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Enhancing Design for Aesthetics Based on Product Platform Architecture

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ABSTRAK

Secara tradisionalnya, kebanyakan orang membeli sesuatu produk berdasarkan prestasi dan kos produk tersebut, akan tetapi kebelakangan ini, keselesaan dan ciri estetika lebih disukai. Pengguna kini semakin komplek dan mengkehendaki produk yang bukan sahaja dari segi prestasinya, tetapi juga penampilannya. Untuk meningkatkan penampilan, pendekatan platform produk dicadangkan sebagai satu pendekatan baru dalam rekabentuk untuk estetika. Dalam kajian ini, platform dikenalpasti berdasarkan perkongsian komponen di kalangan variasi produk. Kemudian garis panduan estetika digunakan pada platform. Indek Estetika Keluarga Produk (PFAI) dibangunkan untuk mengukur prestasi produk. Penilaian adalah berdasarkan kesepunyaan komponen dan aspek estetika. Keputtusan menunjukkan Indek Estetika Keluarga Produk telah meningkat melalui rekabentuk semula beberapa komponen produk tersebut. Satu kajian kes mengenai keluarga kipas rumah telah dijalankan untuk membuktikan metodologi yang telah dibangunkan.

ABSTRACT

Traditionally, most people buy a product based on performance and cost, but recently appearances, comfort and aesthetic are preferred. Customers are now becoming more complex and require not only good product performance but also appearance. To enhance product appearance, product platform has been proposed as new approach to the design for aesthetics. In this work, a platform is identified based on component sharing among the product variants. Then the aesthetic rules are applied to the platform. A Product Family Aesthetic Index (PFAI) was developed to measure the product performance. The evaluation is based on component commonality and aesthetic aspect. The result indicates that the Product Family Aesthetic Index had increased through redesigning several components in the product. A case study of the fan family was conducted to verify the methodology.

Keywords: Product platform, design for aesthetics, commonality, redesign

INTRODUCTION

Traditionally, most people buy a product based on performance and cost, but recently appearances, comfort and aesthetic appreciation are preferred. Aesthetic can be defined as a simultaneous communication of meaning and beauty, which can be principally interpreted as shape, while at the same time colour, texture, material and other visual properties are also important (Tovey 1992). Design for aesthetics will be the focus of research and development in the future due to their role in enhancing product acceptance. Design for aesthetics was to be related to other aspects including ergonomics, manufacturability and suitability in the product development at different levels of dominance. Design for aesthetic is currently more popular in automotive industry as shown in *Fig. 1* but there is a tendency of application in industrial design and engineering (Tovey 1997).

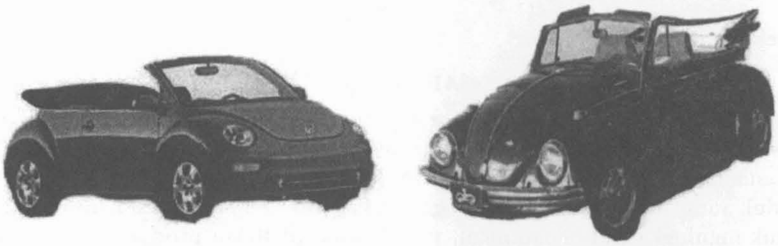

Fig. 1: Evolution of Volkswagen passenger car with aesthetic design from early edition till the latest version (Brenmer 1999)

There are three product characteristics that have interaction with design for aesthetics which are shape, geometry and form. Three parameters that influence the aesthetic design of a product are shape, composition and physical attributes (Chen and Owen 1997). Shape is defined as the totality of local characteristics of the geometry, while composition expressed shape features arrangement. Similarly, the physical attributes such as colour, texture, lighting conditions or material properties also influence the aesthetic characteristics. Geometry has no further contribution but only support the aesthetic shape mapping the design process. Whereas form typically can express the aesthetic characteristics more. This interaction can be illustrated in *Fig. 2.*

Product platform can be formulated as a general optimization problem in which the advantages of designing a common base must be balanced against the constraints of the individual product variants and of the whole family. Gonzales-Zugasti and Otto (2000) define product platform as a set of shared functionality across multiple products from similar or different families. Platform architecture can further be described as a set of selection and configuration choices shared among products (Gonzales-Zugasti *et al.* 2000). This can be viewed through components or part similarity from physical attributes, shape and composition to the developed platform.

The advantages of product platform are that using proven modules that are known to operate effectively at their designated sub-tasks can minimize design risk. Other than that, re-use of previously designed modules can bring savings at least in parts cost of redeveloping those sub-systems (Martin and Ishii 2000). The concept of product platforms and aesthetic aspect has been successfully applied in automotive part design consumer and industrial product recently. For example, Sony used three platforms to support hundreds of different personal portable stereo products in its Walkman family. Volkswagen and their

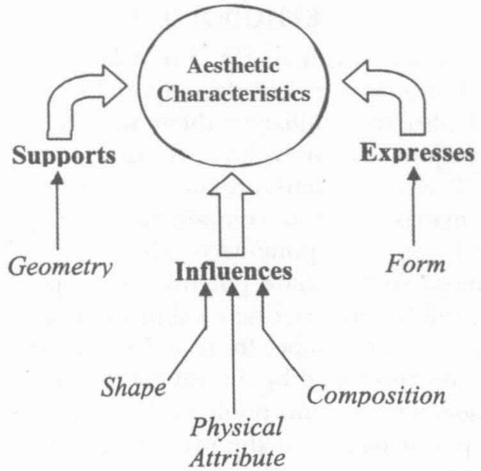

Fig. 2: Product characteristics and the interaction with the aesthetic characteristics

partners in producing new technology of passenger car also used product platform (Brenmer 1999).

The contribution of this work is the presentation of new methodology to increase part commonality and aesthetic value of the product based on product platform. This methodology can be beneficial to the manufacturers and industries that are involved in product design and development. The paper discusses the background of the research, the definition and advantages of design for aesthetic and product platform. It is then followed by related research on the topic. The approach taken is discussed in detail and to implement the approach, a case study was carried out.

RELATED WORK

The methodology and research on product platform development is not new and a number of products have been applied to this technology. Sudjianto and Otto (2001) had developed a product platform from multiple brand products using brand architecting rules. Gonzales-Zugasti *et al.* (2000) used models of several spacecraft to identify possible subsystem that could be made common to all or specific requirements of the missions. Similarly Ripin and Abdullah (2001) developed a methodology to develop modular Unmanned Aerial Vehicle (UAV) based on the multi-mission requirements optimization. One of the objectives of product commonality is to increase product variety and research in the area has shown successful applications (Martin and Ishii, 2000). Research on aesthetic product design is moving towards computer-based design for aesthetic and claimed as one of the areas that will be highlighted in the future (Wallace and Jakiela, 1993; Takala and Woodward, 1988; Hsiau and Chen, 1997 and Knoop *et al.* 1998). But none of the research has taken into consideration the aesthetic aspect together with product platform.

METHODOLOGY

The methodology is summarized in *Fig. 3* and begins with a list of product variants or models. Products are then decomposed to identify all components in the systems and also to familiarize them with the interactions between components. Component assembly level is used to illustrate the product assembly hierarchy. The components are then mapped in the matrix, named as component-variant matrix. Shared components among all the variants are labeled as platform P, and components which are not shared are labeled as accessories A. Components that have potential to be platformed is labeled by an asterisks (*) and will be further discussed in the re-design stage. The introduction of aesthetic rules i.e. shape, form and geometry to the platform and product variants can be developed by choosing and combining the appropriate platform and accessories in the morphological chart to complete the product system. Finally, the performances of the product are evaluated based on commonality and aesthetics.

Analytically, the number of designed models can be determined from the relationship between the number of design and the total number of components (i.e. platform and accessories). The number of models may be infinite for complex system or product which has high number of platform and accessories. Other factors such as performance, reliability, manufacturing and functionality should be considered also before the product can be produced. As shown in *Fig. 4*, a system or products which have n number of platform and accessories and by assuming that the number of design for each platform and accessories are the same, the number of models can be determined as follows;

$$\text{Number of model, } M_n = N_t^D \quad (1)$$

Where Nt is total number of components in the product and D is number of design options.

But in application, the number of design for each platform and accessory are different and depend on the creativity of the designer to initiate new and innovative design. The combination of platform and accessories to form a complete system or product are also different. Thus the number of models cannot be determined quantitatively. Besides that, the contribution of accessories and platform in increase model is different, where accessories are only for certain variants, while platform can affect the whole variant.

The performance of the product and variant can be determined from commonality and aesthetic point of view. Product efficacy, E_i of certain variant can be calculated from the ratio of number of components that are shared with other variants and total number of components from all of the variants as shown in Equation 2, where weightage of 1 and 0 are used to represent best and poor commonality.

$$\text{Efficacy, } E_i = \frac{N_s}{N_t} \quad (2)$$

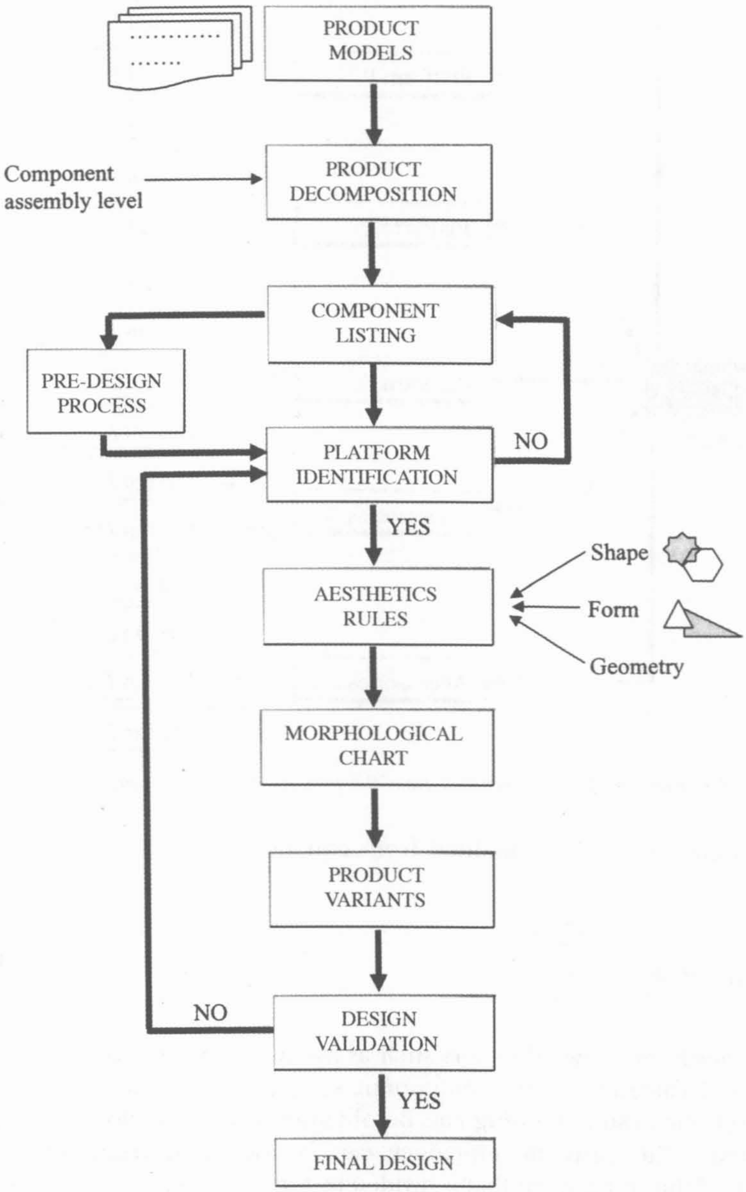

Fig. 3: Platform development process flow chart

$E_i = 1$ (best commonality), $E_i = 0$ (poor commonality)
Note that, $i = 1, 2, \ldots n$ (number of variant)

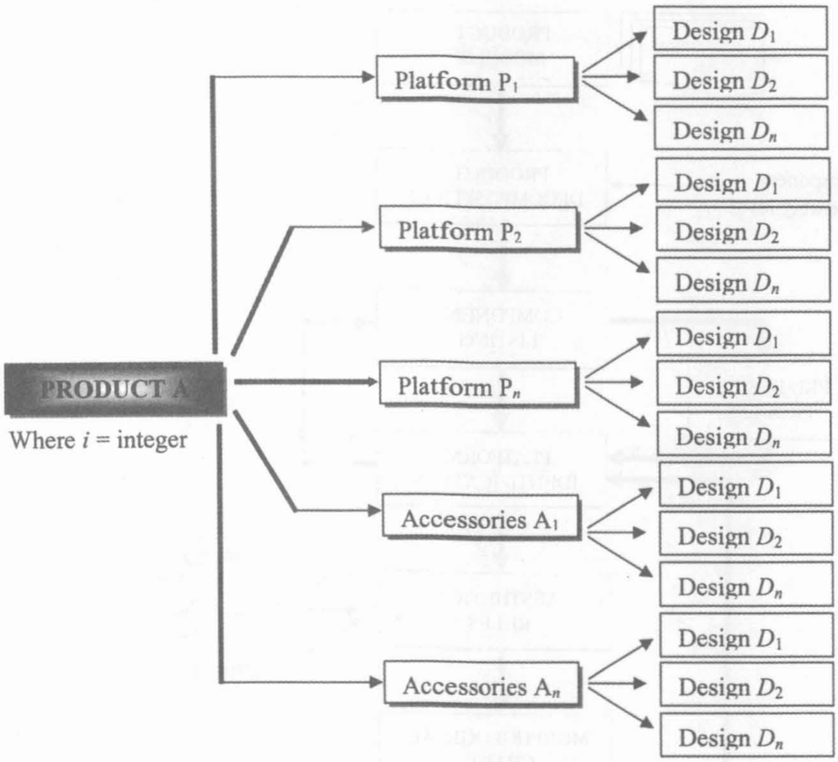

Fig. 4: The number of design resulted from the product platform approach

So the product commonality is obtained from equation 3.

$$\text{Degree of Commonality} = \frac{\sum_{i=1}^{n} E_i}{N_v} \tag{3}$$

In terms of aesthetics, several factors such as assembly level of components, attractiveness and category of the component should be considered. At the component level, the aesthetic rating can be obtained from Equation 4 and at the product level, the aesthetic efficiency can be obtained from total of aesthetic ratings of the component that is divided by total number of components in the variants as expressed in Equation 5.

$$\text{Aesthetic Rating, } C_R = A_j \times 100 \tag{4}$$

$$\text{Aesthetic Efficiency, } \xi_A = \frac{\sum_{j=1}^{m} A_j}{N_t} \tag{5}$$

Note that, $j = 1, 2, \ldots m$ (number of component)

The Product Family Aesthetic Index (PFAI) depends on the commonality and aesthetic characteristics of the components, so that it can be determined by summing up Equations 3 and 5.

$$\text{Product Family Aesthetic Index, PFAI} = \frac{\sum_{i=1}^{n} E_i}{N_v} + \frac{\sum_{j=1}^{m} A_j}{N_t} \qquad (6)$$

Where N_v = Number of variant
N_s = Number of shared component
N_t = Number of total component in the product family
E_i = Efficacy

For better understanding of the methodology, a case study of the home appliances fan family was carried out. The process platform identification begins by the decomposition of the product models to investigate and study the physical configuration of the products. *Fig. 5* shows the components at each assembly level. To avoid complexity, the assembly level is limited to four only. *Fig. 6* schematically illustrates an exploded view of the wall fan to visualize the product configuration and components consist in the product. The motor and oscillation knob are not in the figure.

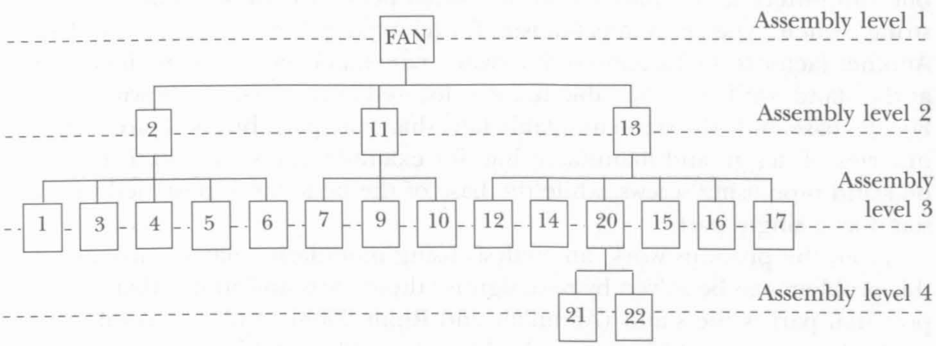

Fig. 5: Components assembly level

For the fan family, there are three variants, i.e. table, wall and stand fan. The wall fan consists of 14 components, 20 components for stand fan and 17 components for table fan as listed in Table 1. The final row indicated category of components either platform (P) or accessories (A). The shaded blocks depict the shared components among the variants. There are three components which cannot be specified either as platform or accessories represented by the asterisks (*) i.e. stand, base and switch panel which will be discussed later.

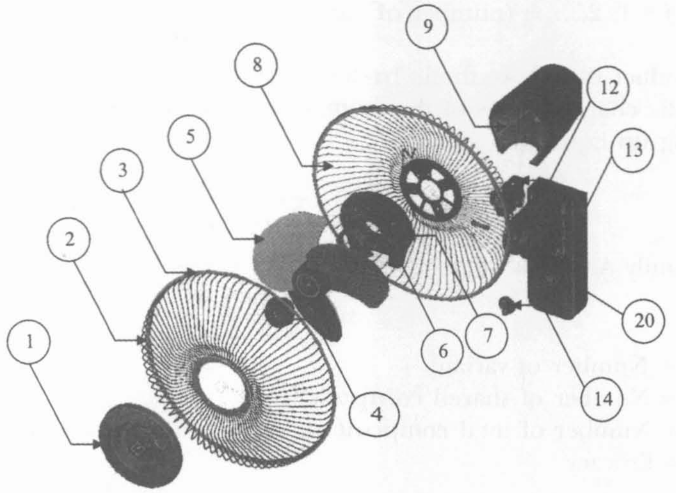

Fig. 6: Exploded view of wall fan

At the re-design stage, several factors and parameters should be taken into consideration such as components configuration, interaction and the constraint. For example, the stand and switch panel in some of the cases share the same functions but are physically different. The stand design for table and wall fan mounted on the base, while for stand fan it is designed as a single part as shown in *Fig. 7*. Similarly the switch panel design, for stand and table fan, are the same but with different orientation and the switch panel for the wall fan uses a pull-string switch type as a mechanism for changing the speed or oscillation. Another factor is the location of the switch panel. For the stand fan, it is located at the stand, while for the table fan it is located at the base as shown in *Fig. 7*. For the base, only the stand and table fans share the part. But both are different in terms of design and manufacturing, for example, the stand fan, is mounted on stand pipe using screws, while the base of the table fan is designed with the stand as a single part.

From the previous work, an analysis using modularity matrix indicates that this problem can be solved by re-designing these parts and found that the most potential part is the stand (Abdullah and Ripin 2003). And as a result of this method, two more platforms can be identified. The total number of platform becomes 13 and accessories are reduced to only 9 components. The stand and base are now designed separately and the location of the switch panel is now mounted on the stand for standardization as is shown in *Fig. 8,* to allow more space for component sharing.

The aesthetic rules can now be applied to the identified platforms. The components, either platforms or accessories have different degrees of attractiveness which can influence the overall appearance of the model. The spinner and guard lock nut which are covered by other components have a low degree of attractiveness compared to the grill or stand. A measure of effluence is introduced by giving

TABLE 1
Product-Components Matrix depicts the similar components shared by home appliance fan family variants. P, represents platform and A, represents accessories. Numbers in the bracket shows the total number of components in the product

Components Listing	Wall Fan (14)	Stand Fan (20)	Table Fan (17)	Category
1. Guard Mark	■	■	■	P
2. Front Guard	■	■	■	P
3. Guard Ring	■	■	■	P
4. Spinner	■	■	■	P
5. Fan Blade	■	■	■	P
6. Guard Lock Nut	■	■	■	P
7. Housing Cover	■	■	■	P
8. Rear Guard	■	■	■	P
9. Motor Housing	■	■	■	P
10. Oscillation Knob		■	■	A
11. Motor	■	■	■	P
12. Neck	■	■	■	P
13. Stand	■	■	■	*
14. Switch Panel	■	■	■	*
15. Pull String	■			A
16. Height Adjuster		■		A
17. Sliding Tube		■		A
18. Outer Pole Bowl		■		A
19. Stand Pipe		■		A
20. Base		■	■	*
21. Wheel		■		A
22. Base Cover			■	A

weightage of 1, 3 and 5 to represent low, medium and strong degree of attractiveness respectively. Then the morphological charts approach (Pahl and Beitz, 1996) can be used to pick and combine the design of components to create variants to proceed for production as shown in *Fig. 9*. The number of design depends on the designer's creativity and customer's demand.

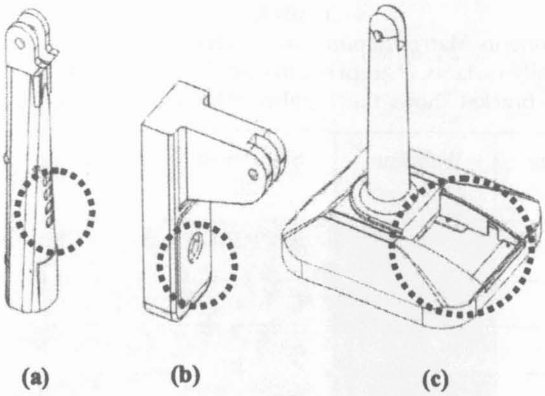

Fig. 7: Multi-design of stand for (a) stand, (b) wall and (c) table fan. Circle depicts the location of switch panel for respective variants

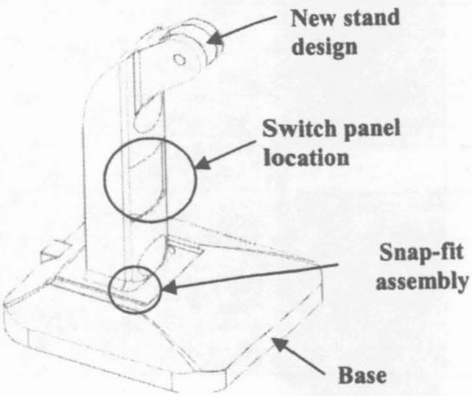

Fig. 8: New fan design of stand and base to enhance component sharing

The evaluation chart used to calculate the aesthetic rating of component and product level is shown in Appendix 1. A weightage is calculated by ratio of column_4 and column_5 and Aesthetic rating at the components level is get form ratio of column_6 and column_7 and at the product level can be get from total of components level aesthetic rating. The evaluation has been done before and after re-design and as a result there is an increase in degree of commonality aesthetic efficiency of the product. Low PFAI of about 11.5% is resulting from low aesthetic efficiency (4.5%). This is because most of the components in the product have a low degree of attractiveness. But the commonality of the product is quite high about 30% which indicates that there is wide possibility of upgrading the components and product appearance. The result is summarized in Table 2. After that, the result is compared to other approaches that developed by Kota *et al.* (2000) for the same case study and the result indicates similar patterns as shown in Table 3.

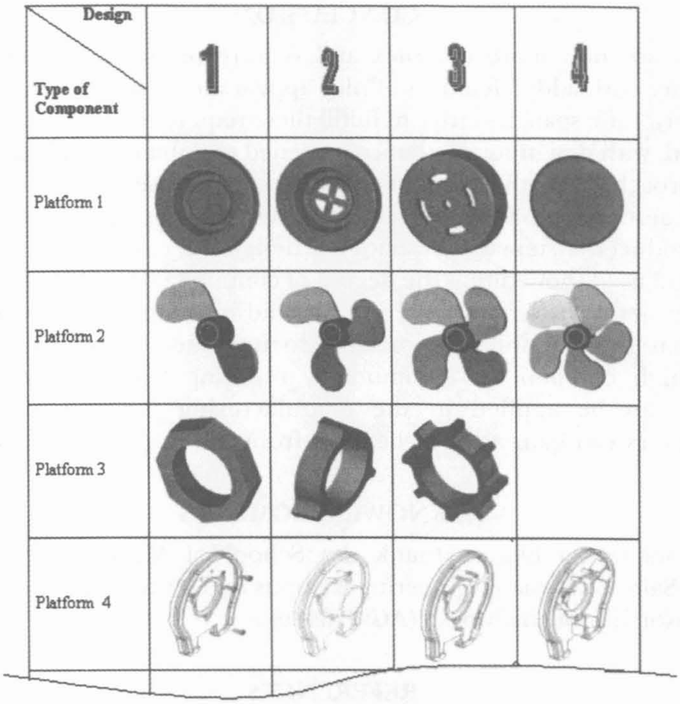

Fig. 9: A morphological chart of platform design

TABLE 2
Result from the methodology

	Before Re-design	After Re-design	Improvement
Efficacy	0.5	0.65	30.0%
Degree of Commonality	0.17	0.22	29.4%
Aesthetic Efficiency	44%	46%	4.5%
PFAI	0.61	0.68	11.5%

TABLE 3
Result for same case study by using Product Line Commonality Index (PCI) developed by Kota *et al.* (2000)

	Before Re-design	After Re-design	Improvement
Number of components, P	22	20	9%
MAX CCI, N	3	3	-
Sum (CCI)	43.028	42.139	2.1%
Sum (MinCCI)	8.943	7.833	14.2%
PCI	59.74%	65.76%	10.1%

CONCLUSION

Customers are now more complex and require products which are good in performance with added features of nice appearance. The products are recently having shorter life span. In order to fulfill these requirements, a product platform is proposed, with design for aesthetics is needed to enhance product appearance. A new approach that exploits product platform to increase variance by considering design for aesthetic has been presented. As a result, the number of variants that can be produced systematically under a designer's control can be increased. The method used showed that the degree of commonality gives higher weightage but the aesthetic efficiency of the product did not improve much. However, it showed that there is wide opportunity to upgrade the product appearance through high components commonality resulting from the re-design. This approach can be applied in the manufacturing industry effectively and manufacturers can gain a lot of benefits from this approach.

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APPENDIX 1

Evaluation chart of the case study before re-design

Components Number and Listing	Category	Degree of Attractiveness C_4	Component Assembly Level C_5	Weightage = $\frac{C-4}{C\_5}$	Number of Variant C_7	Aesthetic Rating, $A_j = \frac{C-6}{C\_7}$
1. Guard Mark	P	5	3	1.67	3	0.556
2. Front Guard	P	5	2	2.50	3	0.833
3. Guard Ring	P	3	3	1.00	3	0.333
4. Spinner	P	3	3	1.00	3	0.333
5. Fan Blade	P	5	3	1.67	3	0.556
6. Guard Lock Nut	P	3	4	0.75	3	0.250
7. Housing Cover	P	3	4	0.75	3	0.250
8. Rear Guard	P	5	3	1.67	3	0.556
9. Motor Housing	P	5	2	2.50	3	0.833
10. Oscillation Knob	A	3	3	1.00	2	0.500
11. Motor	P	1	3	0.33	3	0.111
12. Neck	P	3	3	1.00	3	0.333
13. Stand	*	5	2	2.50	3	0.833
14. Switch Panel	*	5	3	1.67	3	0.556
15. Pull String	A	1	4	0.25	1	0.250
16. Height Adjuster	A	1	3	0.33	1	0.333
17. Sliding Tube	A	1	3	0.33	1	0.333
18. Outer Pole Bowl	A	1	3	0.33	1	0.333
19. Stand Pipe	A	1	3	0.33	1	0.333
20. Base	*	5	3	1.67	2	0.833
21. Wheel	A	1	4	0.25	1	0.250
22. Base Cover	A	1	4	0.25	1	0.250

Number of total components, N_t = 22
Number of shared components, N_s = 11
Number of variants, N_v = 3

Efficacy, E_i = 0.5
Degree of Commonality = 0.17
Aesthetic Efficiency = 44%
Product Family Aesthetic Index = 0.61

TOTAL A_j = 9.75