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Analysis For Determining Factors That Make Good Design Process In Automotive Manufacturing Organization.

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Abstract: *This study involved a literature review as well as information, data collected and analysis in two automotive industries. The paper investigated factors that make good design process in automotive manufacturing organization in order to improve the design process at each stage of manufacturing. The methodology adopted in this work is to evaluate the said factors by qualitative technique in sending structured questionnaires to three automotive companies in Malaysia and Nigeria to fifty five product design engineers in those companies in order to get their input on a specific phenomenon. Reliability, descriptive and correlation analysis were carried out using SPSS software to analyze and justified the consistency, reliability and significant of each factor in order to increase the decision makers confidence. The factors are categorized as independent variables in the analysis namely; Customer requirement, Product life cycle, Process planning. Technology and Information gathering. While products design process was set to be the dependent variable. The study results analysis indicate that all the selected factors are within the acceptable range.*

Key words*: *Design process, Technology, Process planning, Product life cycle, Customer requirement, Information gathering

I. Introduction

Automotive manufacturing is one of the biggest sectors that contributed in global economy every year, with huge amount of investment of over $ 4 trillion globally. But there are numerous challenges which cost the company's losing billions of dollars annually due poor product design process and lack of identifying the critical factors that make good design process in most of auto manufacturing industry, product design process in automotive industry is normally complicated, lengthy, and expensive.The design of a new vehicle, represent a major investment for automotive manufacturers. With research and development costs reaching up to $6 billion U.S. [1] and ultimately determining 70% to 90% of total project costs, the design process poses a significant financial risk. Similarly, auto manufacturers typically require between 3.5-5 years of time to bring a complete vehicle to market [2]. This represents a significant investment of company time, in the form of both employee working hours and the lost opportunities of alternative projects, with success ultimately dependent on the design and development of a product that sells [3].In order to minimize the possibility of unsuccessful design products in the automotive industry, managers and product designers are concerned with understanding the factors that determine the success of new products. Given the highly competitive nature of the automotive manufacture industry, operation efficiency is important for all auto companies. In most cases, operation efficiency leads to competitive advantage and increased market share. The researcher categorized critical factors into five broad categorize that also formed part of the five point Likert scale questions for our primary research. The factors identified are Technology, customer requirement, process planning, product life cycle and information gathering.

II. Technology

Electronic systems are growing more complex, the use of computer aided design (CAD) tools for modeling, analysis, and design is critical for timely and accurate design. In the manufacturing industry, computers and technology plays an essential part in dealing with digital electronic systems and performing duties, which are considered dangerous for human beings. , co-design of hardware and software is critical for meeting design goals, such as high performance, which are the key to commercial competitiveness. Furthermore, in today's highly competitive global environment, a company's ability to utilize technology and come up with innovative products is a key success factor for obtaining and sustaining competitive advantage . Technology is a critical factor in the automotive industry that help companies adapt to evolving market conditions and companies competencies. For instance, the modern automobile has its origins in the late 1700s with the industrial quest of self-propelled highway automobiles [4]. The search intensified on modernization within electric, steam, and core combustion-based motorized technology. This innovation, driven by technological advances, culminated in the development of the predecessor to the contemporary petrol-driven traveller automobile by Karl Benz and Gottlieb Daimler in 1885 [5]. Central to the application of technology in the automotive industry is its ability to allow innovation while also providing an easy, reliable, and efficient way of conducting manufacturing operation. Technology has increasingly altered manufacturing process for motor vehicle, while car are produce at faster rates, modern technologies use in advancing manufacturing for the automotive industry can be a brake through in curving factors that affects good manufacturing, these technologies that is been used in automotive manufacturing include programme machines and tools, high speed data commutation and management, and visualization techniques.

Technological innovation is defined as an iterative undertaking initiated by the perception of a new market or service opportunity for a technology-based invention that brings about development, production and marketing activities striving for the commercial success of the invention. According to [6], technological innovations incorporate product, process, and service invention. The concept can also be extended to include combination of technologies that present worthwhile advantages. Computer Aided Design software represent an area of technological progress that has developed to become one of the most important aspect of car manufacturing. The design process requires high degree of precision and accuracy that is not attainable manually by human beings. With CAD software, engineers are able to build two-dimensional or three-dimensional models of envisioned vehicle that can allow them ascertain its benefits and features even before the actual design process. Furthermore, the introduction of intelligent technologies and adoption of artificial intelligence in the manufacturing industry significantly influenced the sector. Accordingly, the construction of robots with striking has made automotive manufacturing more reliable and convenient for human engineers. Essentially, robotics is used in automotive manufacturing to conduct the dangerous and repetitive tasks.

2.1 Reliability Analysis Result (Cronbach's Alpha)

Reliability analysis is to confirm the data scale based on its internal consistency. It is commonly used when a researcher have multiple likert questions in a survey questionnaire that form a scale you wish to determine if the scale is reliable. Cronbach's alpha simply provides you with an overall reliability coefficient for a set of variable.However, reliability for cronbach's alpha most falls within the range of 0.75 to 0.83 with a least one claiming a cronbach's alpha above 0.90. [7], [24] suggested that ideally the cronbach's alpha coefficient of a scale should be above 0.70.

Table 1: Represents reliability statistics (Technology)

Cronbach's Alpha	Cronbach's Alpha based on standardized items	Number of items
0.798	0.825	5

∞ ≥ 0.9 = Excellent, 0.9 > ∞ ≥ 0.8 = Good, 0.8 > ∞ ≤ 0.7 = Acceptable, 0.7 > ∞ ≤ 0.6 = Questionable, 0.6 ∞ ≤ 0.5 = Poor, 0.5 > ∞ = Unacceptable

Table 2: Representsdescriptive analysis result (Technology)

	N	Minimum	Maximum	Mean	Std. deviation
Technology (TEC)	55	10	25	22.16	3.259
Valid N (List wise)	55				

***Note*:** 1-2 = Minimum, 2-3 = Below Average, 3 = Average, 3-4 = above average, 4-5 = sufficiently above / maximum (Based on mean value). TEC =Technology, Std = Standard deviation, N = Number of questions.
Based on the result shown mean value for TEC was found to be 22.16 which indicate sufficiency observance of TEC. Standard deviation was found to be 3.259 which indicate above average.

III. Customer Requirements

Customer is a group or individual who has a business relationship with the organization those who receive and use or are directly affected by the product and services of the organization. It is important nowadays to meet the specific requirements of each customer needs [8],modern companies have to adopt the products precisely to customer needs, and therefore parameters of manufacturing products are adjusted to the individual requirements of customer. Different customers determine their specific requirements based on their special market strategy in order to satisfy customer needs [9]. Customer requirement became one of the most critical factors in modern automotive manufacturing organizations due to its numerous challenges in communicating with different customers and satisfy different customer need, several empirical studies have been explored on customers requirement needs. According to [10], tools were designed to demonstrate that the new established manufacturing process in automotive manufacturing organizations has potential to produce a product that consistently meets all customer requirement, in order to identify the parts of the design process that are most in need of change for customer satisfaction.Research conducted by [11], indicates that product innovations, staff service, price, convenience and business profile are all determinants of customer requirement and satisfaction based on the customer requirement strategy. [11], suggest to provide the customer with something unique and make the organizations product and services distinctive from its competition. Designing products that are acceptable by consumers is a complex and demanding process where selected objects, the materials used, and the location of specific design features have a deep rooted meaning both in terms of utility and communication. According to [12] "the physical placement and the perceptual appearance, sound, and touch all talk to the users, suggesting actions to be taken." Through the various design tools, designers are able to communicate with the final consumers in a way that cannot be understood in the real world.

The global automotive industry has evolved to become a pinnacle of technological driven innovation, where companies are competing to produce marketable products that are not only high-tech but also appealing to customers. Increasing competition has made automotive firms to focus on the need to develop customer-based approach to automotive manufacturing. According to [13], customer centered approach to automotive production allow companies to differentiate themselves from similar technology optimistic crowd. Focusing on customer requirement appears to be centered on sales and marketing strategy meant for improving market share.In recent times, challenging economic and market conditions have forced majority of automotive companies to question the status quo and come up with new methods of vehicle design that meet the requirements of end users. According to [14], customer needs have become even more important than the greatest technology integrated into their vehicles. This has led to the realization by some automotive manufactures that increasing future competitiveness and sales will be determined by the ability to meet customer needs and not just incorporating advanced technologies in the products. Several customer-oriented approaches exist. Examples of this include emphasize on customer feedback regarding the products, pre-order customer customization of the vehicle and the dependence of more customer experienced sales agents. According to [15] this involves a combination the traditional technology push approach and the complementary design pull approach with more emphasize on the customers perception of the product. Other techniques of customer-centered design include design-driven innovation, user centered design and emotional design [12].[16],Investigated and promoted the importance of vehicles creating positive experiences and fulfilling the psychological needs of users. They argued that technological product design should focus primarily on the experience the product provides the user, rather than on its form and functionality. Similarly, [17] explored the ways in which users interacted with their vehicles, specifically their infotainment systems, in order to refine future designs to provide improved customer experiences. They opined that companies in the automotive industry must focus on understanding the context in which customers, in order to better understand and envision future products that are more likely to meet the needs of these contexts, are using products

Table 3: Represents reliability statistics (Customer Requirement)

Cronbach's Alpha based On standardized items	Cronbach's Alpha	Number of item's
0.981	0.981	5

∞ ≥ 0.9 = Excellent, 0.9 > ∞ ≥ 0.8 = Good, 0.8 > ∞ ≤ 0.7 = Acceptable, 0.7 > ∞ ≤ 0.6 = Questionable, 0.6 ∞ ≤ 0.5 = Poor, 0.5 > ∞ = Unacceptable

Table 4: Represents descriptive analysis result (Customer Requirement)

	N	Minimum	Maximum	Mean	Std. deviation
Customer Requirement (CRT)	55	11	25	21.29	2.789
Valid N (List wise)	55				

***Note*:** 1-2 = Minimum, 2-3 = Below Average, 3 = Average, 3-4 = above average, 4-5 = sufficiently above / maximum (Based on mean value). CRT = Customer requirement, Std = Standard deviation, N = Number of companies.Based on the result shown mean value for CRT was found to be 21.29 which indicate sufficiency observance of CRT. Standard deviation was found to be 2.789 which indicate below average.

IV. Process Planning

Process planning function in automotive industry is used to link the design function and the manufacturing function. A more acceptable definition of the term considers process planning as a subsystem applicable in the conversion of design data to work instructions [18]. As a link between these two critical stages of automotive manufacturing, it is an extremely detailed and difficult task that was traditionally carried out by highly skilled workers who had intimate knowledge of a wide range of manufacturing processes and themselves experienced machine operators.In studying a drawing design, the planner is supposed to ascertain the operations that need to be done on a work piece in order to develop a specific component in a specific order; establish the cutting conditions to be used and in the process obtain the machine times and non-machine times including set ups and tool changing. Moreover, design work can be used to determine the associated costs. According to [19], relevant knowledge, skills and expertise in a particular environment is essential because the decisions are often inevitably affected by such things as the capability of the machine, availability of machines, labor requirement and the associated costs.Computers play a fundamental role in developing knowledge based systems. By means of computers, the boring and monotonous characteristics of process planning are automated and fast-tracked leading to optimization of overall manufacturing job. Similarly, more consistent process plans can be obtained by using standard set of rules that improve confidence in the system and contribute to the rationalization of production. The use of computers in process planning has led to two main types of computer aided process planning: variant and generative process planning [19].

4.1variant Process Planning

This technique is based on the application of group technology (GT) principles. Here, the specific components to be manufactured are aggregated based on their similarities in shape and hence required machine operations. Together, the group is referred to as a family. Accordingly, all members of a family are then manufactured in a single GT cell. The benefit of this is that standardized tools can be used at ones thus minimizing tool changes and optimize routing of each component [19].When applied to process planning, a representative member of a part family is effectively planned and the outcome of the process plan is stored in the computer. Consequently, if the plan is needed for another member of the family, the initial plan is recalled and reviewed by the planner who can conduct specific modification in order to match the plan for the new component.

4.2generative Process Planning

This approach to computerized process planning is aimed at creating a new process plan through a completely automatic means. Here, the planner is required to input some form of geometric description of the specific component to be made. The planner applies some standardized logical rules to input data and the processes necessary to come up with the desired component are generated automatically. A common example of this that is extensively used in the manufacturing industry falls under artificial intelligence (AI). The systems in artificial intelligence are generally based on simple elementary surfaces that can be recognized by some form of algorithm that consequently selects a suitable machine process to generate the surface. This is the most broadly used computerized technique of process planning in automotive manufacturing. Many academic researchers in this industry have attempted to provide some automatic means of linking the designs process (CAD) to the manufacturing process (CAM). The outcome of these researches has often been a variety of CAD systems that include NC part program generation capabilities [18]morespecifically; these systems take advantage of all interactive graphic capabilities of the CAD system to come up with tool path information from mathematical model defining the object in terms of machine. A number of process planning systems exist in the manufacturing literature Automated Process Planning and Selection (APPAS), Interactive Computer Aided Process Planning (ICAPP), Totally Integrated Process Planning System (TIPPS), Computer Aided Process Planning (CAPP), Simi-Intelligent process Planner (SIPP), and Systematic Tool-Oriented Process Planning (STOPP).

Table 5: Represents reliability statistic (Process Planning)

Cronbach' Alpha based	On standardized items Cronbach's Alpha	Number of items
0.772	0.820	5

∞ ≥ 0.9 = Excellent, 0.9 > ∞ ≥ 0.8 = Good, 0.8 > ∞ ≤ 0.7 = Acceptable, 0.7 > ∞ ≤ 0.6 = Questionable, 0.6 ∞ ≤ 0.5 = Poor, 0.5 > ∞ = Unacceptable

Table 6: Represents descriptive analysis result (Process Planning)

	N	Minimum	Maximum	Mean	Std. deviation
Process Planning (PPG)	55	15	25	21.76	2.461
Valid N (List wise)	55				

Note**:** 1-2 = Minimum, 2-3 = Below Average, 3 = Average, 3-4 = above average, 4-5 = sufficiently above / maximum (Based on mean value). PPG = Process Planning, Std = Standard deviation, N = Number of companies.Based on the result shown mean value for PPG was found to be 21.76 which indicate sufficiency observance of PPG. Standard deviation was found to be 2.461 which indicate below average.

V. Product Life Cycle

The life cycle of a product takes the holistic view of its entire development process that is made up of several identifiable phases including product design, process development, production, distribution, use, and disposal [20]. This process is specifically critical in the design and manufacturing industries because it helps to incorporate information and knowledge produced within the product life cycle and in the process promoting innovation. A product life cycle can be used as a collaborative platform for manufacturing industries and especially the teams engaging in product or process development. Many products do not follows prescribed route because of failure, the product life cycle concept is extremely valuable in helping management to look into the future and better anticipate what changes to make to the strategy marketing [5] mentioned that to improve product quality and efficiency in production, automakers should invest heavily on time and money into developing and improving the manufacturing process. Furthermore, product life cycle management (PLM), provides an environment of information sharing as well as work distributed through technological platforms and softwareThe tools used in product life cycle and information gathering play an important role for the realization of design engineering projects as they are integrated into commercial software for Computer Aided Design and others such as Computer Aided Manufacturing and Computer Aided Engineering. According to [20], Product life Cycle management and Supply Chain Management (SCM) must not be considered separately and must be integrated seamlessly if companies wish to build high quality, innovative products to the market quickly and cost effectively. He argues that integrating these two critical aspects of automotive business will not only lead to more profit generation but will also boost customer satisfaction. Furthermore, forward thinking businesses are making serious attempts to take advantage of the interrelationship between supply chain management and Product Life-Cycle Management (PLM) in bid to foster innovation accelerates growth, manage costs, and improve pricing.In a report published in TATA Consultancy Services, [21] argue that PLM systems offer comprehensive approach of gathering requirements and managing interactions with globally dispersed suppliers. Essentially, PLM systems capture information across manufacturing and production processes starting from the design stage all the way to product launch and support. Product life cycle management (PLM) systems take advantage of automated workflows to allow for tracking and communication of critical information on a real time basis, for better traceability and accountability across the product lifecycle. In the end, it allows for effective process control that enables companies to recognize and handle issues as soon as they happen, in that way reducing the possibility of causing interferences to worldwide product creation process.

Table 7: Represents reliability statistics (Product life cycle)

Cronbah's Alpha	Cronbach's Alpha based on standardized items	Number of item's
0.923	0.925	4

∞ ≥ 0.9 = Excellent, 0.9 > ∞ ≥ 0.8 = Good, 0.8 > ∞ ≤ 0.7 = Acceptable, 0.7 > ∞ ≤ 0.6 = Questionable, 0.6 ∞ ≤ 0.5 = Poor, 0.5 > ∞ = Unacceptable

Table 8:representsdescriptive analysis (Product life cycle)

	N	Minimum	Maximum	Mean	Std. Deviation
Product Life Cycle (PLC)	55	12	20	17.84	2.117
Valid N (List wise) 55					

Note:1-2 = Minimum, 2-3 = Below Average, 3 = Average, 3-4 = above average, 4-5 = sufficiently above / maximum (Based on mean value). PLC – Product life cycle, Std = Standard deviation, N = Number of companies.Based on the result shown mean value for PLC was found to be 17.84 which indicate sufficiency observance of PLC. Standard deviation was found to be 2.117 which indicate below average.

VI. Information Gathering

[22], suggested that before going into the design process, there is a need to collect all information available that relates to the problem. Information gathering is pertinent information which reveals facts about the problem that result in a redefinition of the problem. Information gathering in automotive manufacturing begins with asking questions on the project that could be executed; project could be new or exerting one.

Table 9: Represents reliability statistics (Information gathering)

Cronbach'a Alpha	Cronbach's Alpha based on Standardized items	Number of items
0.886	0.886	4

∞ ≥ 0.9 = Excellent, 0.9 > ∞ ≥ 0.8 = Good, 0.8 > ∞ ≤ 0.7 = Acceptable, 0.7 > ∞ ≤ 0.6 = Questionable, 0.6 ∞ ≤ 0.5 = Poor, 0.5 > ∞ = Unacceptable

Table 10: Represents descriptive analysis (Information gathering)

N	Minimum	Maximum	Mean	Std. Deviation
Information gathering (ING) 55	12	20	17.83	2.205
Valid N (List wise) 55				

Note:1-2 = Minimum, 2-3 = Below Average, 3 = Average, 3-4 = above average, 4-5 = sufficiently above / maximum (Based on mean value). ING – Information gathering, Std = Standard deviation, N = Number of companies.Based on the result shown mean value for ING was found to be 17.84 which indicate sufficiency observance of ING. Standard deviation was found to be 2.117 which indicate below average.

6.1Correlation Analysis results

Correlation analysis is used to describe the strength, significance of bivariate relationship of all variables in the study. The purpose of correlation analysis is to measure the interrelationship between product design process variable based on perception of independent variables. In this study, correlation was found out among five components. The result shows that there was high strength correlation between – 0.06 < r < 0.981. That shows the correlation is significant, the lowest was 0.57 while the highest was 0.914 equivalents to 57% and 91% respectively as shown in table 11. Below[23].Has mentioned that the following values below of person's correlation coefficient r as a determining criterion for reporting the results.

Table 11: Represents correlation result analysis.

		PDP	CRT	TEC	PPG	PLC	ING
	PDP	I.000	0.570	0.696	0.672	0.664	0.747
	CRT		1.000	0.818	0.679	0.702	0.762
Pearson Correlation	TEC			1.000	0.898	0.793	0.914
	PPG				1.000	0.821	0.883
	PLC					1.000	0.887
	ING						1.000

PDP = Product design process, CRT = Customer requirement, TEC = Technology,
PPG = Product planning, PLC = Product life cycle, ING = Information gathering

Table: 12. Represents the measuring scale for correlation analysis.

r 0.70	Strong and highest
0.50 < r < 0.69	Large and highest
0.30 < r < 0.49	Moderate and medium
0.10 0.29	Weak and low

V. Conclusion and future work

The factors that make good design process were selected based on the literature review. Furthermore, rigorous statistical analysis was carried out in support of selected factors using SPSS software. The analyses carried were reliability, correlation, descriptive and regression analysis. In order to determine the significance, reliability and consistency level of each factor so that it could help automotive industry to improve their process design processes. Form the result analysis carried out it shows that the five selected factors are within accepted level. The researcher suggested that future studies should focus on selecting more factors through literature review, journals and published papers by scholars.

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