical formulas. The neural network is a trained system capable of mapping customer needs into product specifications. This system is trained by iterative calculations based on existing case samples. In a layered architecture, the flow of information traverses the network in one direction, from input to output, ultimately resulting in product specifications. The first task is to discover customer needs and determine functional requirements with the application of QFD. Then, the neural network is used to define the specifications of other customers who want specific features in the product. The positive aspect of using neural networks is the ability to customize products through variable parameters. However, training neural networks involves complex mathematical calculations based on existing cases and probabilistic samples of training, which hinders its practical application.

The main objective of the present work was to propose and validate an integrated solution (method and tool) for facilitating the generation of target product specifications applicable to home appliance products. In order to concept proof this approach, a field study is carried out by means of comparing current product development practices and final features of a given product launched in the consumer market by a world-wide manufacturer of home appliances, to those virtually obtained with the use of the approach proposed by the present work.

The structure of the article contains a brief theoretical background on methods and tools for generating and managing specifications. The following section discusses methodological issues applied in the work, as well as the procedures for preparing and validating the proposed method. Following the results obtained from the field study, and, finally, the conclusions of this work are presented.

2. Theoretical background

The activity of developing product specifications is one of the most important ones in the beginning of the development phase because it brings together the entire set of attributes and goals that the product must meet (BACK et al., 2008). Therefore, it provides project information for subsequent development tasks. One of the most used and quoted tools in the literature for supporting the translation of customer requirements into product specifications is QFD.

QFD is a systematic way of obtaining information relating to quality, aiming to achieve the focus of quality assurance during product development (CHENG, 2007). According to Pahl et al. (2007), QFD aims to ensure product quality through product planning and the fulfillment of business processes oriented by costumer needs.

The use of QFD is simple. However, it is lengthy and time consuming because it is extensive and depends on many people from different departments. QFD also has certain subjectivity, since the result may vary depending on the participants. Some authors propose it to be adapted for overcoming such drawbacks. Lo, Tseng and Chu (2010) propose the application of QFD in only one step, with the aim of reducing the time and cost of development. The translation of the voice of the customer is conducted by specialists from different departments and occurs simultaneously to three houses of quality. Jiao and Chen (2006), on the other hand, propose that the processing requirements of consumers be divided into three steps: (i) explicitness for the requirements survey based on different types of customers and competitors' products; (ii) analysis for interpreting the voice of the customer; and (iii) specification for the precise definition of functional requirements.

Jiao and Tseng (1999) developed the PDFR method (Functional Requirements Product Database - Database for

Product Functional Requirements), which is a systematic approach to draw up specifications by standards of functional requirements based on existing products. In this approach, the management of requirements is automated in the form of RMDB software (Requirement Management Database - Database for Requirements Management). The advantages of this method are related to the functions implemented by the software to integrate the requirements of consumers and product specification, generate product specifications that will meet customer needs and provide project information for those involved. Research techniques such as clinics, interviews and brainstorming are useful to highlight the voice of the customer, but it is difficult for Marketing to generate design requirements, as it does not have complete understanding of the information that Engineering needs for development. Through PDFR methodology, though, Marketing and Engineering teams share customer information in the same format and structured manner.

There are many other methods for mapping the voice of the customer into the voice of Engineering. Jiao and Chen (2006) comment on some of them, such as the optimization model and evaluation of the consumer (Core), a methodology for organizing specifications in Engineering (Moose), a kit of computational tools to generate specifications for products variants based on known standards requirements, and a redesign methodology based on the determination of specifications by projecting historical data. However, QFD is still recognized as the most used tool. The most discussed products in the literature regarding the specifications are related to the automotive, electronics and OEM products industry. Table 1 presents the main insights on the topic of product specification according to the type of product researched.

Table 1. Product specifications according to product type.

Product Type	Perceptions	Product specifications	Source
Automotive Aircrafts	Marketing elaborates requirements in accordance with customer needs and business strategies. Engineering translates Marketing requirements into Product specifications, involving other areas such as Industrial Design, aftermarket and suppliers.	Technical specifications are generated in the following order: - general characteristics - architecture - subsystems - components In the aircraft industry, specifications are managed through compliance cards.	Nellore, Söderquist and Eriksson (1999)
Automotive	Product specifications have influence on the decisions of development outsourcing to suppliers.	Elaboration of a matrix to assist the decision indicates type of supplier necessary, product, generator, nature of specification, evaluation of degree of competitiveness and strategic vulnerability.	Nellore and Söderquist (2000)
"Black Box" Products	Work plan based on a number of factors involving the relationship with suppliers to assist the development, management and evaluation of product specifications. Modifications on specification throughout development are inevitable, and must be interpreted as a competitive advantage, and not wasted time.	The main specification problems regarding suppliers are of technical content, modifications, cost, interpretation and supplier involvement in the process. Specifications in "black box" are considered adjustable technical documents.	Karlsson, Nellore and Soderquist (1998)
Electronics	A good management system specification product in the customer-supplier collaborative environment is crucial to the development of quality products.	The main specification management problems between company and suppliers are frequent changes, too general or too rigid specifications, standardization and optimization of insufficient cost. Practices for better management performance suggested specifications should be implemented in practice.	Lam, Chin and Cheung (2006)
Bus	Different types of customers; entrepreneur and end-user buyer must be studied for surveying the needs of the consumer.	Product specifications are generated from information from internal sources (strategic planning, business objectives, history of previous development) and external (customer survey).	Lamb and Tamagna (2010)
Sustainable Products	Need to include environmental, social and economic aspects in the design specifications.	Construction of a systematic requirements management appropriate to the sustainable PDP to facilitate the development of sustainable solutions effectively.	Marx and Paula (2011)

Source: the authors.

3. Methodological aspects

A case study was adopted as the research strategy for this work. A field research was conducted in a large transnational home appliance manufacturer enterprise located in Brazil. The research was carried out through individual interviews with open-ended questions using a semi-structured questionnaire, which allows a greater depth in the approach when necessary.

Interviews were conducted with 20 key people in the company, who take part in the planning stage of the project and informational design. The interviewees are managers and project leaders from the departments of Marketing, Industrial Design and Engineering, responsible for different product lines.

The requirements for the proposed method were then identified. Thus, alternatives for a tool were generated for subsequent evaluation. The deliverable for this step was a tool prototype, which presented the best potential to meet the proposed requirements.

3.1. Creation of method and tool

The architecture of the tool is similar to the neural network proposed by Yu, Wang and Yu (2008). It consists of three layers: (i) an input layer that brings data of customer needs; (ii) a hidden layer for processing and crosschecking with the database; and (iii) an output layer composed of target product specifications.

The list of specifications is formalized to the entire project team, and serves as a reference for the development of solutions in the next step of generating solutions for the product. Figure 1 shows the functional model for the proposed method based on the PDFR method. Project information from Marketing should be forwarded to Engineering, which automatically generates target product specifications through a tool based on the concept of an expert system. The list of specifications is formalized to the entire project team, and serves as reference for the development of solutions in the next stage of development, Conceptual Design.

The database tool is created based on previous product development projects and tacit knowledge captured from experts. Thus, it is possible to generate specifications based on requirements, features, metrics and pre-established values. For organizing the database, it is necessary to consider the product structure, in systems and subsystems. The database is comprised of all known customer requirements for each subsystem. Such requirements are directly related to specifications of known products.

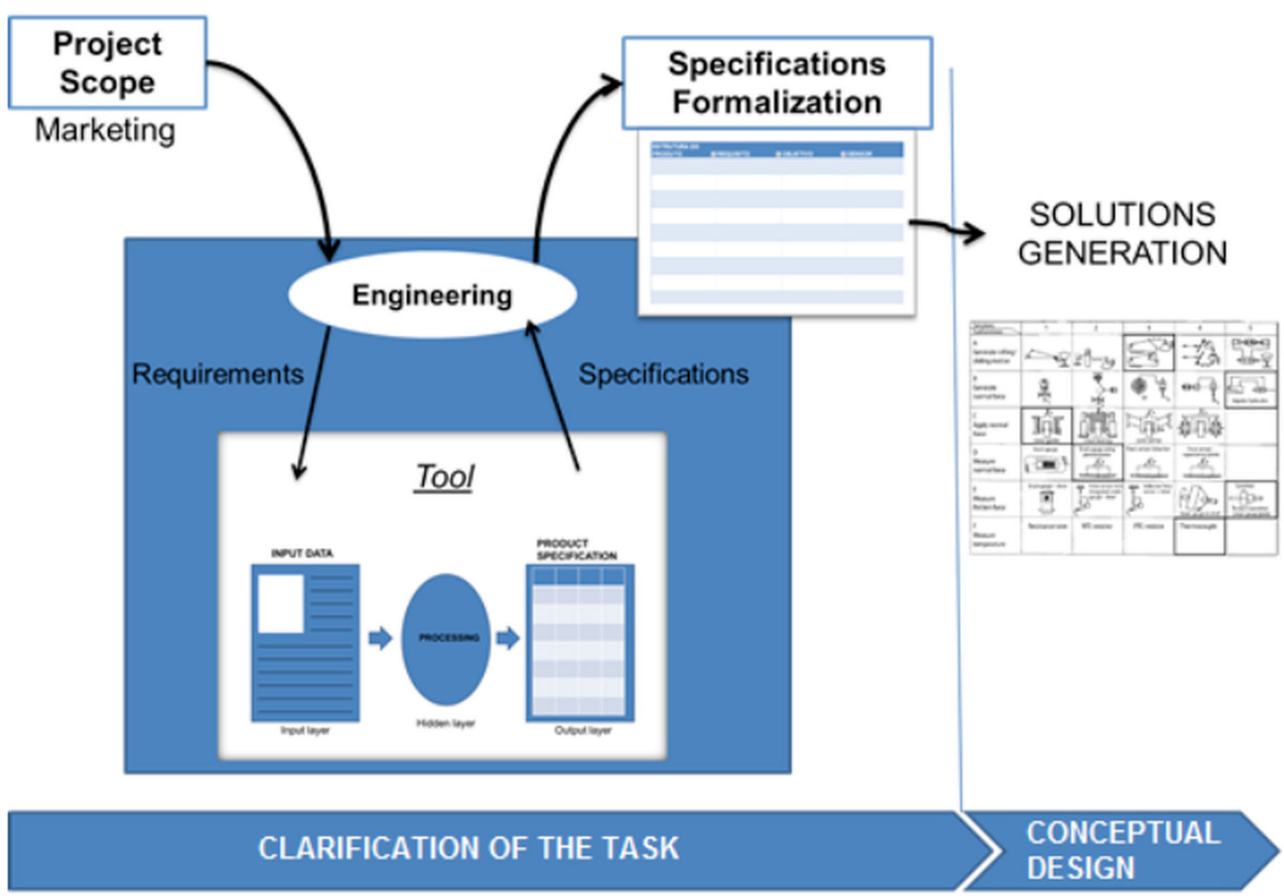


Figure 1. Functional model of the proposed method. Source: the authors.

The correlation structure of the product, which links customer requirements to target specifications, is performed using an operation flow as shown in Figure 2. This overall system is deployed as a combination of subsystems that meet certain requirements. Therefore, the more complex a given subsystem is, the greater the amount of scrolling levels and requirements is. Thus, for each different combination of requirements, there is a set of target specifications for meeting the initial Marketing demand for a product.

In order to test and validate the method, three real cases were selected for tool implementation and verification. The case studies were conducted in the context of projects that had already been finished in accordance with current corporate procedures. The proposed tool and method would be validated if results from its implementation were equal to or better than those found on existing product specifications.

4. Results and discussion

The main perceptions identified in interviews with employees involved in the product development process in the company studied were investigated. A list of requirements that a method and tool should have to be really useful in daily business was obtained. The main requirements raised were: (i) ability to formalize target specifications in a single document, containing objective and clear data; (ii) ease of handling; (iii) ability to increase assertiveness in a project; (iv) accessibility for the sake of constant specifications checking; and (v) no dependence on designer experience.

Based on these requirements, an analysis of existing methods for the generation of target specifications of a cooker was carried out. For that, current practices adopted for product development process within the studied company were considered, as well as input information from Marketing.

Input data are transmitted primarily through briefing and design reviews. This information is then forwarded to Engineering, which would automatically generate target specifications using an expert-system-like tool.

For the construction of the expert system prototype, a cooker was selected as a test case. The product breakdown structure was realized as presented in Figure 3, based on knowledge and experience of the Engineering staff. Then the main requirements and corresponding target specifications for each product subsystem were defined.

Regular spreadsheets were used as a primary means for deploying the system. Thus, three worksheets were created: (i) input data for selecting requirements for each subsystem;

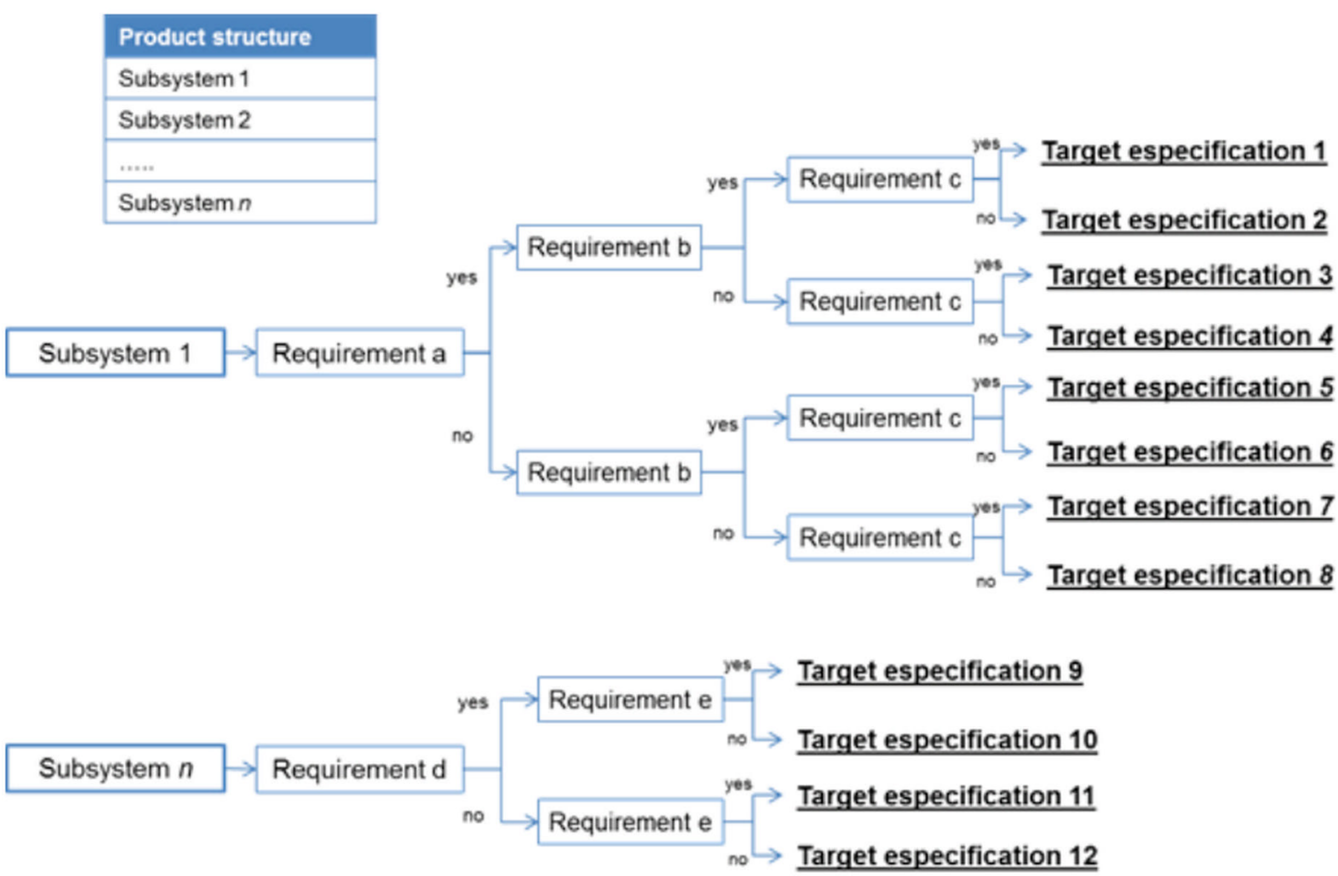


Figure 2. Operation flow. Source: the authors.

- Price*
- Knobs
- Oven
- Platform
- Electrical/electronic system
- Gas - insulation system (big oven)
- Hob
- Cover
- Gas - insulation system (small oven)
- Grill pan support
- Handle
- Ignition
- Burners
- Door
- Color
- Hob efficiency*
- Stove
- Security NBR 13723-1*

**Non-physical project drivers*

Figure 3. Product breakdown structure. Source: the authors.

(ii) processing for capturing input data and exchanging information to and from the database; and (iii) product specifications, which presents the resulting list of target specifications in the form of tables.

The selection of requirements in the input data spreadsheet was performed using combination boxes containing, in most cases, options "yes" or "no" (Figure 4[1]). In some cases, the options of the check box were more specific, e.g. the number of burners that the stove must have. The worksheet cells are protected against modifications; therefore, one can only select the options offered in the combinations boxes and enter the value of the final price of the product at a retail store.

The processing worksheet detects the input data, correlates these requirements with the database, and automatically checks which target specification option meets the desired feature. This check is done automatically through the chain of operations prepared.

The requirement selection in the combinations boxes of the input data spreadsheet returns a numeric value for the processing worksheet. This resulting value is 1 if the "yes" is selected, and 2 for the "no" option. According to the possible combinations of requirements, the corresponding number combinations in the database are identified. Then the resulting values of the combo boxes are confronted by conditional formulas with the database. Therefore, the set of customer requirements is determined, as well as the corresponding target-specification.

[1] In Figures 4, 5, 6, 7 and 8 consider comma as decimal separator.

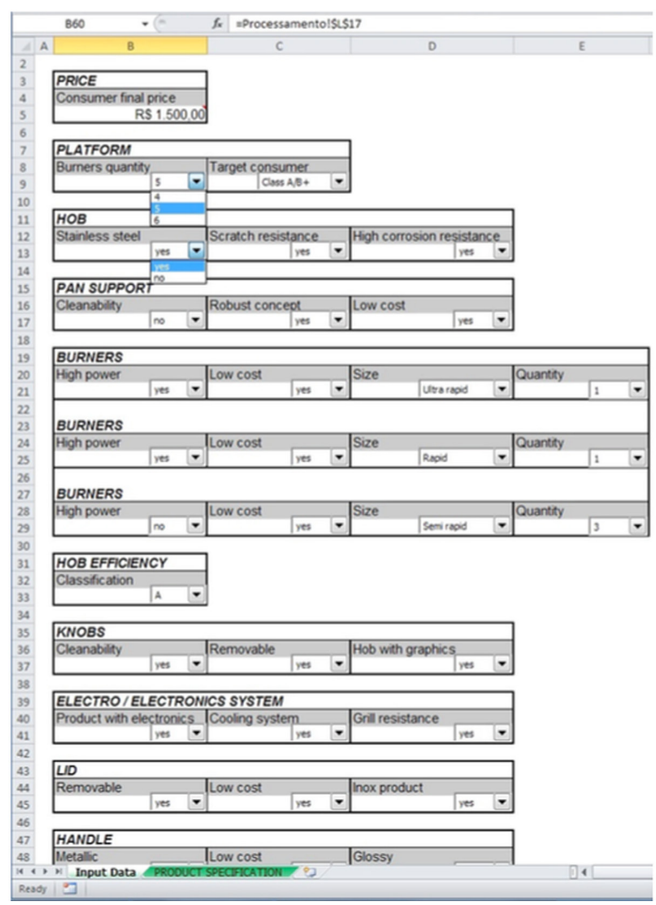
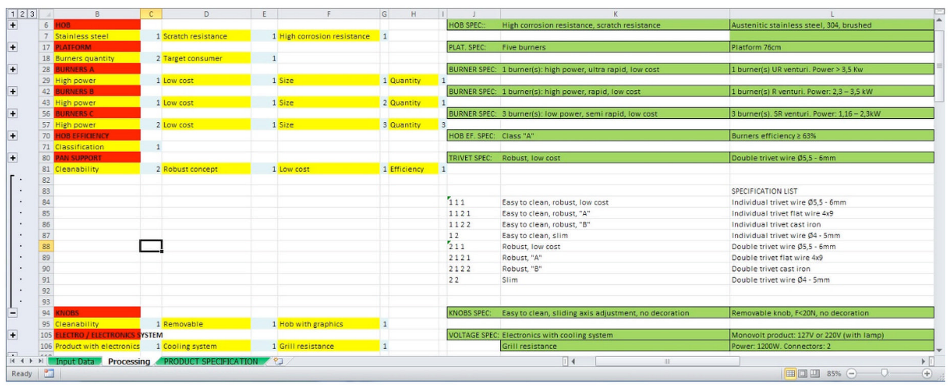


Figure 4. Input data spreadsheet. Source: the authors.

Figure 5 shows the processing spreadsheet, with emphasis on the previous example of the pan support grid. Columns C, E, G and I present the numeric outcome from the selection of combo boxes. Column J lists the possible numerical combinations, or combination of requirements, which the subsystem can meet. Columns K and L show customer requirements and target specifications for each numeric combination.

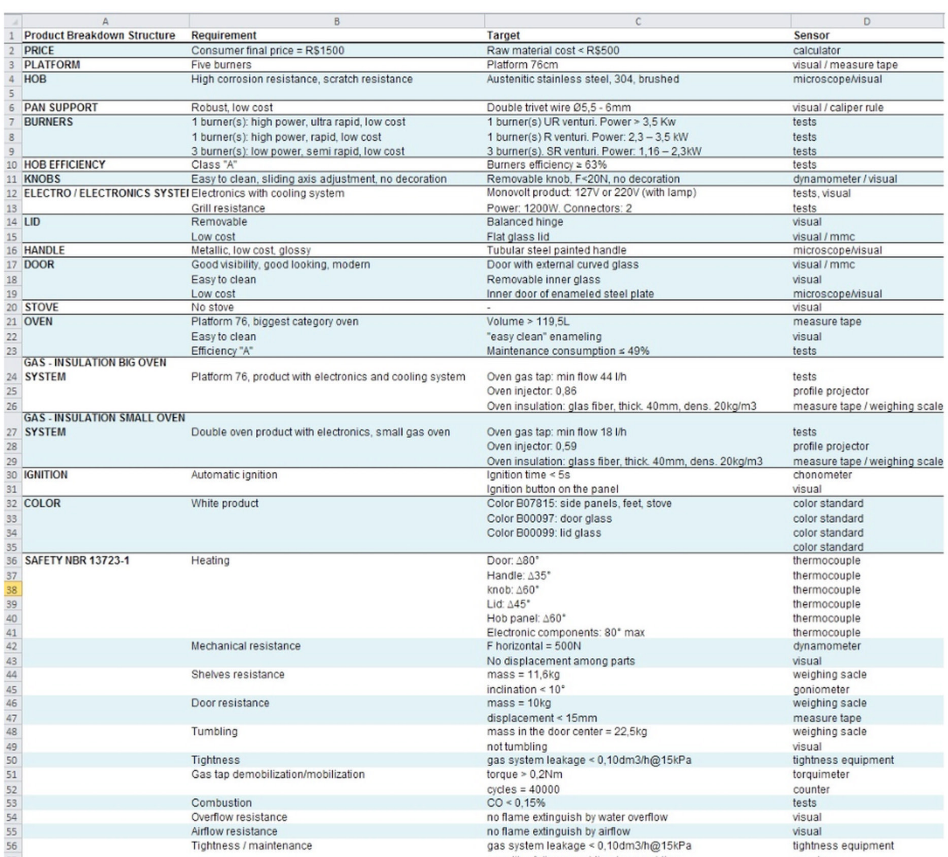
For the end user and in real conditions of tool use, this worksheet should be hidden and protected from modification. This is to preserve the logic implemented on the basis of conditional formulas for determining the specifications. A user with administrator permissions can easily perform tool maintenance, involving database updates with new information and technologies developed.

The result of processing can be seen in the product specification sheet generated by the tool (Figure 6). In this table, the subsystems are characterized with their customer requirements, technical and measurable objectives of target-specifications, and which means are needed for verifying



	B	C	D	E	F	G	H	I	J	K	L
6	HOB								HOB SPEC::	High corrosion resistance, scratch resistance	Austenitic stainless steel, 304, brushed
7	Stainless steel	1	Scratch resistance	1	High corrosion resistance	1					
17	PLATFORM								PLAT. SPEC:	Five burners	Platform 76cm
18	Burners quantity	2	Target consumer	1							
28	BURNERS A								BURNER SPEC:	1 burner(s): high power, ultra rapid, low cost	1 burner(s) UR venturi. Power > 3,5 Kw
29	High power	1	Low cost	1	Size	1	Quantity	1			
42	BURNERS B								BURNER SPEC:	1 burner(s): high power, rapid, low cost	1 burner(s) R venturi. Power: 2,3 – 3,5 kW
43	High power	1	Low cost	1	Size	2	Quantity	1			
56	BURNERS C								BURNER SPEC:	3 burner(s): low power, semi rapid, low cost	3 burner(s). SR venturi. Power: 1,16 – 2,3kW
57	High power	2	Low cost	1	Size	3	Quantity	3			
70	HOB EFFICIENCY								HOB EF. SPEC:	Class "A"	Burners efficiency ≥ 63%
71	Classification	1									
80	PAN SUPPORT								TRIVET SPEC:	Robust, low cost	Double trivet wire Ø5,5 - 6mm
81	Cleanability	2	Robust concept	1	Low cost	1	Efficiency	1			
82											
83											SPECIFICATION LIST
84									1 1 1	Easy to clean, robust, low cost	Individual trivet wire Ø5,5 - 6mm
85									1 1 2 1	Easy to clean, robust, "A"	Individual trivet flat wire 4x9
86									1 1 2 2	Easy to clean, robust, "B"	Individual trivet cast iron
87									1 2	Easy to clean, slim	Individual trivet wire Ø4 - 5mm
88									2 1 1	Robust, low cost	Double trivet wire Ø5,5 - 6mm
89									2 1 2 1	Robust, "A"	Double trivet flat wire 4x9
90									2 1 2 2	Robust, "B"	Double trivet cast iron
91									2 2	Slim	Double trivet wire Ø4 - 5mm
92											
93											
94	KNOBS								KNOBS SPEC:	Easy to clean, sliding axis adjustment, no decoration	Removable knob, F<20N, no decoration
95	Cleanability	1	Removable	1	Hob with graphics	1					
105	ELECTRO / ELECTRONICS SYSTEM								VOLTAGE SPEC:	Electronics with cooling system	Monovolt product: 127V or 220V (with lamp)
106	Product with electronics	1	Cooling system	1	Grill resistance	1				Grill resistance	Power: 1200W. Connectors: 2

Figure 5. Processing spreadsheet. Source: the authors.



	A	B	C	D
1	Product Breakdown Structure	Requirement	Target	Sensor
2	PRICE	Consumer final price = R$1500	Raw material cost < R$500	calculator
3	PLATFORM	Five burners	Platform 76cm	visual / measure tape
4	HOB	High corrosion resistance, scratch resistance	Austenitic stainless steel, 304, brushed	microscope/visual
5				
6	PAN SUPPORT	Robust, low cost	Double trivet wire Ø5,5 - 6mm	visual / caliper rule
7	BURNERS	1 burner(s): high power, ultra rapid, low cost	1 burner(s) UR venturi. Power > 3,5 Kw	tests
8		1 burner(s): high power, rapid, low cost	1 burner(s) R venturi. Power: 2,3 – 3,5 kW	tests
9		3 burner(s): low power, semi rapid, low cost	3 burner(s). SR venturi. Power: 1,16 – 2,3kW	tests
10	HOB EFFICIENCY	Class "A"	Burners efficiency ≥ 63%	tests
11	KNOBS	Easy to clean, sliding axis adjustment, no decoration	Removable knob, F<20N, no decoration	dynamometer / visual
12	ELECTRO / ELECTRONICS SYSTEI	Electronics with cooling system	Monovolt product: 127V or 220V (with lamp)	tests, visual
13		Grill resistance	Power: 1200W. Connectors: 2	tests
14	LID	Removable	Balanced hinge	visual
15		Low cost	Flat glass lid	visual / mmc
16	HANDLE	Metallic, low cost, glossy	Tubular steel painted handle	microscope/visual
17	DOOR	Good visibility, good looking, modern	Door with external curved glass	visual / mmc
18		Easy to clean	Removable inner glass	visual
19		Low cost	Inner door of enameled steel plate	microscope/visual
20	STOVE	No stove	-	visual
21	OVEN	Platform 76, biggest category oven	Volume > 119,5L	measure tape
22		Easy to clean	"easy clean" enameling	visual
23		Efficiency "A"	Maintenance consumption ≤ 49%	tests
24	GAS - INSULATION BIG OVEN SYSTEM	Platform 76, product with electronics and cooling system	Oven gas tap: min flow 44 l/h	tests
25			Oven injector: 0,86	profile projector
26			Oven insulation: glas fiber, thick. 40mm, dens. 20kg/m3	measure tape / weighing scale
27	GAS - INSULATION SMALL OVEN SYSTEM	Double oven product with electronics, small gas oven	Oven gas tap: min flow 18 l/h	tests
28			Oven injector: 0,59	profile projector
29			Oven insulation: glass fiber, thick. 40mm, dens. 20kg/m3	measure tape / weighing scale
30	IGNITION	Automatic ignition	Ignition time < 5s	chonometer
31			Ignition button on the panel	visual
32	COLOR	White product	Color B07815: side panels, feet, stove	color standard
33			Color B00097: door glass	color standard
34			Color B00099: lid glass	color standard
35				color standard
36	SAFETY NBR 13723-1	Heating	Door: Δ80°	thermocouple
37			Handle: Δ35°	thermocouple
38			knob: Δ60°	thermocouple
39			Lid: Δ45°	thermocouple
40			Hob panel: Δ60°	thermocouple
41			Electronic components: 80° max	thermocouple
42		Mechanical resistance	F horizontal = 500N	dynamometer
43			No displacement among parts	visual
44		Shelves resistance	mass = 11,6kg	weighing sacle
45			inclination < 10°	goniometer
46		Door resistance	mass = 10kg	weighing sacle
47			displacement < 15mm	measure tape
48		Tumbling	mass in the door center = 22,5kg	weighing sacle
49			not tumbling	visual
50		Tightness	gas system leakage < 0,10dm3/h@15kPa	tightness equipment
51		Gas tap demobilization/mobilization	torque > 0,2Nm	torquimeter
52			cycles = 40000	counter
53		Combustion	CO < 0,15%	tests
54		Overflow resistance	no flame extinguish by water overflow	visual
55		Airflow resistance	no flame extinguish by airflow	visual
56		Tightness / maintenance	gas system leakage < 0,10dm3/h@15kPa	tightness equipment
57			quantity of disassembling / assembling	counter

Figure 6. Target specifications. Source: the authors.

the targets. Again, this worksheet is also protected against modification of any content, since it contains formulas related to the processing worksheet; its only use is for presentation of results.

To validate the proposed method, a comparative study was conducted, based on three products that have already been developed by the company in the past. The objective was to compare target specifications resulting from the application of the proposed tool to the actual characteristics of the product.

Therefore, validation began with the collection of project information used at the time of development of a particular stove in Company X. Company employees helped provide the information for the validation tool. Figure 7 shows the application tool in this study.

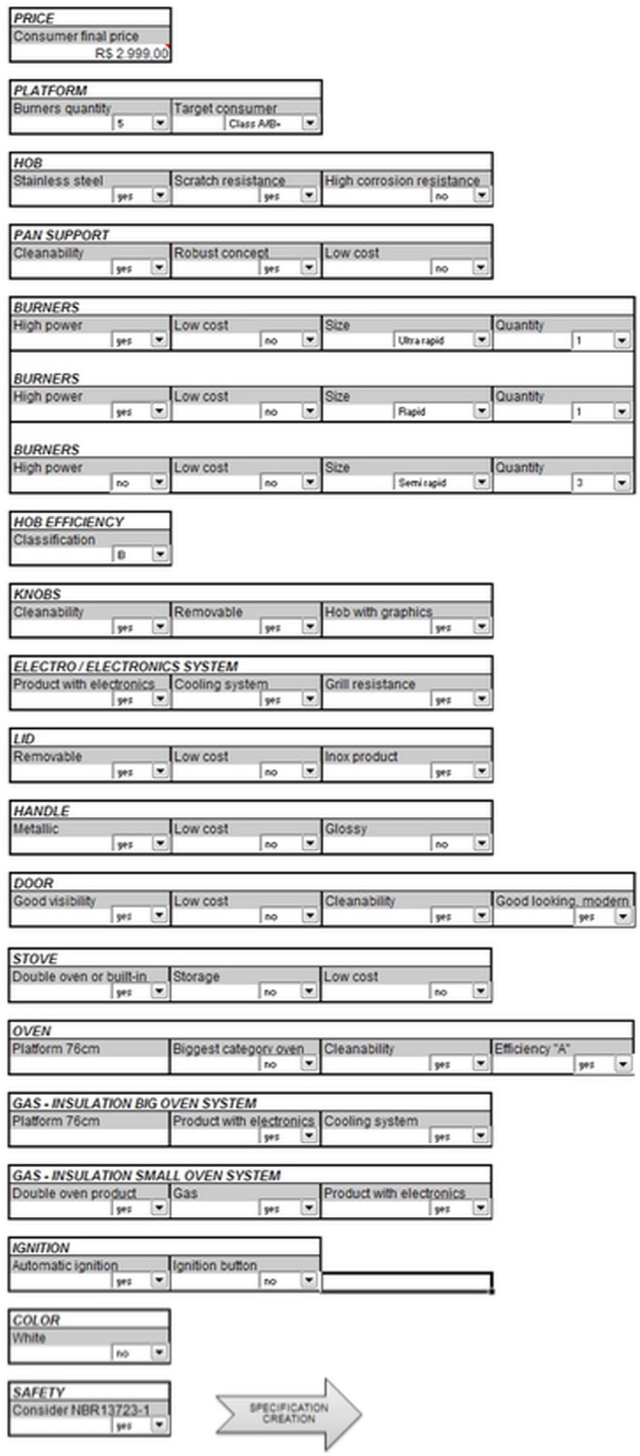


Figure 7. Input data for tool validation. Source: the authors.

Product Breakdown Structure	Requirement	Target	Sensor	Specification OK?
PRICE	Consumer final price = R$2999	Raw material cost < R$999,67	calculator	ok
PLATFORM	Five burners	Platform 76cm	visual / measure tape	ok
HOB	Low cost stainless steel, scratch resistance	Ferritic stainless steel, 439, brushed	microscope/visual	ok
				ok
PAN SUPPORT	Easy to clean, robust, "B"	Individual trivet cast iron	visual / caliper rule	ok
BURNERS	1 burner(s): high power, ultra rapid	1 UR burner(s) sealed. Power > 3,5 Kw	tests	ok
	1 burner(s): high power, rapid	1 R burner(s) sealed. Power: 2,3 – 3,5 kW	tests	ok
	3 burner(s): low power, semi rapid	3 SR burner(s) sealed. Power: 1,16 – 2,3kW	tests	ok
HOB EFFICIENCY	Class "B"	Burners efficiency: 61 - 63%	tests	ok
KNOBS	Easy to clean, sliding axis adjustment, no decoration	Removable knob, F<20N, no decoration	dynamometer / visual	ok
ELECTRO / ELECTRONICS SYSTEI	Electronics with cooling system	Monovolt product: 127V or 220V (with lamp)	tests, visual	ok
	Grill resistance	Power: 1200W. Connectors: 2	tests	ok
LID	Removable	Balanced hinge	visual	ok
	Stainless steel product	Mirrored "stop sol" curved glass	visual / mmc	ok
HANDLE	Metallic, cost is secondary, matt	Extruded anodized aliminium brushed handle	microscope/visual	ok
DOOR	Good visibility, good looking, modern	Door with external curved glass	visual / mmc	ok
	Cost is secondary	Plastic inner door PA6 30% glass fiber Tmáx=220°C	visual / themocouple	ok
	Easy to clean (plastic inner door)	Removable inner glass	microscope/visual	ok
STOVE	No stove	-	visual	ok
OVEN	Platform 76, not the biggest category oven	Volume = 93,2L	measure tape	ok
	Easy to clean	"easy clean" enameling	visual	ok
	Efficiency "A"	Maintenance consumption ≤ 49%	tests	ok
GAS - INSULATION BIG OVEN SYSTEM	Platform 76, product with electronics and cooling system	Oven gas tap: min flow 44 l/h	tests	ok
		Oven injector: 0,86	profile projector	ok
		Oven insulation: glas fiber, thick. 40mm, dens. 20kg/m3	measure tape / weighing scale	ok
GAS - INSULATION SMALL OVEN SYSTEM	Double oven product with electronics, small gas oven	Oven gas tap: min flow 18 l/h	tests	ok
		Oven injector: 0,59	profile projector	ok
		Oven insulation: glass fiber, thick. 40mm, dens. 20kg/m3	measure tape / weighing scale	ok
IGNITION	Super automatic ignition	Ignition time < 5s	chonometer	ok
		Switch attached to the gas tap	visual	ok
COLOR	Stainless steel product	Color B02044: side panels, complement panel, stove	color standard	ok
		Color B00261: feet	color standard	ok
		Color B00094: door glass	color standard	ok
		Color B10002: lid glass	color standard	ok
SAFETY NBR 13723-1	Heating	Door: Δ80°	thermocouple	ok
		Handle: Δ35°	thermocouple	ok
		knob: Δ60°	thermocouple	ok
		Lid: Δ45°	thermocouple	ok
		Hob panel: Δ60°	thermocouple	ok
		Electronic components: 80° max	thermocouple	ok
	Mechanical resistance	F horizontal = 500N	dynamometer	ok
		No displacement among parts	visual	ok
	Shelves resistance	mass = 9,5kg	weighing sacle	ok
		inclination < 10°	goniometer	ok
	Door resistance	mass = 10kg	weighing sacle	ok
		displacement < 15mm	measure tape	ok
	Tumbling	mass in the door center = 22,5kg	weighing sacle	ok
		not tumbling	visual	ok
	Tightness	gas system leakage < 0,10dm3/h@15kPa	tightness equipment	ok
	Gas tap demobilization/mobilization	torque > 0,2Nm	torquimeter	ok
		cycles = 40000	counter	ok
	Combustion	CO < 0,15%	tests	ok
	Overflow resistance	no flame extinguish by water overflow	visual	ok
	Airflow resistance	no flame extinguish by airflow	visual	ok
	Tightness / maintenance	gas system leakage < 0,10dm3/h@15kPa	tightness equipment	ok
		quantity of disassembling / assembling	counter	ok

Figure 8. Processing spreadsheet. Source: the authors.

After processing the information, the tool generates the meta-specifications for the product in question as shown in Figure 8. It was found that the specifications automatically generated by the tool when fed by data available during the project development are in accordance with the developed product, therefore validating the designed system.

Target specifications were confirmed by observation of physical characteristics of the product and results of laboratory tests. Tool validation was made from the point of view of quality, because the method application generates a set of target specifications, which corresponds to the actual product the way it has been implemented.

The tool is not able to identify aspects such as cost and time gains with its implementation. As the tool is based on data from past products, it could only be applied in the process development of well-known products, with no new technologies involved.

5. Conclusion

A method and an expert-system-like tool were designed to outline the generation of target specifications of house appliances. A cooker was selected as a case study. The proposed method is able to automatically generate target specifications for each sub-system of the cooker starting with customer needs as identified by Marketing teams. Information obtained in a systematic and assertive manner can then be used in the Conceptual Design stage of the PDP, when design solutions are generated.

A database was built based on the history of previous developments and tacit knowledge of experts. The proposed method is applicable in cases of incremental change projects on known products. However, this method is not applicable for innovative projects with new technologies, since there is no historical data to be used as a starting step for generating target specifications.

The developed method allows that customer requirements are met. The method provides the following features: (i) ease of use; (ii) grouping and formalization of target specifications in a single document; (iii) insensitiveness to external interference; and (iv) addressing of design assertiveness. Another attribute of the proposed method is the reduction of subjectivity in generating target specifications of appliances.

The proposed approach fills a gap in the literature regarding the generation of target specifications in the home appliance industry. As QFD is not widely used in this industrial sector, no other peculiar method has been identified to assist in generating specifications due to particularities of this segment. Therefore, the proposed method provides the possibility to reduce time and project cost and guarantee quality of the final product due to reduced redesign and rework.

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