UNIVERSITI TEKNIKAL MALAYSIA MELAKA

APPLICATION OF TRIZ METHODOLOGY IN SOLVING ARC WELDING PROBLEMS

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Manufacturing Process) with Honours.

by

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I hereby, declared this report entitled "Application of TRIZ Methodology in solving arc welding problems" is the results of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Process) with Honours. The member of the supervisory committee is as follow:

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ABSTRACT

Generally, this thesis is discussed about how to solve the problem of undercutting and porosity in arc welding by using the TRIZ Methodology. TRIZ is one of the methods to solve the problems in the market. A theory designed for solving problem that has a presence of contradiction and having its own inventive problem solving tools. Initially in this report, the major problems that occur in process arc welding are determined. Secondly, the causes that affect the welding problem to occur are discovered before the TRIZ is implemented to solve the problems. Basically, the 39 Engineering Parameters and 40 Principles tool which are available in TRIZ are used to solve arc welding problems. Although the principles are developed long time ago and it can be represented as the solution for today's problems to show the relevancy of the theory that is general in idea but deep in meaning. Based on the proposed solution from guidance of principle 04 to solve the undercut problem, the result is exposed in Figure 4.14. The undercut problem can be reduced or remove by using proposed solution. Besides, Table 4.12 shows that frequent occurrences of porosity can be reduced based on the proposed solution which guidance from principle 13. A lot of suggestions to solve the arc welding problems are proposed and presented in this report.

ABSTRAK

Secara amnya, tesis ini membincangkan tentang penyelesaian masalah undercutting dan porosity yang biasa berlaku dalam kimpalan arka dengan menggunakan kaedah TRIZ. Kaedah TRIZ merupakan salah satu kaedah penyelesaian dalam pasaran kini. Satu teori yang dihasilkan untuk menyelesaikan masalah di mananya akan menwujudkan percanggahan dalam ciptaan teori tersebut dan ia mempunyai alat-alat penyelesaian masalah tersendiri. Pada permulaan, laporan ini akan menentukan masalah-masalah yang wujud dalam proses kimpalan arka. Seterusnya, menentukan punca yang menjejaskan masalah kimpala sebelum kaedah TRIZ digunakan untuk menyelesaikan masalah. Secara asas, terdapat 39 parameter kejuruteraan dan 40 prinsip-prinsip alat dalam TRIZ boleh digunakan untuk menyelesaikan masalah kimpalan arka. Prinsip-prinsip yang dihasilkan selama ini hanya sebagai penyelesaian masalah kini yang menunjukkan perkaitan dengan teori. Rajah 4.14 menunjukkan keputusan yang dapat dicatat dengan penyelesaian yang diambil berdasar kepada prinsip 04 sebagai rujukan. Keputusan menunjukkan masalah "*undercut*" dapat dikurangkan atau diselesaikan dengan menggunakan penyelesaian yang dicadangkan. Selain itu, jadual 4.12 menunjukkan kebarangkalian kewujudan "porosity" dapat dikurangkan dengan peyelesaian yang dicadang berdasarkan prinsip 13. Beberapa cadangan untuk menyelesaikan masalah kimpalan arka akan dicadangkan dan dibentangkan dalam laporan.

DEDICATION

To my beloved family.

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LIST OF ABBREVIATIONS

A	-	Ampere
AC	-	Alternative Current
ARIZ	-	*Algorithm Rezhenija Izobretatelskih Zadach*
		(Algorithm for Solving Inventive Problems, ASIP)
DC	-	Direct Current
GMAW	-	Gas Metal Arc Welding
GTAW	-	Gas Tungsten Arc Welding
kW	-	Kilowatt
MAG	-	Metal Active Gas
MIG	-	Metal Inert Gas
MMA	-	Manual Metal Arc
NDT	-	Non Destructive Testing
OZ	-	Operative Zone
PSM	-	Project Sarjana Muda
SMAW	-	Shielded Metal Arc Welding
TIG	-	Tungsten Inert Gas
TRIZ	-	Teoriya Resheniya Izobretatelskikh Zadatch
		(Theory Of Inventive Problem Solving)
USSR	-	Union of Soviet Socialist Republics

CHAPTER 1

INTRODUCTION

This chapter is intended to provide background information of the study. It covers background of study, problem statements, objectives, scope and limitation of project and organization of the project.

1.1 Background

There are two groups of problems people face: those with generally known solutions and those with unknown solutions. Those with known solutions can usually be solved by information found in books, technical journals, or with subject matter experts. These solutions follow the general pattern of problem solving shown in Figure 1.1. The particular problem is elevated to a standard problem of a similar. A standard solution is known and from that standard solution come a particular solution to the problem (Mazur, 1995).

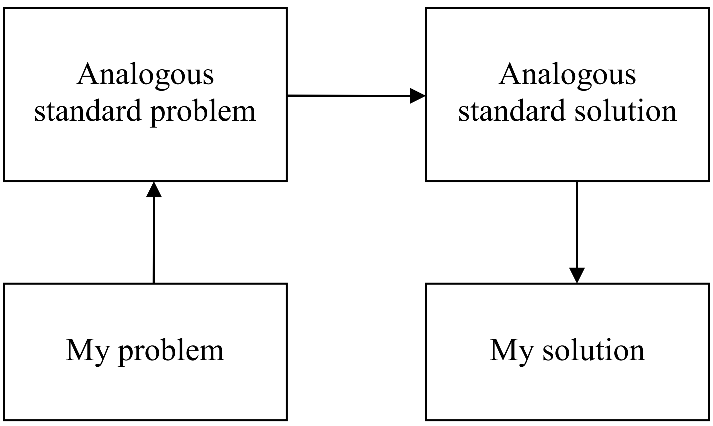

Figure 1.1: General Problem Solving Model (Mazur, 1995).

The word systematic conjures up the image of sequential activities that can be performed repeatedly to yield a desired result. Innovation has an association with creativity, which frequently implies unpredictable and erratic processes. Despite this, the term "systematic innovation" is not an oxymoron. The pillar of the Theory of Inventive Problem Solving (TRIZ) is the realization that contradictions can be methodically resolved through the application of innovative solutions. According to Mazur, this is one of the three premises upon which the theory is built:-

i. The ideal design is a goal,
ii. Contradictions help solve problems, and
iii. The innovative process can be structured systematically.

The assumption that cannot harness and control the innovative processes is incorrect. Inspiration need not be random. Therefore, TRIZ practitioners continually demonstrate that applying common solutions for the contradictions. Besides, it also identified as effective when applied to parallel problem and radically improves the design of systems and products. Once a problem is structured as a contradiction, methods exist for resolving that contradiction. These methods are evolving rapidly and are more widely available (Mazur, 1995).

Traditional processes for increasing creativity have a major flaw in that their usefulness decreases as the complexity of the problem increases. At some point, the trial and error method is used in every process and the number of necessary trials increases with the difficulty of the inventive problem. Some solutions may even require more than one generation of problem solvers. It was Altshuller’s quest to facilitate the resolution of difficult inventive problems and pass the process for this facilitation on to other people. His determination to improve the inventive process led to the creation of TRIZ (Mazur, 1995).

1.2 Problem Statement

Welding discontinuities can be caused by inadequate or careless application of proper welding technologies or by poor operator training. The major causes of discontinuities that affect weld quality are lack of fusion, undercutting, porosity and cracking.

The technique of solving problem plays a central role in the current engineering field to solve a problem. The old way to solve problems is trial and error techniques. This technique cost a lot of time and money to find the right way to solve the problem. Gases, chemical reaction, contaminant and gas released during melting of the weld area are the few factors that cause the problem to occur in arc welding.

This study is to discover a suitable methodology in solving the problem faced in arc welding. It should be able to create the best solution by improving the ideality of the solution.

1.3 Objective

The objectives of this study are:-

1. To determine the major problem that is occur in the arc welding process.
2. To discover the causes that affects the welding problem to occur.
3. To implement TRIZ in solving the common problem for arc welding.

1.4 Scope of study

In this study, in order to solve the current problem of the arc welding, a research on the problem of arc welding was done. The area of research in this project focuses on solving problems in Manual Metal Arc Welding (MMA) by using the TRIZ methodology. "TRIZ" is the (Russian) acronym for the "Theory of Inventive Problem Solving". G.S. Altshuller and his colleagues in the former U.S.S.R. developed the method between 1946 and 1985 (Barry *et al.*, 2006). TRIZ is an international science of creativity that relies on the study of the patterns of problems and solutions, not on the spontaneous and intuitive creativity of individuals or groups. The horizontal (2F) welding position and mild steel plate (6 mm) are chosen in this study. Furthermore, current used is DC (direct current) with current around 100A. The MS 6013 electrode (Ø 3.25mm) is also chosen in this study. In this case, study will only focus on undercutting and porosity.

1.5 Organization of the project

Overall, the organization of the report is organized into six chapters, namely introduction, literature review, methodology, result, discussion and conclusion for future works. All the structure details for each chapter is shown below:-

(a) Chapter 1 : Introduction

This chapter is introduces and describes about the project title. It covers the background, problem statement, and objective, scope of study and thesis contents. Hence, the overview of project will be easy to understand.

(b) Chapter 2 : Literature review

Through this chapter, any information that related or similar to the title is study in order to be familiar with the topic. Subsequently, all the journal findings or previous research about the title is review and the important point is summarized. Finally, an investigation is done for all the information obtained to achieve the entire aim of this project.

(c) Chapter 3 : Methodology

This chapter provides the information on how to perform and conduct the project. The methods approached in this study are based on the objectives which are mentioned in the Chapter 1. Besides, this chapter will present how this project is conducted and these procedures are summarized by using the flow chart.

(d) Chapter 4 : Results and Discussion

This chapter elaborates the solution to solve the arc welding problems. The solutions are created with the assistance of 40 innovative principles.

(e) Chapter 5 : Conclusion and Recommendation

Finally, this chapter concludes the main findings for the thesis. Besides, the recommendation for further study will be done at the same time.

CHAPTER 2

LITERATURE REVIEW

While the first chapter describes the background of study, this chapter proceeds with a fully-referenced review from the relevant literature. It covers history of TRIZ, definition of TRIZ, arc welding and previous study related to TRIZ.

2.1 History of TRIZ

Since childhood, Altshuller showed his talents as an inventor. He received his first certificate of the authorship of invention for an underwater apparatus when he was 15 years old. In 1946, at the age of 20, Altshuller developed his first mature invention which is a method for escaping from an immobilized submarine without diving gear. In the late 1940s he worked in the "Inventions Inspection" department of the Caspian Sea flotilla of the Soviet Navy in Baku. Altshuller's job was to inspect invention proposals, help document them, and help others to invent. By 1969 he reviewed about 40,000 patent abstracts in order to find out in what way the innovation had taken place. He eventually developed 40 Principles of Invention, several Laws of Technical Systems Evolution, the concepts of technical and physical contradictions that creative inventions resolve, the concept of Ideality of a system and numerous other theoretical and practical approaches; together, this extensive work represents a unique contribution to the development of creativity and inventive problem-solving. (Genrikh, 1980)

By examining a large database of his own and other people's inventions, Altshuller soon arrived at his most important observation:

Inventing is the removal of a technical contradiction with the help of certain principles. (Genrikh, 1980)

He argued one must scan a large number of inventions, identify the contradictions underlying them and formulate the principle used by the inventor for their removal to develop a method for inventing. His results are being applied to solve creative invention problems not just within all branches of engineering, but within many other technical and non-technical fields as well.

According to Genrikh (1980), the effectiveness of TRIZ is in dispute in many engineering circles. Claims by some inventors that they arrived at their inventions with the help of TRIZ cannot be independently verified. Frequently, TRIZ is also sold to people outside of engineering disciplines as a way to 'produce' creativity in any field of human activity without any grounds for that and ignoring the fact that traditionally TRIZ has grown up in the domain of engineering.

2.2 What is TRIZ

TRIZ is a romanized acronym for Russian "Теория решения изобретательских задач" (***T**eoriya **R**esheniya **I**zobretatelskikh **Z**adatch*) meaning "The theory of solving inventor's problems" or "The theory of inventor's problem solving". It was developed by a Soviet engineer and researcher Genrich Altshuller and his colleagues starting in 1946. It has been evolving ever since. (Victor F. et. al., 2005)

TRIZ is a problem solving method which is based on logic and data. TRIZ also provides repeatability, predictability, and reliability due to its structure and algorithmic approach.

TRIZ is spreading into group use across several parallel paths. It is increasingly common in Six Sigma processes, in project management and risk management systems and in organizational innovation initiatives.

Nowadays, TRIZ is a methodology, tool set, knowledge base and model-based technology for generating innovative ideas and solutions for problem solving. TRIZ provides tools and methods for use in problem formulation, system analysis, failure analysis, and patterns of system evolution (both ‘as-is’ and ‘could be’). TRIZ is contrast to techniques such as brainstorming which is based on random idea generation. Besides, TRIZ is also aims to create an algorithmic approach to the invention of new systems and the refinement of old systems. (Genrikh, 1980)

2.3 Inventive Problems

The other type of problem is one with no known solution which is called an inventive problem and may contain contradictory requirements. As long ago as the 4^{th} century, an Egyptian scientist named Papp suggested there should be a science called heuristics to solve inventive problems. Inventive problems solving has fallen into the field of psychology where the links between the brain and insight and innovation are studied, methods such as brainstorming and trial-and-error were suggested at present. Generation of solution will depend on the complexity of the problem and directly affect the number of trials. (Mazur, 1995)

The number of trials will be fewer when the solution lies within one's experience or field. The inventor must look beyond his experience and knowledge to new fields such as chemistry or electronics if the solution is not forthcoming. In that case, the number of trials will grow large depending on how well the inventor can master psychological tools like brainstorming, intuition, and creativity. A further problem is that psychological tools like experience and intuition are difficult to transfer to other people in the organization. (Mazur, 1995)

This leads to what is called psychological inertia, where the solutions being considered are within one's own experience and do not look at alternative technologies to develop new concepts.

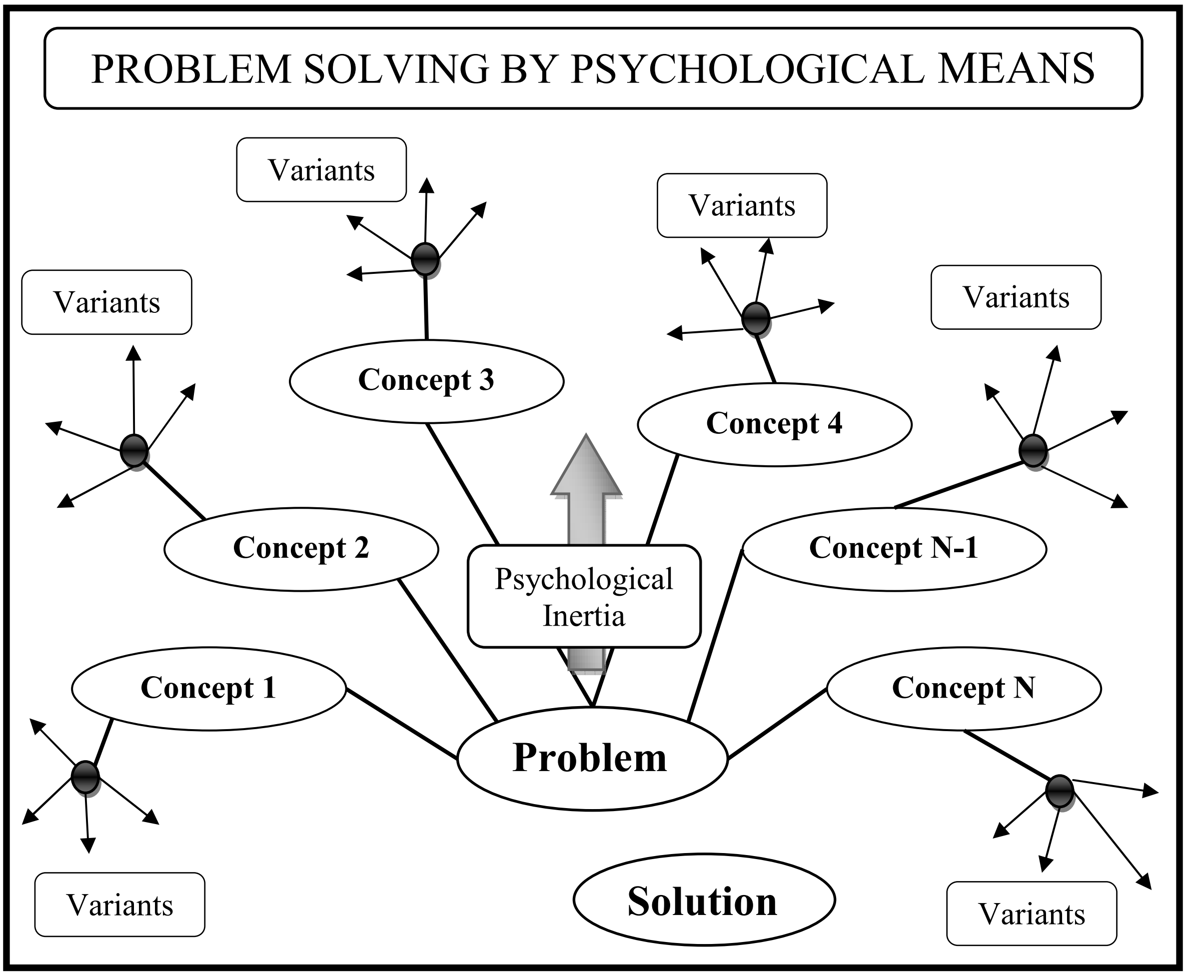

Figure 2.1: Limiting Effects of Psychological Inertia (Mazur, 1995).

Based on Mazur (1995), the ideal solution may lie outside the inventor's field of expertise. It also will be finding when overlay the limiting effects of psychological inertia on a solution map covering broad scientific and technological disciplines. The ideal solution is electromechanical but is outside the experience of the mechanical engineer and so remains untried and may even be invisible (Refer Figure 2.2). If problem solving was a random process, it would expect solutions to occur randomly across the solution space. Psychological inertia defeats randomness and leads to looking only where there is personal experience.