IMPROVED DESIGN SOLUTION FOR MOTION RESISTANCE PROBLEM THROUGH INTEGRATION OF ROBUST DESIGN AND THEORY OF INVENTIVE PRINCIPAL (TRIZ)

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A project report submitted in partial fulfilment of the

requirements for the award of the degree of

Master of Engineering (Industrial Engineering)

Faculty of Mechanical Engineering

UniversitiTeknologi Malaysia

JANUARY 2015

Alhamdulillah, praise to Allah S.W.T for blessing me and giving me the strength to complete this project in time.

Specially dedicated to

My beloved wife Khairani Abdul Rahman,

My parents, family and friends.

For their endless love, encouragement, sacrifices and support

ACKNOWLEDGEMENTS

Firstly, I wish to express my sincere appreciation to my project supervisor, Dr. Syed Ahmad Helmi for encouragement, guidance and critics throughout the completion of this project. Without his continued support and interest, this thesis would not be the same as presented here.

I am also very thankful to my lovely wife for his morale support during preparation of this research. I am very appreciating for your sincere kindness.

Librarians at Universiti Teknologi Malaysia also deserve special thanks for their assistance in supplying the relevant literatures.

I am also indebted to my employer for understanding my commitment to my study. It has been a hectic years and without his support I would never make it to the end.

Finally, thank to my family, friends, colleagues, classmates and all those unmentioned that helped me with direct or indirectly.

ABSTRACT

Solving design problem related to technical contradiction are very challenging for engineers. There are always design constraints which require engineers to compromise certain specification and requirement. Trying to solve design problems traditionally is difficult and often leads to trial-and-errors. This research is a study of systematic problem solving approach related to technical contradiction through combination of robust design method and TRIZ methodology to generate concept solutions. Using a case study of vacuum cleaner motion resistance issue, five solutions options are identified and tested to verify the improvement ideas. The result shows that the integration of TRIZ into robust design method at problem formulation stage has created a more capable problem solving definition and solution generation scheme. The motion resistance is reduced significantly to more than half, which is from 76.47N to 26.48N. The pick-up performance is slightly dropped by 5% compare to the original design. However, this 5% drop is considerably minimal when compare to significant improvement on motion resistance.

ABSTRAK

Menyelesaikan masalah rekabentuk yang berkaitan dengan percanggahan teknikal sentiasa menjadi cabaran kepada jurutera. Kebiasaannya wujud kekangan rekabentuk yang memerlukan jurutera berkompromi terhadap spesifikasi produk dan keperluannya. Menyelesaikan masalah rekabentuk secara tradisional kebiasaannya adalah sukar dan sering menggunakan kaedah cuba dan jaya. Projek ini membentangkan kajian tentang pendekatan menyelesaikan masalah secara sistematik yang berkaitan dengan percanggahan teknikal melalui gabungan kaedah “robust design” dan kaedah TRIZ untuk menghasilkan konsep penyelesaian. Pembersih vakum digunakan sebagai kajian kes berkenaan masalah rintangan pergerakan. Lima pilihan penyelesaian dikenalpasti dan diuji untuk mengesahkan idea penambahbaikan. Keputusan kajian menunjukan bahawa integrasi kaedah TRIZ ke dalam kaedah“robust design” di peringkat formulasi masalah telah menghasilkan satu kaedah penyelesaian masalah yang lebih berkebolehan. Rintangan pergerakan dapat dikurangkan dengan ketara iaitu lebih dari separuh, daripada 76.47N ke 26.48N. Prestasi “pick-up” sedikit menurun iaitu sebanyak 5% berbanding dengan rekabentuk asal. Walau bagaimanapun penurunan sebanyak 5% ini adalah minima jika dibandingkan dengan hasil yang besar ke atas pengurangan masalah rintangan pergerakan.

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LIST OF ABBREVIATIONS

TRIZ	-	TeoriyaResheniyaIzobretatelskikhZadatch
TIPS	–	Theory of Inventive Problem Solving
QFD	–	Quality Function Deployment
IFR	-	Ideal Final Result
ARIZ	-	Algorithm of inventive problems solving
USIT	–	Unified Structured Inventive Thinking
HCD	–	Human Centre Design
IPDP	-	Innovative Product Development Process
CNC	-	Computerized Numerical Control
DPU	–	Dust Pick Up
IEC	–	International Electrotechnical Commission

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter discusses the general overview of the paper. This study is about improving system design by using integration of robust design method with TRIZ methodology. The vacuum cleaners ease of use or handling problem is used as a case study in this project. This study provides a framework that facilitates the use of TRIZ and robust design method in solving system design issues. The objective, scope and limitation of the project are discussed in this chapter.

1.2 Background of the Problem

System design issue is one of the biggest challenges faced by designer. To solve a complex system design problem, it requires a systematic problem solving approach, good engineering knowledge and skills in order to get the most effective solution, reliable and productive. The engineering decision involved in product development is categorized into two:

- Make no error by implementing past experience and knowledge.
- Generate new design information including performance, quality, reliability and cost.

Many companies in the industry are seeking better ways to solve technical issue so that they can minimize the development cost and time to market. Currently one of

the popular approaches to solve design problem in product development is by using robust design method. This method provides a thorough analysis of the design parameters. However the generation of the idea to solve the problem is still relying on brainstorming, engineer experience and skills. These processes involved trial and errors and usually result in developing more than one design iterations to achieve the requirements. That process also takes longer time to complete the development work and involves high expenditure. To optimize the development process, this study proposes to combine robust design method with TRIZ methodology.

In this study vacuum cleaner has been chosen for a case study as it has a complex system design. Vacuum cleaner is a household product that is used to clean floor, wall, ceiling fan and optionally for other areas in a household environment. There are wide-ranging technologies, configurations, and designs are available for both domestic and commercial vacuum cleaner. For domestic vacuum cleaner there are several types available in the market like upright, canister, stick, hand held and robot. These days the choices in vacuum cleaners are amazing and depending on type they perform differently and offer an assortment of features and benefits. People normally choose vacuum cleaner based on their performance, suction power (ability to collect dust), usability, outlook and the price.

Larsson and Petersson (2009) explained that customers need to determine the type of vacuum that works best for their house. If they have a house with large rooms, an upright vacuum is the best choice for them. Upright type generally is heavier than canister vacuums, so they usually clean better than canisters. However, if the users have a lot of furniture that needs to be cleaned, upright type can be awkward. For a smaller house or floor surfaces that have rugs covering hardwood floors underneath, a canister or stick vacuum is the best solution. Both of these models are lightweight and easy to maneuver.

When users buy a vacuum cleaner, there is an area that they normally cannot make initial judgment. It is about handling of the product in use. There are a lot of comments or review from users complaining about the handling. The machine is

difficult to move forward, backward and maneuver. This problem is related to high motion resistance between cleaner head and the cleaning surface.

Larsson and Petersson (2009) describe motion resistance as a certain amount of force required to move a cleaner head across a surface. The amount of force depends on the friction between the nozzle and surface, the different surface roughness which is also increased friction on carpet, vacuum pressure and airflow. Vacuum cleaner with low airflow generally has lower motion resistance. There is a high variation between different nozzles but a maximum motion resistance of 50N is considered to be user friendly.

To solve the motion resistance issues, there are a lot of problem solving approach and design tools available. However to choose the systematic approach and effective tools for problem solving some time is difficult. Trying to solve design problems traditionally is challenging and often engineer have to do trial-and-errors

1.3 Statement of the Problem

To become more competitive in market, engineers needs to consider more design aspects of its requirements when designing products. Also in the future markets, products need to adapt fast changes in their business environments over their lifecycle. To cope with this challenge, manufacturers need to have a systematic design and problem solving approach. In the increasing complexity of the technological–economic environment, product manufacturers must evolve in a framework led by the principles of the ‘science of complexity’ in order to cope better with rapid changes and to explore and exploit high-level creativity and innovation (Brad, 2008).

Manufacturer always struggle to design a vacuum cleaner that can provide high performance cleaning and good handling (easy to move around). Figure 1.1 illustrates the interaction between human and the vacuum cleaner. Base on this concern, designing a product that can meet customer needs is always a big challenge

to designers. There are always limitations or design constraints, which require designer to compromise certain requirements when developing a product. This issue is also called technical contradictions. Engineer can solve or improve one parameter but put negative impact on other parameter. At some point a tradeoff is required between these two elements.

Figure 1.1: Upright vacuum cleaner operation

For the upright vacuum cleaner, one of the system design contradictions is the high air speed or air flow as illustrated in Figure 1.2 although it is required to increase dust pick up ability, it also increases the force needed to move the cleaner head/nozzle i.e. motion resistance, over the floor or carpet.

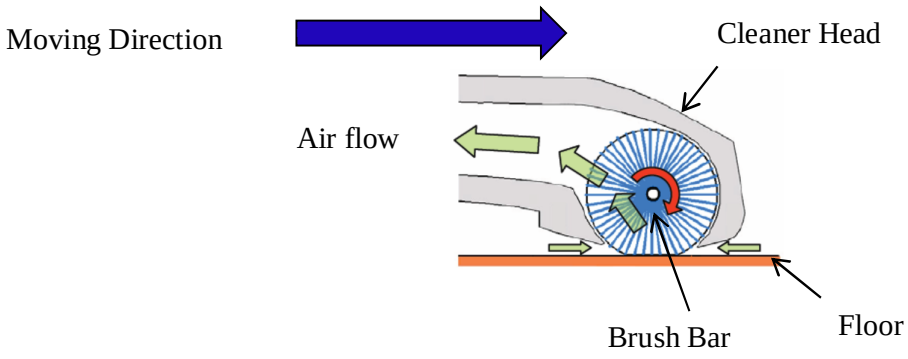

Figure 1.2: Detail section view of cleaner head Assembly

Because of the existing constraints requirements in this product, based on the literature survey, TRIZ methodology is one of the tools that can be used to solve technical problem systematically and the robust design method is the other method that can be used to ensure the solutions are reliable and efficient. A combination of TRIZ and robust design methods is analyzed in this study.

Robust design method is an important approach to improve engineering productivity and reliability. Founded by Dr. Genichi Taguchi after the end of the Second World War, the method has developed over the last five decades. Robust design is a set of engineering methods for achieving high-quality function despite variations due to deterioration, the environment, manufacturing and customer use patterns [Jugulum and Frey, 2007]. Many companies have made savings by reducing their manufacturing cost by using this method in different industries such as automobiles, home appliances, medical equipment, electronics, software, telecommunications, etc.

TRIZ is a creativity method and described as a structured problem solving approach. It involved the integration of a problem definition and resolution tools that were created based on the analysis of millions of world-wide patents. With more than a few decades of development and practices, TRIZ has been proven in its efficiency and effectiveness in solving technical issues for product design.

1.4 Research Question

In order to solve the identified problem, following research questions must be answered in this study:

i. How to solve system design problem using integration of robust design and TRIZ?
ii. How to integrate TRIZ to problem formulation in robust design method to enhance engineering design problem solving process?

1.5 Objective of the Project

The main objective of this study is to find the effectiveness of integrating robust design method with TRIZ methodology in solving system design problem related to technical contradictions. This design improvement study is presented by structured problem analysis and generation of inventive solution. Also this study uses vacuum cleaner head as case study to reduce motion resistance problem through systematic problem solving approach. The conceptual framework is illustrated in Figure 1.3.

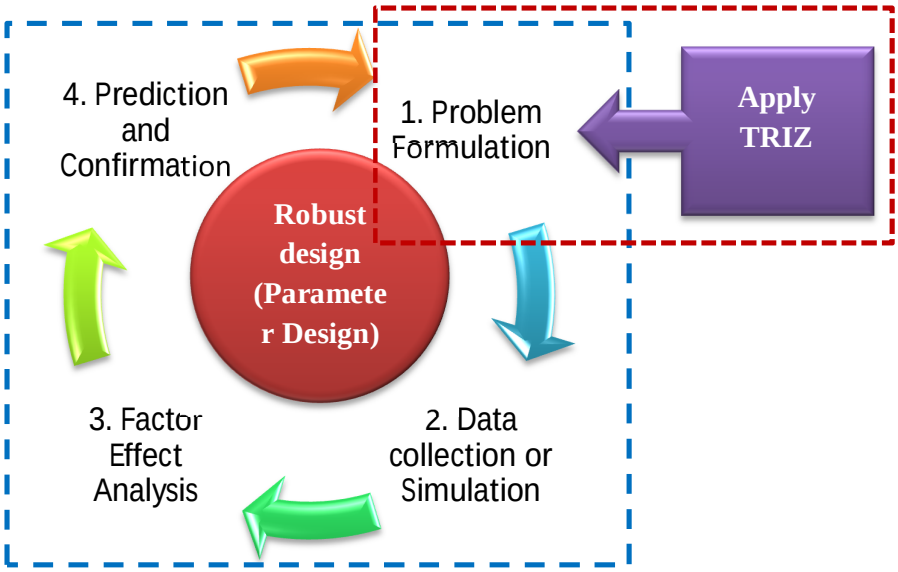

Figure 1.3: Conceptual Framework

Figure 1.3 presents the combination of robust design method with TRIZ methodology in systematic problem solving approach. TRIZ is applied at problem formulation stage in parameter design study as outlined in robust design method.

1.6 Scope and Limitation

The scope of the study describes the focuses area of the project and to set out an idea of the purpose of the study. The limitation describes the restriction or difficulty in conducting the study.

1.6.1 Scope

The following are the scopes of the study:

i. The study is confined to motion resistance issue
ii. The study uses one of the upright vacuum cleaners as a case study.
iii. The study uses product performance data taken from vacuum cleaner manufacturer's competitors test result.
iv. The study focuses only problem formulation in robust design method and use technical contradiction tool from TRIZ methodology.
v. The study is conducted at a manufacturing company in southern peninsular Malaysia.
vi. The propose solution validation is conducted in test lab at the company.

1.6.2 Limitation

The following are the limitation of the study:

i. This study only focuses on making improvements to vacuum cleaner head and its functions, other parts of the vacuum cleaner are not considered in this study.
ii. The improvement design validation is conducted on a single unit only.

1.7 Importance of the Project

This study provides an idea on how different problem solving methods or tools help design engineer to solve engineering problem thoroughly in systematic approach. The result from this study can be used as a reference for design base company to the select best problem solving tool. Also a combination of robust design method and TRIZ methodology has never been use at a manufacturing company in southern peninsular Malaysia.

The study is focused on the usability of the product versus the performance. Pelt (2011) describes usability as the methods and the easiness of users interact with a product. It is not just about how easy a product can be used, also the senses that are engaged, the contexts in which engagement take place, and the affordances that the product can provides. Excellent product usability will provide high user satisfaction and good user experience.

1.8 Organization of Report

Chapter 1 provides the introduction of the study which is to describe what are the problems and the objectives. The introduction includes the background of the study and also the idea of TRIZ and robust design method.

Chapter 2 provides the literature review of the study. This chapter discuss the theoretical aspects of TRIZ and their application. As robust design method is already widely known in industry, this chapter only discuss the overview of the robust design process.

Chapter 3 provides the methodology, tool and technique

Chapter 4 discusses the detail analysis, solution ideas and testing

Chapter 5 discusses the finding of the study, significance of the study, suggestion for future work and conclusion.

1.9 Conclusion

This chapter presents the justification of the study by carrying out the research, background to the problem, problem statement, identify research questions, objective, scope and limitation and the organization of the thesis. The next chapter reviews the literature of area of the study and problem solving methodology.

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