DEVELOPMENT OF GREEN DESIGN FRAMEWORK FOR MALAYSIAN AUTOMOTIVE INDUSTRIES

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Abstract

Currently the level of competition is intensifying as the business environment shifts from being national to global. As manufactured vehicles have become more global, the competitive pressures from multi-national companies have increased substantially. Based on that, it is clearly shows that, the important of understanding the implementation of green indicators concept. This situation will be giving a big impact to the Malaysian automotive industries to become more competitive in the world market. Furthermore, with realization of Asian Free Trade Area (AFTA) in 2005, it has badly hit Malaysian's carmaker sales. Malaysia used to be the largest automotive market in Asian but recently it has been overtaken by Thailand and Indonesia. Prior to AFTA, the Malaysian automotive industries enjoyed considerable growth but now faces intense competition from Asian and other global manufacturers. Based on that, there is a strong need for this concept in designing a vehicle. It could provide assistance in making decisions at the early stage of the vehicle design and development process in order to avoid the costs and time consumed through later redesign. It is believed that this project is becoming a key factor in order to help National Automotive Policy (NAP) to achieve their objective and make it reality and also the proposed output in this research can help Malaysian car manufacturers to become more competitive. Hence, the aim of this paper is to highlight the establishment of Green Design framework for Malaysian automotive industries by establishing a set of 'Critical Success Factors' and 'Critical Parameter Chain' that will be applied at the design stage. As a summary, this paper will highlight the new paradigm in product design and development process by using green design concept.

Keywords: green design, Malaysian automotive industries, environmental issues, end-of-life vehicle, vehicle design process, design methodology.

1. Introduction

Environmental problem is a global issue that worries all parties. Hence, there is great need for a design process that not only considers economy and technology as basic input for the design, but also considers environmental protection as one of the important parameters. The needs for environmental protection have been publicized extensively due to the increasing environmental consciousness of the public, organized groups and the government. Development of green environment initiatives in the government sector and consumer heightened focus on environmentally conscious products has placed increased pressure on industry to impose the use of cleaner technologies, the reduction of emissions as well as the recycling of used products in an environmentally conscious way.

In many past situations, environmental effects were ignored during the design stage for new products and processes. Hazardous wastes were dumped in the most convenient manner possible, ignoring potential environmental damage. Inefficient energy use resulted in high operating costs. Waste was common in material production, manufacturing and distribution. Consumer products were cast aside, usually with only minimal remanufacturing or recycling. The challenge of design for environment nowadays is to alter conventional design and manufacturing procedures to incorporate environmental considerations systematically and effectively. This requires change in these existing procedures. Change for any existing process is difficult. Changing design procedures is particularly difficult because designers face many conflicting objectives, uncertainties, and a work environment demanding speed and cost effectiveness [1, 2]. Environmental concerns must be introduced in practical and meaningful fashions into these complicated design processes. This project takes a glance at the past and a hard look at the present in the hope of catching a glimpse of the future. The ultimate solution for the manufacturing processes will have to be sympathetic to the environment; benign at worst, beneficial at best!

1.1 Background of the research

Malaysia is a main producer and exporter of vehicle parts, components and accessories, which have found acceptance in many foreign countries including Thailand, Singapore, Taiwan, Indonesia, Japan and the UK. The automotive industry is one of the most important and strategic industry in the Malaysian Manufacturing sector. It is an important industrial driver of industrial development, design, marketing, the provider of technological capability and generator of inter-industry linkages, because it brings together various components, which are manufactured by suppliers in other industries. This also means that the automotive industry actually supports a large number of Small and Medium Enterprises (SMEs) supplying components, subassemblies to the car manufacturer. The automotive sector assembles various components and many parts which are manufactured by other industries, such as steel, plastics, rubber, plastics, composites and so on.

The automotive industry currently faces huge issues and challenges. The fundamental technological paradigm relies on it. Volume production has become progressively more unprofitable in the face of increasingly segmented niche markets. At the same time it faces increasing regulatory and social pressures to improve both the sustainability of its products and environmental issues. Thus, most countries have set new legislation, which is planned to force automotive industries to recover and recycle their products at the end of the life especially in developed countries. Malaysian automotive industries must focus on strengthening the competitiveness market by implementing an effective green design framework. Green design refers to practice that is intended to yield products whose aggregate environmental impact is as small as possible. On the top of everything else, designer now are being asked to contribute to reducing the environment impact of products. Unfortunately, practical green design guidelines and other tools are hard to come by at this stage. Most likely, green design will not be come widely practice throughout industry until good and easy framework and tools become available.

1.2 Malaysian Automotive Industries

The local automotive industry has definitely come a long way since its birth in the early eighties. It is common knowledge that our former Prime Minister, Tun Dr. Mahathir Mohamad was a passionate and firm believer in our country's ability and need to develop indigenous automotive capabilities to meet the rising demands of a young and growing nation. His vision for this industry led to the establishment of the two national car manufacturing companies that we now know so well, Proton and Perodua. This bold step has had a significant and lasting impact in shaping the automotive industry landscape. Today, the industry contributes significantly to the country's development in terms of creating skilled employment, deepening our R&D capacity, and strengthening our component manufacturing and assembly capabilities. The automotive industry has also played a catalyst role in the growth and development of other related industries. Our healthy growth trajectory has contributed to a significant increase in the demand for motor vehicles. Over the last 10 years, new Total Industrial Vehicles (TIV) registrations have grown from 200,000 annually to an estimated 500,000 for this year (2005). Our domestic motor vehicles market represents about 30 per cent of the total demand in the 5 largest ASEAN economies (Indonesia, Malaysia, Philippines, Singapore and Thailand).

2.3 ASEAN Free Trade Area

Malaysia is a signatory to the WTO. We are a leading player in the ASEAN Free Trade Area (AFTA) process, and we are actively seeking bilateral Free Trade Agreements with several of our most important trading partners. ASEAN initiated the ASEAN Free Trade Area, or AFTA, which laid out a comprehensive program of regional tariff reduction, to be carried out in phases through the year 2008 at the Fourth ASEAN Summit in Singapore in January 1992. This deadline was subsequently moved forward to 2003. Over the course of the next several years, the program of tariff reductions was broadened and accelerated, and a host of "AFTA Plus" activities were initiated, including efforts to eliminate non-tariff barriers and quantitative restrictions, and harmonize customs nomenclature, valuation, and procedures, and develop common product certification standards. In addition, ASEAN later signed framework agreements for the intra-regional liberalization of trade in services, and for regional IPR cooperation. An industrial complementation scheme designed to encourage intra-regional investment was approved, and discussions were held on creating a free investment area within the region. During the financial crisis of 1997-98, ASEAN reaffirmed its commitment to AFTA, and as part of a series of "bold measures," agreed that the original six AFTA signatories would accelerate many planned tariff cuts by one year, to 2002 from 2003.

2. Green Design

Previously, environmental solutions were in the form of end-of-pipe pollution control strategies. These are peripheral solutions that focus primarily on chemical, biological and physical treatment of terminal streams to reduce the toxicity and undesirable pollutants in industrial discharges. Although this strategy can relieve negative environmental consequences, it generally focused on symptoms and not the true causes of the environmental problems. Therefore, this strategy lack of sustainability and effectiveness.

Prevention is always better than cure, in this context; the ideas of pollution prevention have become established in the process engineering. The concept enables engineers to address the root causes of the environmental problems at the heart of the process. Report of successful case studies, guides on waste minimization and pollution prevention are available [3]. These involve ranking waste minimization alternatives and proposing practical techniques that can be applied to waste generation problems such as technology replacement, source reduction by process changes and environment modifications, and recycling of waste materials. It is evident that by employing pollution prevention ideas such as energy and mass discharges, process emissions can be reduced. Nevertheless, it does not necessarily follow that the total environmental impact of the process is reduced [4].

Catalysts improvement or purer starting materials may lead to less emission from the process under consideration, but may incur a greater overall degree of environmental damage through the catalysts production stage or raw material purification. Therefore, it is essential to develop a detailed methodology at early stage of process design that considers assessment and minimization of the environmental impacts. Besides, this methodology has to be practical and achievable that can be put into practice in design process, considering the manufacturability, functionality and safety of the product.

2.1. Design Process

The life cycle of any product basically consist of 5 stages as shown in Figure 2.1, from material production until to the disposal of the product. Each stage could bring adverse effect to the environment if it is not controlled properly. Stage 1 (Design Stage) is a crucial stage which can affect the other stages in a greater extent.

During the process design phase, it actually takes into account the effect of all the other 4 stages to the environment. Therefore, how a product is being design will determine the effect to the environment, from early stage of material production in manufacturing until the product's end of life[5]. A design methodology will be set up to make sure the product will not bring harmful effect to the environment, from cradle to grave.

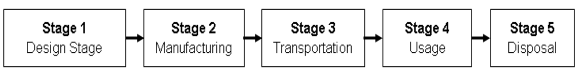

Figure 2.1 Life cycle of a product

2.2 Design tools and techniques

There are various methods that can be used in design stage. Selection of method must be done carefully so that the design outcomes suite for the design purpose and target result. Besides, the design flow can be tracked and any problem arises can be solved immediately.

3. Pilot Framework Developed

A pilot framework which applies the green design concept is developed. This framework contains five critical success factors which is selection of material, selection of manufacturing process, design of component, legislation and International Organization for Standards (ISO).

(1) Selection of material

A technical product is usually made of one or several materials. However, there are examples of immaterial products like computer programs. The sustainability of a certain material based product is mainly depending on the material or materials used for the product itself or during its lifetime according to, e.g., a LCA (Life Cycle Assessment). During the life cycle of a material product, different stages are passed, like material extraction, manufacturing, packing, transportation, product use and disposal. All these stages will give a certain environmental impact, which is mainly caused by the materials involved in the different stages. Hence, the selection of materials for a certain product is of vital importance, while the material determines the use of our natural resources as well as the amount of energy used for the production and the use of the product. Manufacturing of products typically involves chemical substances like cutting fluids during machining, cleaning aids, paint, etc. Technical lifetime, maintenance, service and repair of a product are other examples of areas, which are typically dependent on the material used for the product itself [6].

Structural materials for material products can be divided into six groups: *Metals*, *ceramics*, *synthetic polymers*, *natural organic materials, natural inorganic materials and composites*. These groups cover probably more than 99% of all materials used in mechanical, civil and electrical engineering. The use of renewable materials, like wood versus non-renewable materials, like plastics (made of raw oil), is also important to consider in product development. Renewable materials are materials which in a short time can be formed again in the nature and give no or very little impact on the environment [7]. If, e.g., a tree is cut, used in a product and burnt and a new tree is planted, the new growing tree can bind the carbon dioxide formed when the old tree is burnt. If the ash, containing minerals and fertilizers, is brought back to the earth, the new tree will use the ash when growing. This is an example of the life cycle of a renewable material. However, if a forest has been cut down and no new trees have been planted again, the environmental balance is changed. This can lead to earth destruction, a change in the climate due to changed water balance and in the worst case the forming of a desert. When a tree is cut a price can be estimated to ensure the sustainability, which in this case means that a new tree is planted and the forests are kept and maintained in the future. A polymer made from raw oil is an example of a non-renewable material, while the raw oil cannot easily be brought back to its initial state again. This leads to an environmental impact when raw oil is used. The term renewable is typically used for organic materials.

Selection of material is traditionally made by technical demands like price, strength of material, temperature stability, density, hardness, etc. However, for a successful product development the technical or physical demands are not enough. Factors like reputation, fashion, product, cultural aspects, etc. must also be taken into account when developing sustainable products [7]. As a result of metaphysical reasons like 'feelings' for a certain material, the materials selection is often not easy. Clothes made of synthetic fibres are often more easy to clean and to keep free from wrinkles, but the natural materials are generally more popular because of its feeling and the fact that they are generally more popular. Wooden floors are more popular for certain people even if concrete floors are more wear resistant and durable. Anyhow, materials selection for sustainable products is mainly based on the ultimate impact on the nature as well as market demands and economic factors.

(2) Selection of manufacturing process

The need to provide the design activity with information regarding manufacturing process capabilities has been recognized for many years and some of the work that has been done to address this problem will be touched here. There is relatively little published work in this area; the texts on design rarely include relevant data and while a few of the volumes on manufacturing processes do provide some aid in terms of process selection and cost, the information is not sufficiently detailed and systematically presented to do more than indicate the apparent enormity of the problem. Typically, the facts tend to be process specific and described in different formats in each case, making the engineer's task more difficult. There is a considerable amount of data available but precious little knowledge of how it can be applied to the problem of manufacturing process selection. The available information tends to be inconsistent: some processes are described in great detail, whilst others are perhaps neglected. This may give a disproportionate impression of the processes and their availability. Information can also be found displayed in a tabulated and comparative form on the basis of specific process criteria. While useful, the design related data tends to be limited and no or very little detailed data is included. Such forms may be adequate if the designer has expertise in the respective processes, but otherwise gaps in the detail leave room for misconceptions and may be a poor foundation for decision making.

(3) Design of component

Modularity in design is an approach aiming to subdivide a system into smaller parts (modules) that can be independently manufactured, and used in different systems to drive multiple functionalities. Besides reduction in cost (due to lesser customization, and less learning time), and flexibiity in design, modularity offers other benefits such as augmentation (adding new solution by merely plugging in a new module), and exclusion. Examples of modular systems are cars, computers and high rise buildings. Computers, in fact, are the first systems in which modularity in architecture was implemented to overcome changing customer demands and to make the manufacturing process more adaptive to change. Modular design is an attempt at getting both the gains of standardization (high volume normally equals low manufacturing costs), and the gains of customization. Simple example of the use of modular design in cars would be to note the fact that while many cars come as a basic model, paying extra will allow for "snap in" upgrades. Such as a more powerful engine or seasonal types; these don't require any change to other units of the car such as the chassis, steering or exhaust systems [8].

(4) Legislation

There are some legislation should be followed in green design concept:

Restricted Materials

European Union Directive 2002/95/EC—"Restriction on the use of certain Hazardous Substances" (RoHS)—restricts the use of lead, cadmium, mercury, hexavalent chromium, PBB (polybrominated biphenyls) and PBDE (polybrominated diphenyl ethers). Ergotron products are now made to be 100% RoHS compliant. The People's Republic of China has implemented its own RoHS requirements: Administration on the Control of Pollution caused by Electronic Information Products (ACPEIP). In its first phase of implementation, ACPEIP requires a label be applied to all affected electronic products indicating the product's environmental protection use period, as well as listing the concentration of harmful materials in the manual. The allowed limits for harmful materials given in ACPEIP are much tighter than in the EU RoHS Directive. The standard is still under development and further requirements, including a catalog of specified products and their testing requirements have not yet been defined. Ergotron will monitor the development of this standard and maintain compliance as further requirements develop.

Disposal of Electrical Equipment
The European Union has enacted the Waste Electrical and Electronic Equipment Directive (2002/96/EC), requiring that manufacturers and distributors of electronic equipment are responsible for managing the collection and further handling (including recycling) of their products

Packaging and Package Waste
In the EU Directive on Packaging and Packaging Waste (94/62/EC) and other legislation calling for the abolition of toxics in packaging, packaging is designed without inclusion of heavy metals and to maximize its recyclability. No excess covers or wrappings are used, and shipment quantities are carefully calculated to reduce waste of container space (and concomitant waste of fuel in transportation). When used, the shipping pallets have been heat-treated rather than fumigated to reduce the use of harmful insecticides and vermifuges while still controlling the spread of non-native insect species.

Be transparent
All the product materials must be transparent. No skepticism out there. Consumers must believe in the legitimacy of the product and the specific claims you are making.

(5) International Organization for Standards (ISO)

The ISO 14000 environmental management standards exist to help organizations minimize how their operations negatively affect the environment (cause adverse changes to air, water, or land), comply with applicable laws, regulations, and other environmentally oriented requirements, and continually improve on the above. ISO 14000 is similar to ISO 9000 quality management in that both pertain to the process (the comprehensive outcome of how a product is produced) rather than to the product itself [9]. The overall idea is to establish an organized approach to systematically reduce the impact of the environmental aspects which an organization can control. Effective tools for the analysis of environmental aspects of an organization and for the generation of options for improvement are provided by the concept of Cleaner Production.

As with ISO 9000, certification is performed by third-party organizations rather than being awarded by ISO directly. The ISO 19011 audit standard applies when auditing for both 9000 and 14000 compliance at once. ISO 14001 is an internationally accepted specification for an environmental management system (EMS). It specifies requirements for establishing an environmental policy, determining environmental aspects and impacts of products/activities/services, planning environmental objectives and measurable targets, implementation and operation of programs to meet objectives and targets, checking and corrective action, and management review.

ISO 22628:2002 is a methodology that can be applied during the design of motor vehicles is part of fresh global standards for recycling autos. The International Organization for Standardization (ISO) has published the standard as "ISO 22628, RoadVehicles—Recyclability and Recoverability—Calculation Method." The main purpose of ISO 22628 is to minimize environmental harm in the disposal of motor vehicles at the end of their life cycle. It provides manufacturers with a method for calculating the percentage of recoverable and recyclable materials of motor vehicles, their components, and materials before the products leave the factory. France's M. Paul Serre, chairman of the ISO technical committee that drafted ISO 22628, said he expects that use of the standard will raise the percentage of recoverable and recyclable materials used in the manufacture of motor vehicles as well as those recaptured during the dismantling process. That, he adds, will shrink the amount of waste that needs to be buried or incinerated, saving considerable energy.

4. Data Analysis and Discussion

This study use survey to get the research objectives. The methodology used in this research is questionnaire. Survey through questionnaire is conducted to get information about the level of green design concept adoption and understanding in Malaysian industries. The samples in this pilot survey were distributed to 30 manufacturing companies via mail and email. The data of 30 questionnaires collected will be analyzed by Statistical Package for the Social Science (SPSS). The results of the data analysis are presented in descriptive analysis of respondent on general information about company such as number of employee, how long they applied green design concept and etc. It is followed by general green design concept on the respondents. Critical success factors (CSFs) are presented regarding the perception on the importance for green design concept in Malaysian automotive industries.

4.1. Descriptive Statistic of Respondent

The first aspects to be investigated were the general information of the companies such as number of employees, companies' certification, etc. Using descriptive statistics, the results are summarized in tables and figures in the percentage and frequency. From the results, information about characteristics of the respondents can be identified such as classification of companies, experience and maturity in implementing green concept design.

4.1.1 Current Position of the Respondents

With regards to the job position of the respondents, Table 4.1 shows that 60% of respondents hold the position of Engineering department manager, 20% of design department manager, 16.7% of production manager and 3.3%

of general manager. This indicates that the questionnaire has been answered by appropriate person in the company. It means the data has high degree of reliability and validity because the answers have been obtained from people who has direct responsible for the green design concept in the company.

Table 4.1 Current position in the company

	Frequency	%	Valid %	Cumulative Percent
CEO/GM/Director	1	3.3	3.3	3.3
QA/C manager	0	0.0	0.0	3.3
Design department manager	6	20.0	20.0	23.3
Engineering department manager	18	60.0	60.0	83.3
Production manager	5	16.7	16.7	100.0
HR and development manager	0	0.0	0.0	0.0
Total	30	100.0	100.0	

4..1.2. Number of Employees

Number of employees determines the company size and used to categorize the company into Small and Medium sized Enterprises (SMEs) and large enterprises. This study categorized SMEs as a company with approximate number of employee between 1 to 300. The companies with approximate number of employee above 300 can be categorized as large enterprises. Table 4.2 summarized that 80% of the respondents are from SMEs meanwhile 20% are from large companies.

Table 4.2 Approximate number of employee

	Frequency	%	Valid %	Cumulative Percent
Less than 50	3	10.0	10.0	10.0
50 to 150	18	60.0	60.0	70.0
151 to 300	3	10.0	10.0	80.0
More than 300	6	20.0	20.0	100.0
Total	30	100.0	100.0	

4.1.3. The Certification

With regards to environmental system qualification, all of the respondents have at least one certification in placed (Table 4.3). When examine the result in more detail, it was found all companies have MS ISO 9001:2000 and 90 % are certified to MS ISO 9002:2000. This is followed by ISO 14001 and ISO 14004, 40%. Both of the certificates show that the companies achieved the requirements for environmental management systems. Only 10% of respondents get the QS9000.

Table 4.3 Number of companies certified to green design concept

		Frequency	Percent
Valid	QS9000	1	10.0
	MS ISO 9001:2000	10	100.0
	ISO 14001	4	40.0
	MS ISO 9002:2000	9	90.0
	ISO 14004	4	40.0
	Others	0	0.00

Note: Some of the companies get more than 1 certificate.

4.1.4. Types of material used

Table 4.4 shows the information of the type of material used to produce the product.

Table 4.4 Types of material used

Material used	Frequency	Percent
Metal	10	100.0
Synthetic polymer	7	70.0
Composite	2	20.0
Natural organic material	1	10.0
Ceramic	0	0.0

As can be seen, the material used is quite diverse between the companies. The result shows that all of Malaysian manufacturing companies who answered the questionnaire are metal based producer. 70% companies use synthetic polymer as their product material. This is followed by composite, 20% and natural organic material, 10%.

4.1.5. Length of Time involve in Green Design

This data indicates the experiences and maturity of the company in adopting green design. Table 4.5 shows that half of the respondents' company adopt green design concept more than 3 years. This means that the experiences of companies in green design concept are good and acceptable in providing appropriate answers to questionnaire.

Table 4.5 The length of the time

	Frequency	%	Valid %	Cumulative Percent
Less than 3 years	15	50.0	50.0	50.0
3 to 6 years	12	40.0	40.0	90.0
More than 6 years	3	10.0	10.0	100.0
Total	10	100.0	100.0	

4.2. Level of Understanding about Green Design

One of the reasons the failures in implementing green design concept is low level of understanding and knowledge on green design concept. In order to investigate the level of understanding and knowledge about green design through the techniques to cultural aspects, the respondents were asked to indicate their level of agreement with each one on a scale of 1 to 5. Table 4.6 shows the mean score of level of understanding about green design.

Table 4.6 Mean score for the level of understanding in green design concept

STATEMENTS	Mean	Rank
1.Green Design concept is one that has a particular urgency in a world of growing population, limited resources, and increasing consumption.	4.2	4
2.Green Design concept is based on delivering performance with minimum negative impact on the environment.	4.7	2
3.Green is directed at both natural and built environments and includes our systems and our attitudes.	4.5	3
4.Subsidy of government is encouraged to develop Green Design concept	4.0	5
5.The 100% recyclable product is the most desirable design product	4.9	1
6.Teamwork and participation are important for achieving a continuous improvement culture	4.0	5

4.3. Hypothesis Test

4.3.1. Perception for a factor contributes its importance in Critical Success Factor of green design concept

The objective of this study is to obtain Critical Success Factor (CSFs) of green design concept. The factors contributes its importance in CSFs of green design concept are investigated in this survey. (1 for the most critical to 5 for the least critical.) After analyzing the data from respondents, the importance of CSFs are shown in Table 4.7.

Table 4.7 Mean score with rank for CSFs

Critical success factor	Mean	Rank
Selection of material	1.4	1
Selection of manufacturing process	3.0	2
Design of component	3.4	3
ISO	3.4	4
Legislation	4.5	5

The assumption that the most importance factor will get the mean 5 value, the second one will get the mean 4 value and so on till the least importance will get the mean 1 is made. So such hypothesis are made

Hypotheses 1 for test are:

- Ho: There is no significant selection of material contributes the most importance in CSFs of Green Design Concept.
- Hi: There is significant selection of material contributes the most importance in CSFS of Green Design Concept.

Hypotheses 2 for test are:

- Ho: There is no significant design of component contributes the second importance in CSFs of Green Design Concept.
- Hi: There is significant design of component contributes the second importance in CSFs of Green Design Concept.

Hypotheses 3 for test are:

- Ho: There is no significant ISO contributes the third importance in CSFs of Green Design Concept.
- Hi: There is significant ISO contributes the third importance in CSFs of Green Design Concept.

Hypotheses 4 for test are:

- Ho: There is no significant selection of process contributes the 4th importance in CSFs of Green Design Concept.
- Hi: There is significant selection of process contributes the 4th importance in CSFs of Green Design Concept.

Hypotheses 5 for test are:

- Ho: There is no significant legislation contributes the least importance in CSFs of Green Design Concept.
- Hi: There is significant legislation contributes the least importance in CSFs of Green Design Concept.

The one simple T-test by using SPSS was employed for analyzing the test. The result in Table 4.8 shows the p-value of the five CSFs are lower than 0.05(i.e. significant level), hence the all of the null hypothesis was rejected. In short, it can be concluded that there was a significant importance for each factor in CSFs of green design concept.

Table 4.8 The result of T-Test for the CSFs

			p-value		95% Confidence Interval of the Difference		
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper	Test Value
Material	2.449	9	.037	.40000	.0306	.7694	1
Design	5.250	9	.001	1.40000	.7968	2.0032	2
ISO	.739	9	.049	.40000	-.8252	1.6252	3
Process	-2.739	9	.023	-1.00000	-1.8260	-.1740	4
Legislation	-3.000	9	.015	-.50000	-.8770	-.1230	5

4.4. Reliability Test

Reliability is defined as the extent to which measurements are free from random-error variance [11]. An internal reliability test analysis was employed in this research. The Cronbach's alpha coefficient is used to test the reliability of questionnaire. It determines the extent to which items within a factor should be excluded from the scale so as to improve reliability.

Using SPSS version 15.0 to analyze section 2 in the questionnaire, Table 4.9 shows that Cronbach's Alpha Based on Standardized Items is 0.719 yet Cronbach's Alpha in this research is 0.776. Thus, this survey has higher internal consistency and therefore it is reliable.

Table 4.9 Reliability Test

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.776	.719	6

4.5. Validity Test

Content validity is not evaluated numerically, it is subjectively judged by the researchers. A measure has content validity if there is a consensus among researchers that the instrument includes items that covers all aspects of the variable being measured [10].

For this study, the items included in the survey instrument have been developed based on exhaustive review of the literature review of the literature and detailed by academics and advisors. 2 questionnaires were sent out in a pilot survey and revised by under graduate project supervisor and a professor from UK. Thus, it is believed that this research instrument fulfill the content validity.

A measure has construct validity if it measures the theoretical construct or trait that was designed to measure. The construct validity for each statement in section 2 is analyzed by using SPSS15.0 Data Reduction factor, Factor Analysis: Descriptives of KMO and Barlett's test and sphericity. The KMO value of 1 show the items have the strongest correlation in Kaiser-Meyer-Olkin Measure of Sampling Adequacy. The value of KMO from the analysis is shown at Table 4.10. KMO value of 0.625 means the correlation of the items is strong and acceptable.

Table 4.10 KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.625
Bartlett's Test of Sphericity	Approx. Chi-Square	35.810
	df	15
	Sig.	.002

5. Conclusion

From the questionnaires, all the qualitative and quantitative data are collected and analyzed according to the methodology. From here, it can be considered that the developed green design framework is an effective tool to enhance and simplify environmental benign design. This research successfully describes a structured system for addressing the environmental concerns at an early product design stage. The proposed system is a multi-perspective approach that requires the consideration of all product life cycle environmental impact. Reducing a product environmental impact is not only the obligation of environmental professionals, but also the responsibility of designers and engineers that responsible for new product development. Therefore, the framework developed will be a useful tool for designers to design an environmental friendly product.

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