UNIVERSITI TEKNIKAL MALAYSIA MELAKA

APPLICATION OF TRIZ METHODOLOGY IN CASTING PROCESS: A CASE STUDY

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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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

This report discussed about how to solve problem arise from casting process by using the TRIZ Methodology. TRIZ methodology is a theorem use for creating an ideal solution in solving a problem, it is done by solving the contradiction arise in the problem. During the project, casting process is selected as the case study for application of TRIZ methodology in order to solve the defects arise in the process; theory designed aims to solve the problem innovatively. Initial part of the report discussed about casting process and followed by the common type and cause of defects found in casting process. Further on, discussion in the report continue to discuss about the solution towards casting defects, it is done by using TRIZ methodology (Mini-ARIZ and 40 innovative principles). Principles selected will be applied in this report, it tends to show how to solve manufacturing problem in casting and come out with a concrete solution, which is cost effective and efficient from various aspect. As for result and outcome of experiment, TRIZ implementation brings a major impact towards the result of casting. During the case study, TRIZ application has successfully solved four main problems identified in the casting experiment; these defects include surface cavities defects (pinholes), flash formation, rough surface and metallic projection. TRIZ application has successfully solved the problem by generating useful guidance and provides direction in future steps. Report also include the result and verification of solution effectiveness, solution generated outcome has been verified and proven to be effective by experiment. As in general, TRIZ successfully solve the problem of flash formation, rough surface, metallic projection and reduce the formation of surface cavities.

ABSTRAK

Secara umumnya, laporan ini adalah mengenai keberkesanan sistem penyelesaian TRIZ dalam mengatasi masalah yang dihadapi dalam proses tuangan. TRIZ merupakan teori yang digunakan untuk menyelesaikan masalah, ia berfungsi dengan menyelesaikan masalah percanggahan yang terbentuk di dalamnya. Sebagai permulaan, perbincangan projek bermula dengan pengenalan jenis-jenis kerosakan/ ciri-ciri tidak dihendaki yang terbentuk dalam prosess tuangan dan sebab pembentukannya. perbincangan turut merangkumi bahagian penyelesaian masalah melalui cara TRIZ (Mini-ARIZ dan 40 innovative principles). Prinsip-prinsip yang dijanakan dari sistem TRIZ akan digunakan dalam experimen proses tuangan, ia bertujuan menunjukan keberkesanan TRIZ dalam penjanaan penyelesaian yang berkos rendah dan berkesan. Laporan ini turut menbincangkan tentang keputusan dalam experimen yang dijalankan, kehadiran TRIZ telah menpengaruhi cara penyelesaian dan keputusan yang dijanakan, dan ia dapat dikesan berdasarkan experimen yang dijalankan. Secara umumnya, TRIZ telah membantu dalam penyelesaian 4 masalah utama; antara masalah yang dinyatakan adalah masalah keliangan, pembentukan flash, permukaan kasar (rough surface) dan pembentukan besi di bahagian luar daripada bentuk tetapan (metallic projection). Kehadiran TRIZ member kesan yang menggalakan dalam penjanaan cara penyelesaian, ini adalah kerana ia telah menyelesaikan masalah dengan baik melalui panduan yang mencukupi. Selain itu, kertas kajian ini turut merangkumi keputusan dan pengenalpastian keberkesanan cara penyelesaian. Cara penyelesaian yang dijanakan telah dibuktikan berkesan melalui experiment proses tuangan, perbandingan hasilnya turut menbuktikan hasil bentuk tuangan selepas applikasi TRIZ adalah lebih baik.

DEDICATION

To my beloved parent, aunts, siblings' and cousins.

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LIST OF ABBREVIATIONS

ARIZ	-	Algorithm for Inventive Problem Solving
PSM	-	Project Sarjana Muda
TRIZ	-	Theory Of Inventive Problem Solving
USSR	-	Union of Soviet Socialist Republics
Vol.	-	Volume
CICO	-	Cluster-In-Cluster-Out
CROST	-	Constructive Result & Resource Orientated Strategy of Thinking/ Transformation
Psi	-	Pound square inch

CHAPTER 1

INTRODUCTION

1.1 Case Study Background

(**T**eoriya **R**esheniya **I**zobretatelskikh **Z**adatch/ theory of inventive problem solving), TRIZ methodology is a theorem use to creating an ideal solution in solving a problem, this report aims to seek out the application of TRIZ methodology for ideal solution to curb with problems found in casting process. The main objective of conducting this study is to see for the compatibility of TRIZ methodology in providing an existing problem an ideal solution. The application of TRIZ methodology in problem solving should demonstrate how effective the solution are based on the tools introduced by the TRIZ. Implementation of the project aims to come out with an ideal solutions to the problems found in casting.

TRIZ is a non-intuitive problem-solving method based on logic and data analysis, which accelerates the ability to solve problems creatively. TRIZ also provides predictability, and reliability due to its structure and algorithmic approach. TRIZ is a (Russian) acronym for the "theory of inventive problem solving," which was developed on the study of the patterns of problems and solutions, not on the spontaneous and intuitive creativity of individuals or groups. In the formulation of TRIZ methodology, more than 3 million patents have been analyzed to decipher the patterns that predict breakthrough solutions to problems. TRIZ has always been famous with solving problem and emphasizing on the ideality of the solution, the enhancement of ideality is done by overcoming contradictions, mostly with minimal introduction of resources.

Research in this topic is to implement the TRIZ methodology into solving the problem arises during the process of casting. The project tends to see the compatibility of TRIZ methodology in solving out the problem raised in casting process.

1.2 Problem Statement

Technique of solving problem is increasingly important in the current engineering field.

However, conventional ways of solving the problem faced in engineering field is nothing more than a mere trial and error techniques, this can be costly, time consuming and lack of practicality on the ideas generated.

Conventional ways of solving the problem is done via the trial and error. Inability to understand its problem have always lead engineer to come out with unsuitable solution and caused waste of time and energy. In this case, the study conducted in this report tends to solve problem faced in casting process.

Hence, in order to solve the problem surfaced by case study of casting process; a suitable methodology will be used to overcome the problem during casting process. Problem will be investigated and the best solution will be generated to enhance the ideality of current existing solution.

1.3 Objectives

1. To adopt TRIZ methodology in problem found in casting process and come out with an ideal solution.

2. To construct a model for problem solving based on TRIZ methodology and moving towards the ideal solution (IFR) by:-
   i. Using 40 principles of innovation to create a good solution.

ii. Increasing the ideality of solution
iii. Implementing TRIZ into casting problem solving.

3. To further understand and improve current existing solution in casting process.

1.4 Scope

This project aimed to focus on how to solve problem arise from casting process using TRIZ methodology and it should covers the scope as stated below:

1. Apply TRIZ methodology into solving problem arising in sand casting.
2. Unified the TRIZ tools used in the project.
3. The tools of TRIZ involved in generating ideal solution are:
    i. Mini-algorithm of inventing (Mini-ARIZ).
    ii. 40 innovative principles of TRIZ.
4. Verify solution effectiveness.

1.5 Organization of the project

Generally, organization of the report consists of six chapters, namely introduction, literature review, methodology, result, discussion and conclusion for future works. All the structure details for each chapter had been shown below:-

a) Chapter 1 : Introduction

This chapter contains introduction and description about the project title. Generally, it covers the background, problem statement, and objective, scope of study and thesis contents. It is done to enable an easier overview of the project.

b) Chapter 2 : Literature review

Throughout this chapter, information relevant to the study will be included, it is the topic to study for better understanding. Subsequently, summarization of important information is done here.

c) Chapter 3 : Methodology

This chapter contains information on how to conduct the analysis on the case study. Methodology show here provides the information on how to perform and conduct the project.

d) Chapter 4 : Case study

Chapter 4 explains about the sequential steps of conducting the experiment, it consists of vital information need to know in order to conduct the experiment correctly.

e) Chapter 5 : Result

Chapter 5 is regarding the result obtained from the case study experiment, it is conducted to identified all the defects formed during the experiment.

f) Chapter 6 : Discussion

This chapter contains vital information that elaborates the solution for solving the sand casting problem. Result obtain here must apply the methodology describe in chapter 3.

g) Chapter 7 : Conclusion

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

CHAPTER 2

LITERATURE REVIEW

2.1 Casting Process

Casting is a manufacturing process by which a liquid material is pour into a mold contains a hollow cavity of the desired shape, and then allowed to solidify. Solid casting is then eject or broken out to complete the process. Casting can also be use to form hot liquid metals and often used for making complex shapes that would be otherwise difficult or uneconomical to make by other methods. Casting processes have been divided into two distinct groups, which are the expendable and non-expendable mold casting. Expendable molds are use only once and other molds are made of metal (permanent molding and die-casting) and can be used repeatedly. Pattern must be removable from the mold without damage, and the casting must be removable from the mold or die without damaging the die and the casting product (Anonymous, 2008).

2.2 Expendable Mold Casting

Expendable mold casting is a generic classification that includes sand, plastic, shell, plaster, and investment (lost-wax technique) moldings. This method of mold casting involves the use of temporary, non-reusable molds and usually need gravity to help force molten fluid into casting cavities (Anonymous, 2008).

2.2.1 Sand Casting Process

One of the most popular and yet simplest types of casting that has been use for centuries will be sand casting. Sand casting can be used for smaller batches production compared to permanent mold casting and at a very reasonable cost. Besides of allowing manufacturers to create products at a low cost, there are other benefits to sand casting, such as very small size operations. From castings that fit in the hand's palm to train beds (one casting can create the entire bed for one rail car), it can all be done with sand casting. Sand casting also allows the casting of most metal depending on the type of sand used for the molds. Casting is a process by which a fluid melt is poured into a mold, allowed to harden within the mold, and then ejected or revealed to make a fabricated part or casing. Four main elements are required in the process of casting: pattern, mold, cores, and the part. Pattern, the original template from which the mold is prepared, creates a corresponding cavity in the casting material (Cambridge Encyclopedia Vol. 13, 2008).

In this process, sand mixed with binders and water is compacted around wood or metal pattern halves to produce a mould. Mould is removed from the pattern, assembled with cores, if necessary, and metal is poured into the resultant cavities. After cooling, moulds are broken to remove the castings. This process is suitable for a wide range of metals (both ferrous and non-ferrous), sizes and shape complexity. (Ravi, 2004). Sand casting primarily uses green (moist) sand, and it has almost no part weight limit whereas dry sand has a practical part mass limit of 2300-2700 kg. Minimum part weight ranges from 0.075-0.1 kg. Sand is bonded together using clays (as in green sand) or chemical binders, or polymerized oils (such as motor oil). Sand can be recycled many times in most operations and requires little additional input. The term green sand does not refer to color, but to the fact that a raw sand and binder mixture has been tempered with water. Sand molding is a versatile metal-forming process that provides freedom of design with respect to size, shape, and product quality (Anonymous, 2008).

Plaster casting is similar to sand molding except that plaster is substituted for sand. Plaster compound composed of gypsum, strengthener and water, parts were typically made of the plaster casting are lock components, gears, valves, fittings, tooling, and ornaments. The finished product of plaster casting has a very high surface resolution and fine tolerances, it is inexpensive but low production. Plaster casting cannot be use for non-ferrous metal, gypsum in the plaster will slowly reacts with the iron; the maximum temperatures of plaster casting is limited to 1200^o, it limits the material cast using this methods. A thin layer of parting film is usually spray to the pattern to prevent mold from sticking the pattern, this step is necessary in the preparation step. Unit of the preparation will be shaken to allows the filling of the small cavities around the pattern, it is then dried at the temperatures between 120^o to 260^o and preheated when molten metal is poured in (Ravins *et. al*, 1989).

2.3 CASTING DEFECTS

There are only seven categories of casting defects, which have been established. These defects are (Donohue *et. al.*, 1999):

(a) Metallic Projections
(b) Cavities
(c) Discontinuities
(d) Defective Surface
(e) Incomplete Casting
(f) Incorrect Dimensions or Shape
(g) Inclusions or Structural Anomalies