IJAPIE-2016-10-404, VOL 1(4), 21-28

INTERNATIONAL JOURNAL OF ADVANCED PRODUCTION AND INDUSTRIAL ENGINEERING

(A Blind Peer Reviewed Journal)

Product Platform Design Based on Common Components

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Abstract : *Product family design, based on platform is one of the effective means for mass customization. The vastness of different brands and rapid acquiring of different companies by one has created different platforms and designs for the same product family. For a company to minimize the PLM (Product Lifecycle Management) efforts and to maintain a common platform for different brands, there is a need for Common Design of Interface for the different platforms. Different subsystem design for different platforms has its own design and maintenance cost. To create things simple and common, attempts has been made by taking different case study to understand the interface features among different products of same family and generate different concepts maintaining the common interface features and also allow customization for different product set. Concepts were then evaluated using pugh matrix screening and FMEA is performed on the selected design. The main contribution of the paper is to show the common interface approach in different platform of product family which was done by taking oven range product as case study and generate concepts allowing common components and evaluate them.*

Keywords: *Product Design, Common Interface, Concept Generation, FMEA*

1. INTRODUCTION

A group of related products that share common features, components, and subsystem to satisfy different markets is known as a product family [1]. Product family design based on platform is one of the effective means for mass customization. Many manufacturing giants have successfully applied this approach to their product development giving them great economic benefits and advantage in term of quality, competitive, market value and cost effectiveness [2]. A Platform is a set of parts, subsystems, interfaces, and manufacturing processes that are shared among a set of products. Platform based product development includes two main phases, developing the platform and then customize the platform into individual product variants to satisfy customer, market and engineering needs [3]. But the development, maintenance, and application of right product platforms are very complex.

The rapid growth of an organization and acquiring different companies into one creates different platforms for the same product family [4]. Development, maintenance, and Product Lifecycle Management (PLM) for different platforms design are complex and hence there is a need to create common design of interface between different platforms keeping the flexibility to customize the platform into the individual product [5].

2. LITERATURE REVIEW

The methodology used for conceptual design from the very first stage of problem description to concept evaluation is unique for different organizations, but more or less the combination of the same defined steps from different design methodologies. And in the current work design methodology up to conceptual design step is considered. Below given is the product development process used in industries which includes the conceptual design phase given by Lehtonen in 2006 [6]. And further concept development process as given in Product Design and Development book by Ulrich and Eppinger [7].

To start with the knowledge of product family and platform based product design, Zha et al. [1] investigated the methodology and advantages of platform-based product family design and development. They investigated the fundamental issues and proposed module based product family design with knowledge support for modelling product architecture, product platform, product family generation, module-based product family design, advantages and mass customization possible.

Similarly, Jiao et al. [3] reviewed the work of many researchers on the field of product family design and platform based product development. They concluded that there is need for product family design, and is satisfied by subsequent research works carried out over the time and it can be implemented from designing products to services.

Yang in 2008 [8] investigated and categorized various concept generation methods and suggested methods to improve the quality of generated concepts by increase in the number of concepts. The design outcome is dependent on the volume of concept sketches and that too at the beginning of the project.

Concepts generated needs to be evaluated in very effective and efficient way and there are many methods to evaluate the concepts. King et al. [9] reviewed all the concept generation and concept evaluation methods. They have discussed

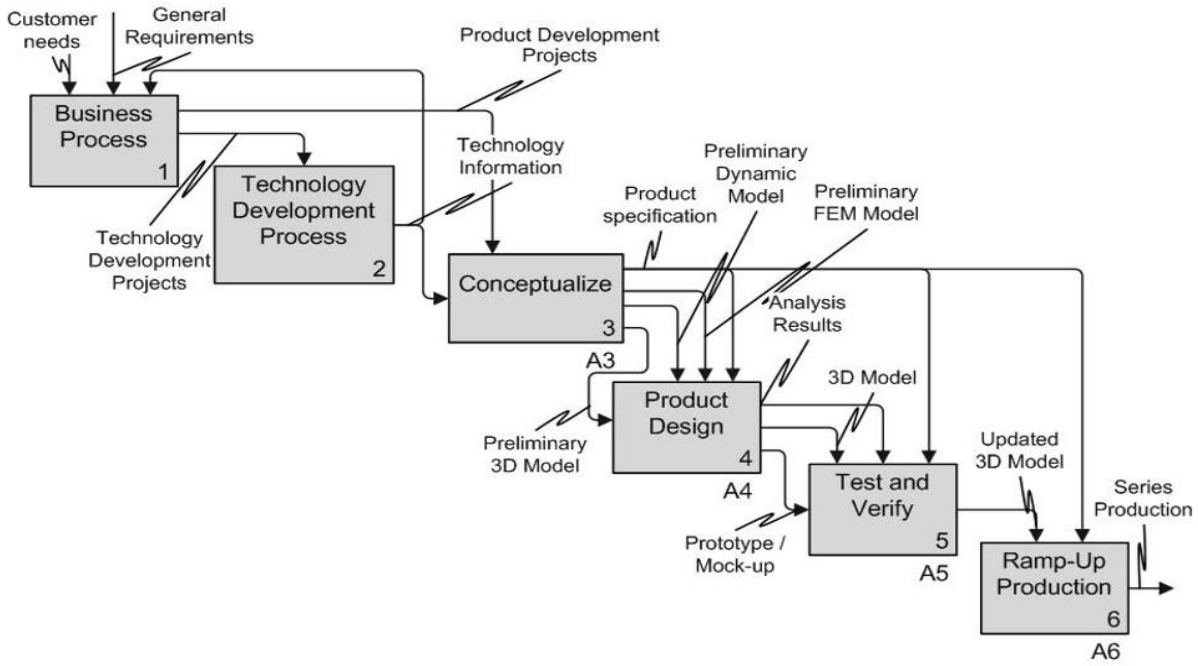


Fig. 1: The Overall Product Development Process Used in Industries [6]

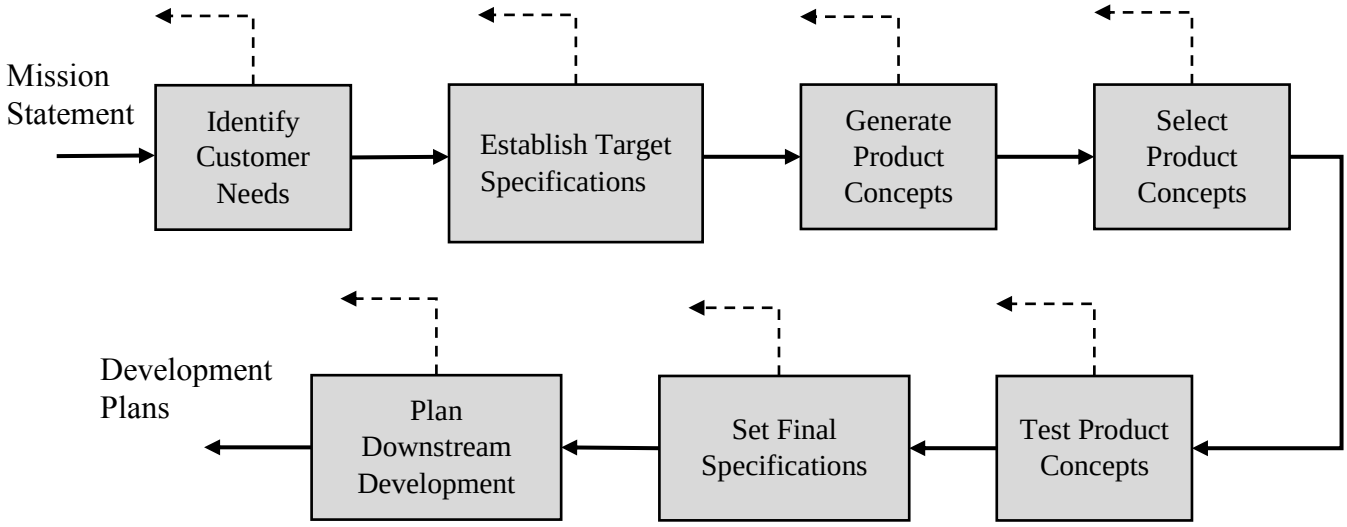


Fig. 2: Concept Development Process [7]

different methods under same attributes. Pugh matrix evaluation seems very appropriate and simplified for the current problem definition.

Conceptual design needs to be evaluated for potential failure modes to improve the product quality and productivity. Teoh et al. [10] investigated the evaluation of failure modes and effect analysis and discussed, how FMEA method is implemented in Industrial product design. They have concluded that a knowledge fragment method is more effective for FMEA as it is an organized way for FMEA based on previous libraries of objects, functions, and models with minimal information input.

3. Design Attributes

Design attribute is a characteristic that defines a particular product and will affect the product from the initial design stage till the end of product lifecycle [11]. It depicts the product visual brand language, quality, and reliability. Before start to generate new concept, clear understanding of affecting parameters, functional parameters and design attributes is very important and for the current work the design attributes considered are explained below.

i. **Aesthetics:** Functional, visual and ergonomically attractiveness of a product design is known as aesthetics [12]. Aesthetics can be defined in many different aspects of design like Shape, Size, finish, material etc.

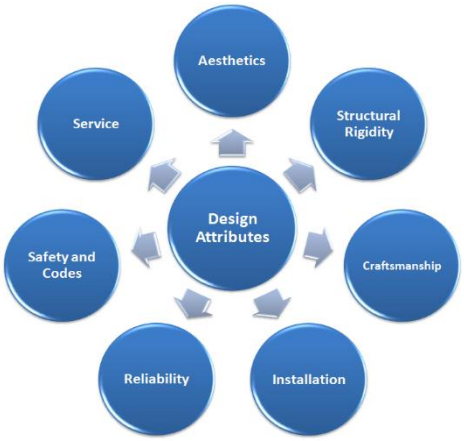


Fig. 3: Design Attributes

ii. **Structural Rigidity:** Any functional component must be structurally rigid. Three critical engineering parameters which are of importance for structural rigidity of console are deflection, maximum stress, and principal strain.

iii. **Craftsmanship:** Skill and art of design maintaining the required quality and precision in design is known as Craftsmanship. This can be seen in design in term of the type of construction of component, visible components, precision in interfaces, tight corner radius etc. The precision of interface gap, the corner radius of the visual part, construction of interactive components like knobs, buttons and touch panels all are craftsmanship.

iv. **Installation:** Fastening methods, sequence, and ease of assembly are very important factors while designing interfaces. As the number of components increases, the type of material of components differs and the design becomes complex. The critical knowledge of installation process is required before designing of any concept.

v. **Reliability:** Reliability is not directly related to design instead it emphasizes the dependability in lifecycle management of the product. And this can be obtained by knowing the behavior of the product under the various working condition for entire life cycle of the product or equivalent to that.

vi. **Safety and codes:** This is the most important design attribute which has to be taken into consideration from the very first step of design. Before brainstorming, idea sketching safety and codes are understood clearly.

vii. **Service:** Service means the maintenance and repair of the product. As a design attribute service of the product should be easy in terms of interface and fasteners.

4. Case Study:

For the current study Cooking Oven Ranges is considered and most importantly Free-Standing Oven and Slide-In Oven.

4.1. System Description

The system in the current investigation was a cooking oven used to cook food by different principles, such as convection, direct heating, microwave and Cooktop having different options for radiant heating, induction, coil heating or gas burner type. The description and difference between two product family, FSR and SI range is given as under.

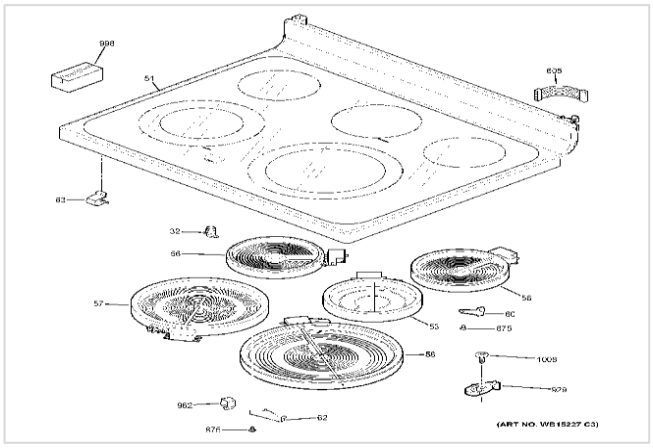
Fig. 4: Free-Standing Range

- Free-Standing or Stand alone can be kept separately without cabinet.
- Finished side panels.
- Have a back guard.
- Oven control at rear side (electric cooktop control at rear and gas burner knobs at front)
- No side overlap with countertop.

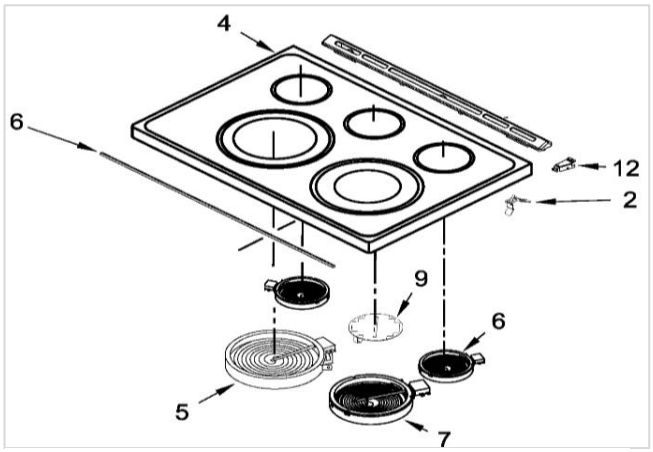
Fig. 5: Slide-In Range

- Slide-In is not kept separately without cabinet.
- Unfinished side panels.
- No back guard
- Burner and oven controls at front
- Range overlaps the countertop on either side as well as the back

Based on the product knowledge and analyzing different brands for same product family i.e. Free-Standing and Slide-In Ranges and the important fact to notice is that for all the brands manufacturing the particular product family of cooking oven, the architecture and geometric design of the cooktop is same. As cooktop panel is one of the major component which has the potential to make a difference by making it common to both the ranges is Cooktop panel. Below given is the different cooktop of FSR and SI range.



(a)

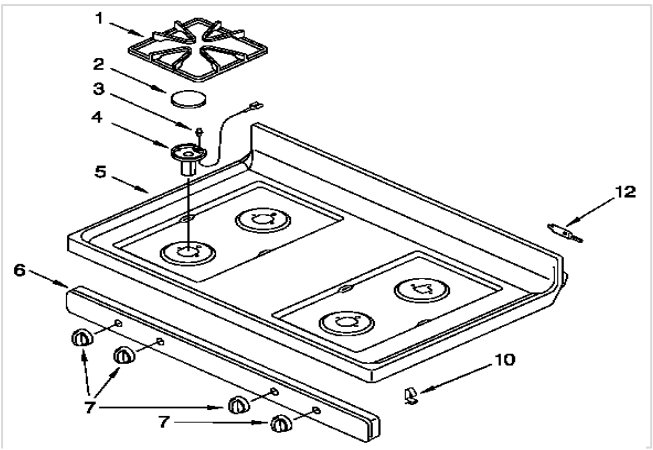


(b)

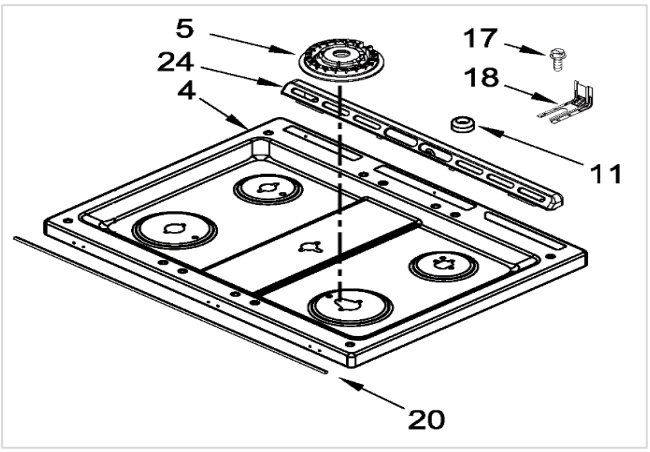
Fig. 6: Cooktop Electric (a) Free-Standing Range (b) Slide-In Range

From the above two figures it is clear that the cooktop panel of both the range type is same in outer dimension, the position of heating elements is also same but the major difference is the curved surface in FSR range which covers the area between cooktop and console while for SI range the cooktop is flat and the other difference is the interface of flue with the cooktop.

Also the design of cooktop panel architecture is same for both electric and gas variants of range types. The geometric dimension and relative position of burners is same in gas variants, and the main difference is same as in case of electric variant which is the curved and flat surface of cooktop and the interface of flue with the cooktop, which can be analyzed in the consecutive figures.



(a)



(b)

Fig. 7: Cooktop Gas (a) Free-Standing Range (b) Slide-In Range

Cooktop panel for both the range type serves the same purpose and shares same geometric and material properties with similar features and hence it is most probable component which can be made common to both the FSR and SI ranges.

4.2. Concept Generation

Different concepts allowing common component for oven system were generated in form of sketches which are explained as under.

i. Large Flue Cover

Flat VSI cooktop interfacing with single U wrap end-post and similar console base. The front gap which was earlier covered by cooktop curved neck has been covered by the separate aesthetic part which could be called as flue cover. Two small brackets were required to give strength to the end-post for bending loads.

Besides the advantage of common cooktop module, this concept also eliminated the requirement of Z bracket as the console and flue are separated by flue cover. Also, the flue cover design was similar to the current production VSI platform with elevated height according to FSR need bottom as shown in Figure 8.

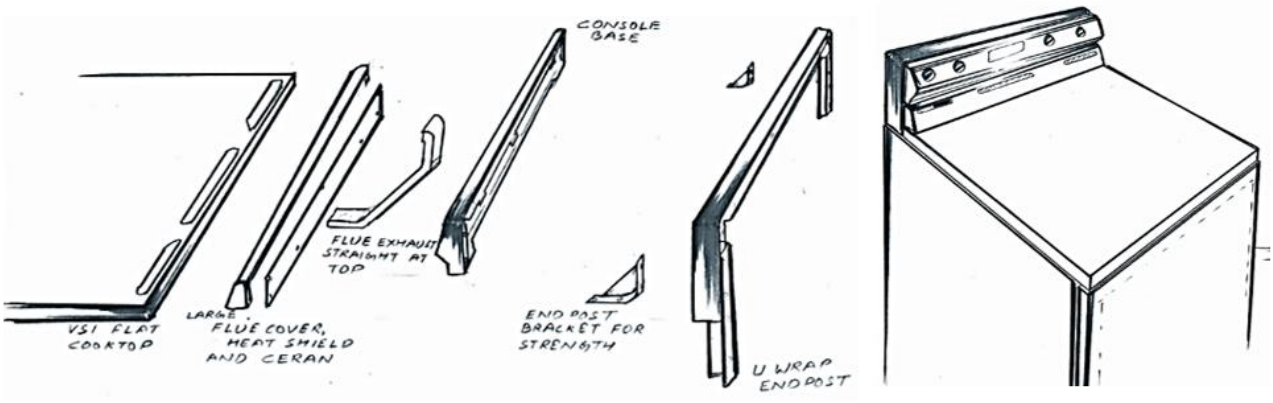


Fig. 8: Flat Cooktop Concept Sketch - Large Flue Cover

ii. Separate Front Aesthetic Cover

In this concept, the flue design was not altered so as to keep the exhaust rate intact and the end-post design was changed keeping in mind that most of the features could be obtained by current end-post tools only while manufacturing. To strengthen the Console structure brackets were required for both the end-post. The additional front aesthetic cover was similar to the current FSR cooktop curved neck bottom as shown in Figure 9.

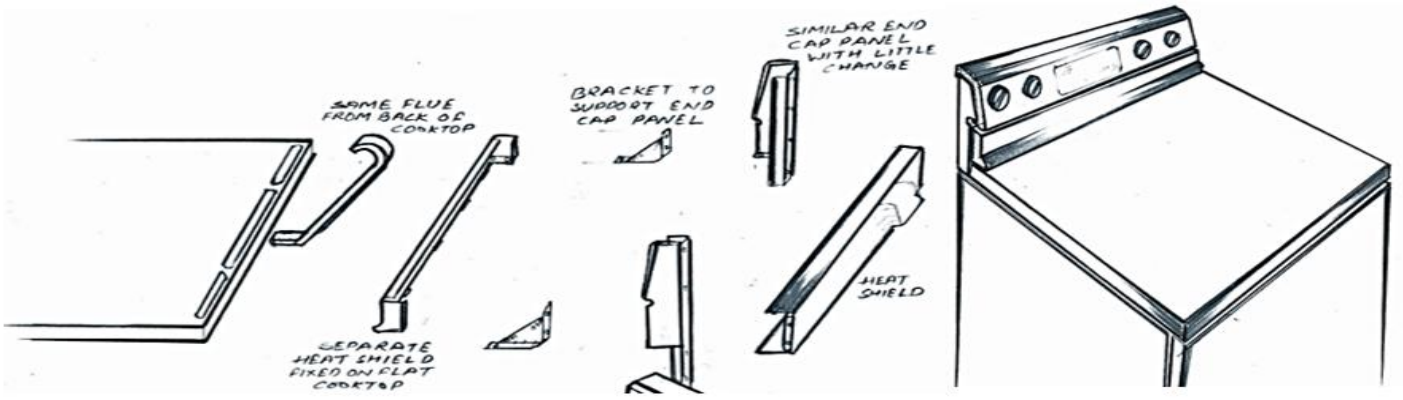


Fig. 9: Flat Cooktop Concept Sketch - Separate Front Aesthetic Cover

iii. Tubular End-Post with Door Hinge Mechanism

To allow same cooktop module and flue cover as VSI and with single U wrap tubular end-post, this concept was one of the detachable concepts with door hinge mechanism as main attachment mechanism between chassis and console subsystem. To cover the front open part between flue, cover and console base, the console base was extended at the bottom as shown in Figure 10.

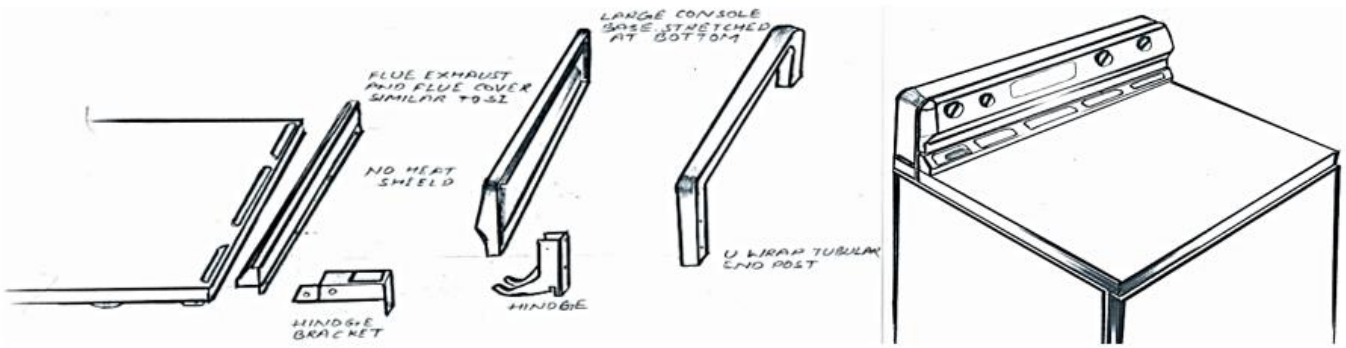


Fig. 10: Flat Cooktop Concept Sketch - Tubular End-Post with Door Hinge Mechanism

4.3. Concept Selection (Pugh Matrix Screening)

Pugh screening matrix is one of the concept evaluation methods using during the conceptual design phase of product development. It is used to evaluate the best concept among the set of different concepts generated based on design attributes considered. Below given is the snapshot of the pugh screening matrix to evaluate the concept.

Concept Evaluation - Pugh Matrix Screening

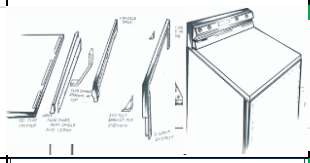
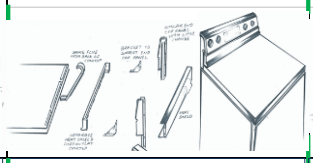
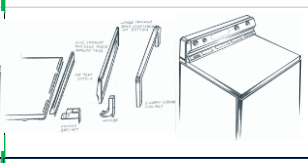
			Concept Name 6A (TUBULAR ENDCAP)	Concept 2B- U WRAP ENDPOST WITH BRACKET	Concept 2B- U WRAP ENDPOST WITH BRACKET
		Description	Console base and U wrap Endpost with bracket similar as earlier concept Flue with extended neck coming out from cooktop flue cut	Same flue as current model Separate Ceran fixed on flat cooktop as attachment Endcap brackets to provide strengh to endcap for bending consition	Flat cooktop, Flue exhaust and Flue cover same as current model Tubular U wrap endpost Door hindge mechanism to attach console to Oven unit
		Conceptual Image			
		PROS AND CONS	PROS *U wrap tubular endcap *Extended Flue cover acts as Ceran and back cover of *Flue cover acts as heat shield *No Z bracket required CONS *Flue exhaust and extended Flue cover design change	PROS *Same Console base, backer overlay, heat shield as Vesta can be used *little modification in Flue exhaust, and Endcap *Endcap bracket to provide strength to Endcap CONS *Wire harness from flue cut on cooktop makes cooktop dependant on Console.	PROS *Flue Cover same as VSI *Detachable Console *No heat shield required *Simple U wrap tubular endpost *Strong and rigid hindge attachment *Same concept for Vesta gas CONS *More number of parts *Special Wire harness attachment to make console detachable
Predicted delivery of Design target to achieve Product Attribute Leadership Strategy (PALS) [Add rows as required to fill details]	Aesthetics	Target Value	+	$0	$0
	Shape	Flat/curved/corner radius	Large flue cover as Ceran with Flue exhaust cut, Flat console base	similar to exixting, separate Ceran	Flat console panel with extended bottom, flue cover same as VSI, Door hindge
	Finish	Brushed/ Painted	painted or Metallic finish console base, Painted U wrap endcap, uncoated raw	similar to current model	painted or Metallic finish console base, Painted U wrap tubular endcap, uncoated
	Material	CRS, SS, Al	CRS for both console base and endcap, thick sheet endcap bracket	CRS Ceran, other similar to Current Model	Galvanised thick Steel both for brancket and hindge, CRS for U wrap console base,
	Structural rigidity	Maximum stress and deflection	U wrap end cap with thick endcap bracket both attached to oven chassis	Thick sheet endcap bracket attach endcap to oven chassis rigidly, Ceran	Hindge mechanism provide enough rigidity
	Craftsmanship	Interface gaps/ flushing of	+	+	$0
	novelty		Common Cooktop Module	Common Cooktop Module	Common Cooktop Module and detachable console
	Installation		+	+	+
	Ease to assemble console	Simple fasteners i.e. Tabs, Screws		cooktop and console are independent to each other, endcap bracket fixed on	easy as assembly of oven door
	No. of basic component	(endpost, console base, heat shield,	$9	8 (same flue)	$7
	Reliability		Single piece U wrap endpost	Endcap bracket is supporting structure attached by screw to oven unit and	Dooe hindge cantake upto 65kg load
	Structural and fixture reliability		$0	+	+
	Service	Ease in service	same as current production with single end post	same as current production with extra brackets	detachable console
	ease to deassemble console from unit		+	+	+
	Safety & Codes		tests on sonsole	tests on console	tests on sonsole
Rating Tool		++	0	**0**	**0**
		+	4	**4**	**3**
		=	1	**1**	**2**
		-	0	**0**	**0**
		--	0	**0**	**0**
		Total	**4**	**4**	**3**

Fig. 11: Pugh Screening Matrix

4.4. Selected Concept

Common Cooktop Module (Separate Front Aesthetic Cover)

Advantages: -

- Same current model flue behind cooktop rear end (no contact)
- Separate front neck aesthetic part fixed on VSI cooktop as attachment
- End-Post brackets to provide strength to end-post, therefore, console subassembly
- End-Post design to be manufactured from the same tool
- Wire harness position either from below cooktop or from flue cut on cooktop
- Same concept for FSR gas as the dimension constraints are same for both FSR electric and gas.

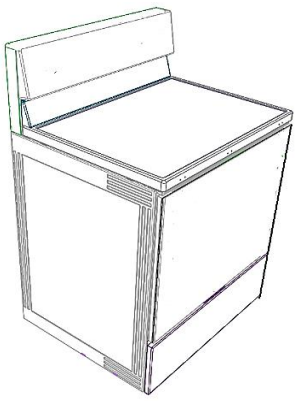


Fig. 12: Perspective Diagram Showing Common Cooktop Module with Separate Front Aesthetic Cover

4.5. Failure Mode and Effect Analysis (FMEA)

Failure Mode and Effect Analysis is an analytical method for evaluating the potential failure modes of any product, subsystem or component, during its lifetime. The analysis discovers the failures, their mechanism, and risk involved with the failure mode. There are two types of FMEA, one design FMEA and the other is process FMEA. For the current case study design FMEA has been done for the selected concept to capture all the potential failure, their severity, occurrence and detection and also the prevention methods to control the failure in the design phase.

Component/ System/ Process/ Operations/ Index	Function	Potential Failure Mode	Potential Effect(s) of Failure	Severity	Potential Cause(s) / Mechanism(s) of Failure	Occurrence	Current Design/ Process Control PREVENTION	Current Design/ Process Control DETECTION	Detection	SOD
INDEX &/or Component, System, Number/ Name.	**What must this design? What is the purpose of this component, ?**	**What could go wrong? How might the design / process / process step fail to meet the function?**	**How does the failure mode effect customers, trade partners, manufacturing, the next process step, etc?**		**What in the design could cause the failure mode? Be specific & focus on causes.**		**What will be done to prevent the cause / failure mode from occurring?**	**What verification method will be used to detect the Cause or the Failure Mode?**		
End Cap	Provide structural strength to Console subassembly	Structurally weak console causing backlash & distorted surface profile	Deflection of console while operation makes customer dissatisfy	5	Part material is weak	7	Proper material selection & thickness of material	Console Impact test	1	571
	Safety Requirements	water entry from gaps while cleaning	Chances of shock to customer	9	Design is not sufficient		Proper geometric tolerance to have tight geometry	Knife probe test		9__
	Interface with cooktop (Flat cooktop)	Improper flushing of interfacing surfaces	Doesn't meet Aesthetic requirement	3	improper dimensional tolerances	3	Proper geometric tolerance to have tight geometry	Aesthetic targets	3	333
	Acceptable Aesthetics	Non uniformity of finish	Doesn't meet Aesthetic requirement	3	coating & painting process	1	Control coating parameters	Aesthetic targets	3	313
	Meet Craftsmanship target	Non uniform gap or large gaps	Doesn't meet Craftsmanship target, Customer displeased	3	lack of dimensional tolerance	1	Proper geometric tolerance to have tight geometry	Craftsmanship targets	3	313
End Cap bracket	Provide structural strength to Endcap	Structurally weak Bracket allowing deflection to console while operating controls	Deflection of console while operation makes customer dissatisfy	3	Wrong material selected	5	Appropriate material as per requirement	Console drop test & Console twist test	1	351
		Screw get loose during twisting of console while handling & during transit	Loose console creates backlash which is undesired	5	Screw thread slippage	5	Use screw with more pull out force & strip torque	Console twist test	1	551
Cooktop (Flat)	Give structural strength for cooktop subassembly	Structurally weak design causing backlash & distorted surface profile	Deflection and dent and irregular surface profile makes customer dissatisfy		Improper part material, improper design		Proper material selection, design & thickness of material	Console drop test		
	Interface with Flue from back	Cooktop may hit flue while assembly	Problem in assembly process	3	insufficient gap between cooktop & flue	1	Design with proper clearance	Ease in assembly	1	311

	Provide enclosure to heating elements	radiated & convective heat may accumulate & not escape	Undesired extra heating of cooktop surface	3	Less opening exposed to ambient	3	Carry over current design & check impact on surface temp.	Cooktop surface temperature	3	3 3 3
Neck Part (Front Aesthetic cover)	Covers the front portion between cooktop & console	Neck part may deform due to heavy impact from front, Cooktop flue cut may be exposed	Customer perceives the range as a low quality product, item may enter beneath cooktop from the gap	3	Design not sufficient, Weak structure	1	Use strengthning features llike ribs, embossing, bending	Front impact test	1	3 1 1
	Provide required Aesthetics	Finish may degrade due to mixed environment of high temperature & abusive use	Doesn't meet Aesthetic requirement	3	Material finish & coating	1	Coating to resist heat penetration (porcelain)	Gloss test	3	3 1 3
	Interface with cooktop	uneven flushing of interfacing surface	Doesn't meet Craftsmanship target	1	improper dimensional tolerances	1	Proper geometric tolerance to have tight geometry	Craftsmanship targets	1	1 1 1

5. Conclusion:

The common component approach is the need of the industry, as for the same functional product different platform design is not required and common component approach is an effective method to reduce the number of component and all the development, maintenance and PLM cost associated with different designs. To prove the same theory, the case study of cooking oven and the selected concept is appropriate as it justifies the method adopted to perform the common component approach. Also the same approach can be implemented to any of the product family or product platforms.

References

[1] X. Zha and R. Sriram, "Platform-Based Product Design and Development: Knowledge Support Strategy and Implementation," Intelligent Knowledge-Based Systems. 2005.

[2] OLAF KOWALIK, "PRODUCT PLATFORM STRATEGY," productbookshelf, 2011. [Online]. Available: http://www.productbookshelf.com/2011/10/product-platform-strategy/.

[3] J. Jiao, T. W. Simpson, and Z. Siddique, "Product family design and platform-based product development: A state-of-the-art review," J. Intell. Manuf., vol. 18, no. 1, pp. 5–29, 2007.

[4] K. Kim and D. Chhajed, "Product design with multiple quality-type attributes," Manage. Sci., vol. 48, no. 11, pp. 1502–1511, 2002.

[5] Siemens P L M, "Enabling global innovation through commonization and re-use," UGS, 2013.

[6] M. Lehtonen, "Simulation-based design process of smart machines," VTT Tied. - Valt. Tek. Tutkimusk., no. 2349, pp. 3–184, 2006.

[7] K. Ulrich and S. Eppinger, Product Design and Development. McGraw-Hill/Irwin, 2008.

[8] M. C. Yang, "Observations on concept generation and sketching in engineering design," Res. Eng. Des., vol. 20, no. 1, pp. 1–11, 2009.

[9] A. M. King and S. Sivaloganathan, "Development of a Methodology for Concept Selection in Flexible Design Strategies," J. Eng. Des., vol. 10, no. 4, pp. 329–349, 1999.

[10] P. Teoh and K. Case, "An evaluation of failure modes and effects analysis generation method for conceptual design," Int. J. Comput. Integr. Manuf., vol. 18, no. 4, pp. 279–293, 2005.

[11] D. L. Thurston, "A formal method for subjective design evaluation with multiple attributes," Res. Eng. Des., vol. 3, no. 2, pp. 105–122, 1991.

[12] S. J. Zafarmand, K. Sugiyama, and M. Watanabe, "Aesthetic and Sustainability: The Aesthetic Attributes Promoting Product Sustainability," J. Sustain. Prod. Des., vol. 3, no. 3–4, pp. 173–186, 2003.

[13] S. Takai and K. Ishii, "Modifying Pugh's Design Concept Evaluation Methods," DETC200457512 ASME Des., vol. 4, pp. 1–10, 2004.

[14] Quality-one, "Failure Mode and Effects Analysis (FMEA)," 2016. [Online]. Available: http://quality-one.com/fmea/.

[15] NPDsolutions, "Failure Modes and Effect Analysis (FMEA)," 2016. [Online]. Available: http://www.npd-solutions.com/fmea.html.