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ROBUST DESIGN STRATEGIC IN THE CONCEPT SELECTION OF NEW PRODUCT DEVELOPMENT; CASE STUDY PEDESTAL GUIDE DESIGN

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ABSTRACT

In the concept selection of new product development is not uncommon for more than one design team to be involved. Often these teams are formed along disciplinary lines, each responsible for the design of a single part (subsystem) of the overall system.

Generally, the problem off the concept selection of new product development, quit possibly, each subsystem has it own goals and constraints that must be satisfied along with the system-level goals and constraints. The goals of the individual subsystems might be contradictory. This paper will be solved the problems modification of pedestal guide design. There are many disciplinary in the modification of pedestal guide design; structure, material, cost, manufacturing process, strength, and maintenance. Actually that disciplinary will be contradiction. That problem will be solved with Robust Design Strategic especially in the concept selection of new product development. In addition, this paper concerned with minimizing the effect of uncertainty or variation in design parameters in the concept selection.

The strategy developed in this study can be used to help designer team in the concept selection process with minimizing effect of uncertainty or variation in design parameters.

***Keyword**: robust, design, concept, selection*

1. INTRODUCTION

Design concept selection or selection of design concept is one of the important activities for a new product development process. Design concept selection is the decision making phase of concept design, where designers evaluate concepts with respect to customer needs and the designers' intention (Xiao et al.,2007).

The determination of the best design concepts at the conceptual design stage is a crucial decision. The selection of the most appropriate design concepts is important because a poor design concept can never be compensated for by a good detailed design and will incur great expense of redesign cost (Hsu and Woon, 1998) and (Zhang et al. 2006). Design concept selection is also considered as a multi-criteria decision making problem due to many factors affecting the selection process that has to be considered. Therefore, selecting the best design concepts is not the esay task and the most critical stage in product design development due to many factors influencing the selection need to be considered.

The right decision at the design concept selection of product development is very important. The result of that stage is conceptual design. Conceptual design is an early stage of the product development process which involves the generation of solution concepts to satisfy the functional or design requirements of a design problem. Generally, the main goal of conceptual design stage is to select the most suitable concept from a number of possible options. The main concern of conceptual design is the generation of physical solutions to meet the design specification (Hsu and woon, 1998)

Therefore, conceptual design stage has become one of the most important activities in the development of a new product. It is also indicated that the importance of the correct decisions made at the conceptual design stage. In order to support the efficiency in selecting the optimum design concepts at conceptual design stage, an appropriate evaluation and decision tools need to be considered.

2. THEORITICAL BECGROUND

Robust Design Strategy

Fundamentally, robust design is concerned with minimizing the effect of uncertainty or variation in design parameters on a design without eliminating the source of the uncertainty or variation (Phadke 1989). In other words a robust design is 'less sensitive' to variation in uncontrollable design parameters than the traditional optimal design point. Robust design has found many successful applications in engineering and is continually being expanded to different design phases (Lewis and Parkinson 1994; Parkinson 1995;Chang, Ward, et al. 1994). There are two general categories of robust design (Chen, Allen, et al. 1996).

In Type I robust design, the goal is to minimize the variation caused by uncontrollable noise factors. Examples might include changes in ambient temperature, operating environment, or other natural phenomena that are impossible or prohibitively costly to control. Figure 2 illustrates this. In this figure the variation in performance f(x) for a traditional 'optimal' design and a robust design are compared when the design variable *x* varies a quantity Dx about its mean value μ.

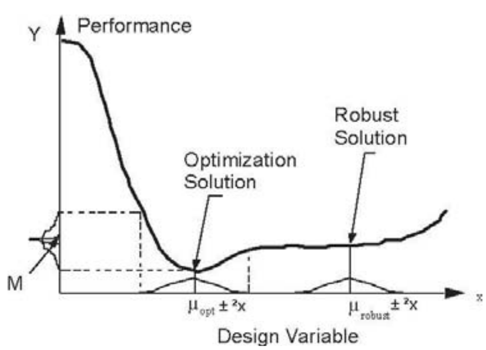

Figure 1. Illustration of Type II Robust Design

In Type II robust design, the goal is to minimize variations caused by deviation in the control factors. This could result from manufacturing tolerance limitations, material quality variations, or even evolving design preferences (Sundaresan, Ishii, et al. 1993). Although robust design has been traditionally applied in manufacturing there has been research recently into applying these techniques to make the design *conceptually* robust (Chang and Ward 1994; Chen, Allen, et al. 1996). The important roles of modeling and calculation of robustness in a multidisciplinary design environment was discussed in (Su and Renaud 1997). Our research builds upon the philosophy of these references; we are trying to make design decisions robust to uncertainty caused by evolving design goals and constraints in a multidisciplinary design environment.

The approach we are presenting is an integration of Type I and Type II robust design. Type I will be used to make the leader's solution robust to unknown design decisions made by the follower. Recall that the leader in a sequential design process must solve a disciplinary sub-problem under uncertainty, not knowing how the follower will act. The fundamental difference between what we are proposing and traditional Type I robust design lies in the definition of the noise factors. As opposed to *external* noise factors (ambient temperature, humidity) which by their very nature are uncontrollable (or prohibitively expensive to control), we are concerned with *internal noise variables*, deterministic decisions made by the other designers, but not controllable or even known by everyone. The end goal is the same, however, to minimize the influence of uncertainty on the subsystem under consideration.

Type II robust design is to introduce flexibility into the design. In this approach, developed in Chen and Lewis (Chen and Lewis 1999), the idea of a robust solution range is introduced. The first designer chooses a range of satisfactory designs instead of a traditional point solution. In this way, Designer 1 is allowing the proceeding designers more freedom to find a satisfactory solution to their disciplinary sub-problems.

This technique is effective for problems where there is strictly one-way

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coupling between the subsystems, specifically in problems where the follower needs design information from the leader, but the leader needs no design information from the follower.

2. RESEARCH METHOD

The proposed framework of this paper is the selection process at the conceptual design stage (Figure 2). Generally, conceptual design stage comprises 3 main design activities namely concept generation, concept selection and concept development. At the concept selection stage, the decision tasks can be divided into 2 main parts. The first part is called the design concept selection and the second part is called the materials selection. Both of these parts are simultaneously performed by implementing Robust Design Strategy.

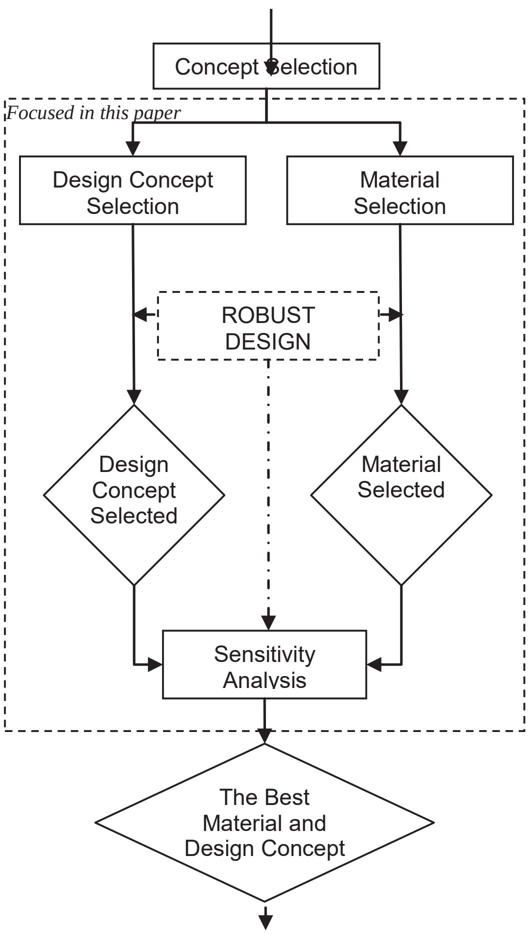

Figure 2. A Framework of Research

This simultaneous system use concurrent design concept selection and material selection. This stage assists designers to evaluate and determine the best design concepts and materials simultaneously during concept selection process at the conceptual design stage. After the ranking of decisions have been determined (called design selected), then various scenarios of sensitivity analysis are per-formed to see how sensitive the decision options which will change with the importance of the criteria. Thus, the proposed provides a systematic approach for designers to determine the most optimum decision during concept selection at the conceptual design stage.

Intuition tells us that collaboration between the designers should yield the best results, but in many cases there may be barriers which make full cooperation difficult or impossible. Communication between the interacting disciplinary subsystems might be hampered by geographical separation. Guessing at the unknown design information is always an option, especially when based on experience. But if the guess is far off, the result is degradation in performance and expensive and time consuming iteration.

Modeling the interaction between the designers and making the solution robust to the uncertainty may be the preferred strategy in many cases (Figure 3).

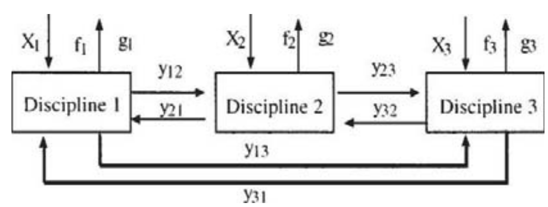

Figure 3. Modeling the interaction between the designers

The approach in this paper provides an additional option to handling the uncertainty. The unknown linking variables, y21, needed by Designer 1 are modeled as noise variables with uniform probability distributions varying within *modified bounds* that lie within the actual bounds of the linking variables. The modified bounds are the maximum ranges of these linking variables within their total bounds that guarantee a robust and feasible local solution for Subsystem 1. This idea is illustrated in Fig. 4, which shows the true and modified bounds. Designer 1 selects these bounds by dividing the design space of the non-local linking variables y21 into a number of ranges within which y21 is uniformly distributed. Designer 1 then optimizes his model for performance and robustness for each of these ranges of y21.

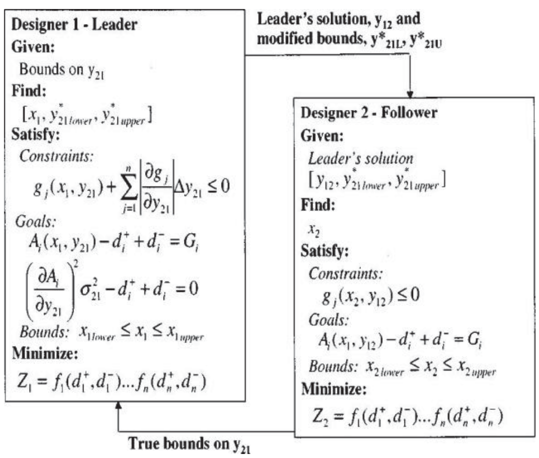

Figure 4: Compromise formulation for leader/follower design protocol

Although this requires running an optimization for each range it allows a good region of the design space to be identifying further analysis. The largest range possible that allows Designer 1 to found a feasible and satisfactory solution is chosen. The upper and lower bound to this range is then passed to Designer 2. Note that there is a minimum bound on this range cannot collapse to zero to ensure that a robust region is found.

4. CASE STUDY

4.1 Modification of Pedestal Guide

Pedestal-Guide and Journal Box Wear Plates (figure 5) are the components which joining the under frame assembly with the wheel assembly and axle assembly. That component is very important for under frame system of the train. Generally, the damage of the wear plate usually happened. In this paper, we will give the modification of pedestal guide to simplify the maintenance process, reduce the cost and strengthen the part. Maintenance process in the pedestal guide doing with check the component from damage or crack in the welding wear plate.

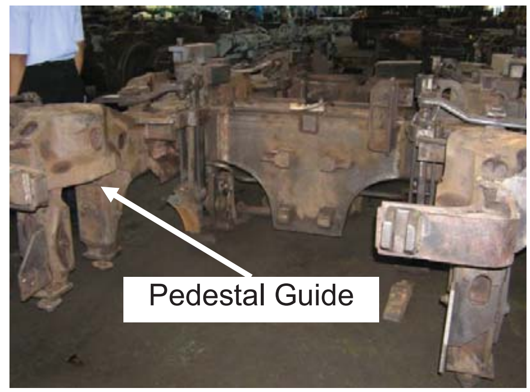

Figure 5. *Pedestal-Guide and Journal Box Wear Plates*

4.2 Design Requirement of pedestal guide

Design requirements of pedestal guide illustrated in the figure 6 and figure 7.

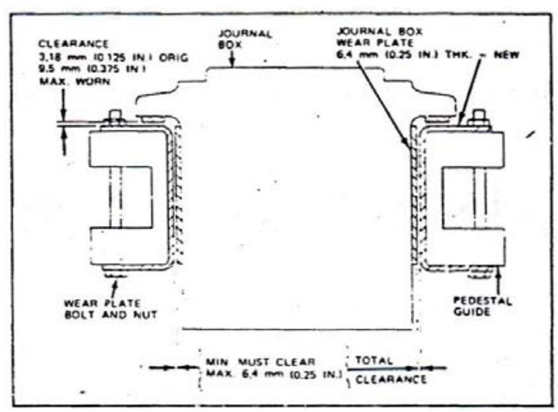

Figure 6. Clearance pedestal guide and journal box for the axle side
[**Reference :** *Manual Instructions* GE]

In the replacement process of wear plate, Welding process must be special monitoring. That is important, because if the assembly process wear plate is not precession then will be unsteady in the wheel and axle assembly

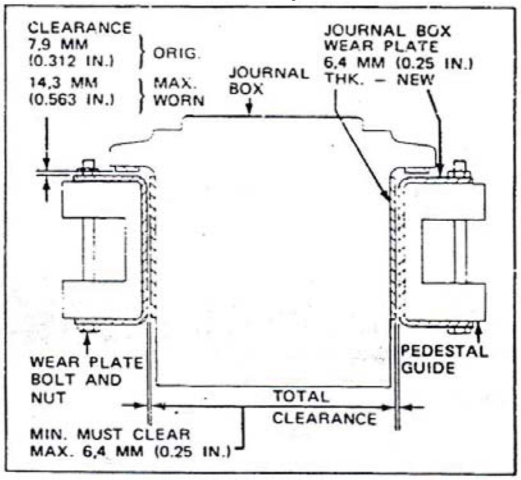

Figure 7. Clearance pedestal guide and journal box for the middle axle
[**Reference:** *Manual Instructions* GE]

Figure 8 and Figure 9, will be explain the clearance of wear plate welding and the welding technique

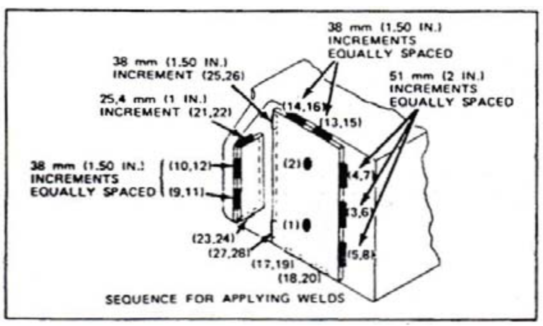

Figure 8. Welding clearance at the wear plate
[**Reference:** *Manual Instructions* GE]

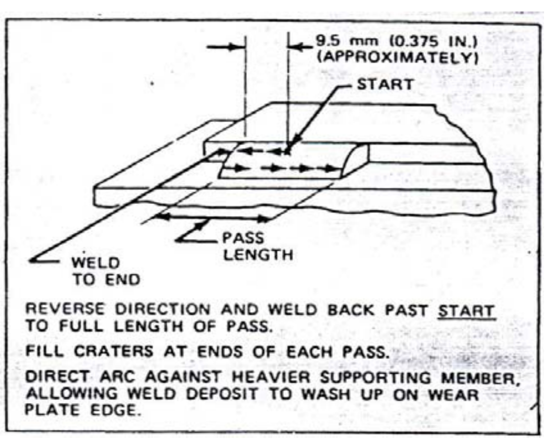

Figure 9. Welding Process
[**Reference :** *Manual Instructions* GE]

4.3 Design Concept Selection

There are 3 design concept of modification pedestal guide that have been evaluate in order to determine the most appropriate one to be carried forward to a final conceptual design.
The design concepts of modification pedestal guide are:

a. 1 st concept: Shrink Plate
   In the 1st concept we use shrink plate to satisfy clearance of the design requirement. The shrink plate will be preparing same as with the clearance requirement of the design.
b. 2 rd concept: Adjustment side of pedestal guide
   The modification of the pedestal guide is doing with the adjustment side pedestal guide.
c. 3 rd concept: Welding Improvement.
   Welding improvement process is doing with welding wear plate.

The selection of the best design concept for the modification pedestal guide depends upon the variety of factors which include:

a. Structure of pedestal guide beam (SC); structure of pedestal guide beam is important in determining the capability of the beam. There are 2 factors that have to be considered are cross section (CS) and thickness (TC)
b. Cost (CT): Therefore, it is very important to design and develop modification pedestal guide to the cost reduction without sacrificing its safety. There are 3 most important costs required as follows: Material Cost (MC), Manufacturing Cost (MFC), Repair Cost (RC)
c. Manufacturing Process (MP); manufacturing process is also needed to be considered when modification pedestal guide at the early stage of the product development process. The selection of the best design concept is also determined by considering of how

easy product to be produced or fabricated by given machine without increasing cost of manufacturing.

d. Strength (ST); It is important to produce safety pedestal guide
e. Material (MT); Modification of pedestal guide is greatly influenced by the material selected.
f. Maintenance (MTN); There are 3 main factors influencing the selection design as follows: easy to repair (ER), easy to dismantle (ED), Easy to Install (EI).

4.4. Materials Selection

Material selection in the design of modification pedestal guide is very important. The safety is the first in this product. The first step in the process, we must calculate the loads in the pedestal guide in the max loads. The maximum loads will be happened if the train in the condition of the way. The frame work of the material selection:

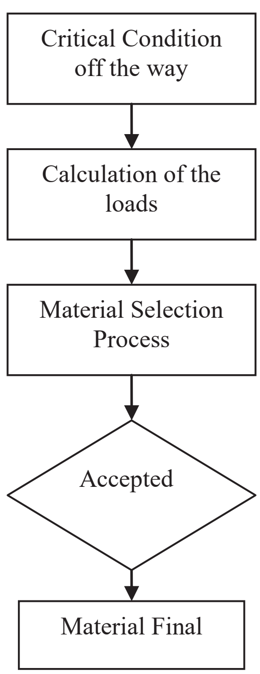

Figure 10. A Framework of Material Selection

4.5. Sensitivity Analysis

The sensitivity analysis assists designer to evaluate and determine the best design concept and materials simultaneously. Modeling the interaction between the design aspects, knowing by the linking variable as follow:

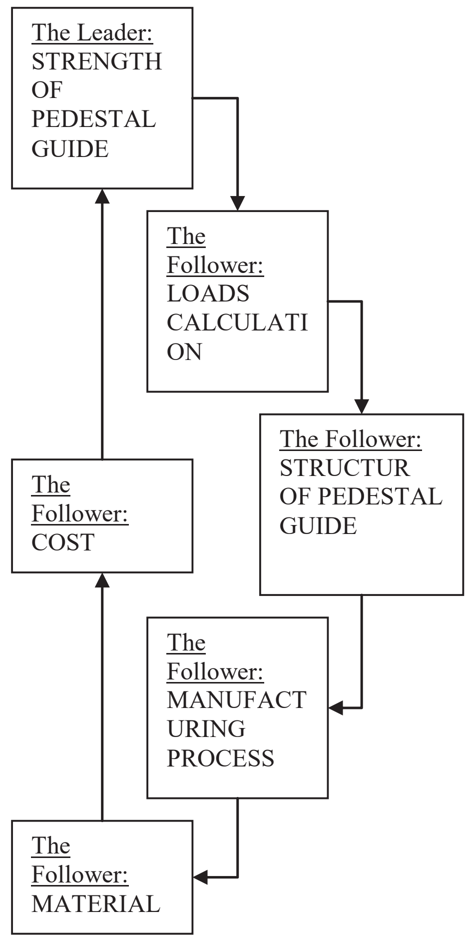

Figure 11. A Framework of Material Selection

5 CONCLUSION

The proposes model called Robust Design Strategy in the design concept selection is a model that provides systematic approach to assist designer to effectively evaluate and determine the most suitable design concept for the modification pedestal guide. It is clear that Robust Design Strategy is a useful

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method in decision-making process as it provides clear criteria and priority in design concept selection.

6. REFFERENCES

a) Hambali (2009), Application of analytical hierarchy process in the design concept selection of automotive composite bumper beam during the conceptual design stage, Scientific Research and Essay Vol. 4

b) Hsu W, Woon IMY (1998). Current research in the conceptual design of mechanical products. Computer-Aided Design. 30: 377-389

c) Ullman DG (1992). The Mechanical Design Process. New York: McGraw-Hill

d) Xiao A, Park SS, Freiheit T (2007). A comparison of concept selection in concept scoring and axiomatic design methods. http://cden2007.eng.umanitoba.ca/resources/papers/69.pdf. Accessed on 22 Mac 2008

e) Zhang C, Jiang Z, Lu D, Ren T (2006). 3D MEMS design method via Solidworks. In Procedding of the 1st IEEE international conference on Nano/Mirco engineered and molecular systems. Zhuhai, China. pp.

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FOREWORD

This issue is published in line with the third International Seminar on Industrial Engineering and Management (3rd ISIEM). The articles cover a broad spectrum of topics including Quality Function Deployment, Decision Support System and Artificial Intelligent, Ergonomics, Supply Chain Management, Production System, Operation Research, and Industrial Management. The articles provide an overview of critical research issues reflecting on past achievements and future challenges. Those papers were selected from 165 abstracts. This statistics shows the high competition to get published on this proceeding.

This issue and seminar become special as more delegates come and join from various country as well as universities. We host 86 delegates both from abroad and local. We are very happy as we gather more than thrice delegates this year compare to previous year. This could be happened since more universities join as committee. First and second ISIEM are hosted only with three universities, namely Trisakti, Gunadarma, and Indonusa Esa Unggul Universities. This year event, It's hosted by six universities, i.e. Gunadarma, Trisakti, Indonusa Esa Unggul, Bina Nusantara, Atma Jaya Catholic, and Petra Christian Universities. This becomes evident to us that with cooperation we will succeed.

It is then our expectation so that to the future more universities join us as organizing committee. In this occasion, let us give special thank to Prof. Dr. E.h. Dr.-Ing. habil. Josef Schlattmann from Hamburg University of Technology, Germany. Your contribution to this seminar as reviewer, and as keynote speaker makes this event more valuable. Allow us also to thank Prof. Emeritus Adnyana Manuaba and Ir. I. Made Dana M. Tangkas from *Direktur Teknik dan PIC. Toyata Motor Manufacturing Indonesia*, for their contribution as keynote speakers. We are also grateful to all reviewers, for their commitment, effort and dedication in undertaking the task of reviewing all of the abstracts and full papers. Reviewing a large number of submissions in a relatively short time frame is always challenging. Without their help and dedication, it would not be possible to produce this proceeding in such a short time frame. I highly appreciate all members of committees (advisory, steering, and organizing committees) for mutual efforts and invaluable contribution for the success of seminar.

As closing remarks, Let's say thanks to the Lord Almighty God for all His blessing on us.

Dr. Ir. Hotniar Siringoringo, M.Sc.
Chair

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