UNIVERSITI TEKNIKAL MALAYSIA MELAKA

HEAT FLOW DURING CLADDING PROCESS OF NICKEL BASED DEPOSITED MATERIAL ON CAST IRON SUBSTRATE

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

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 (Engineering Process) (Hons.). The member of the supervisory is as follow:

……

(Dr Nur Izan Syahriah binti Hussein)

ABSTRAK

Tujuan kajian ini adalah untuk mencari aliran haba bahawa kesan pelapisan parameter aloi nikel berasaskan disimpan di besi substrat tuang. Objektif utama adalah untuk mengkaji kesan faktor pembolehubah yang arus, voltan dan kelajuan perjalanan dimensi berpakaian atau berpakaian manik geometri. Proses pelapisan akan dijalankan menggunakan logam gas lengai (MIG) kaedah kimpalan. Pengetahuan latar belakang tentang pemendapan logam termasuk bentuk bahan , sumber-sumber haba atau haba yang membawa tenaga haba untuk membentuk kolam lebur. Permohonan dalam industri yang berkaitan dengan proses pelapisan adalah kebanyakannya atas permohonan yang berat contohnya mewujudkan stim dandang menggunakan kimpalan atau teknik pelapisan. Kaedah eksperimen melibatkan memanipulasi satu pembolehubah (parameter pelapisan) untuk menentukan jika perubahan ini menyebabkan perubahan pembolehubah dalam pembolehubah lain (dimensi geometri) . Kaedah ini bergantung kepada kaedah dikawal dan manipulasi pembolehubah untuk menguji hipotesis. Akhir sekali , dimensi geometri pelapisan tungsten karbida nikel berasaskan aloi pada besi tuang yang telah menjana menggunakan Smart Weld Perisian. Di samping itu, Minitab 16.1 Perisian yang dilaksanakan teknik faktorial penuh telah digunakan untuk memastikan pengoptimuman parameter semasa menjalankan penyelidikan uji kaji ini. Kajian ini telah berjaya menganalisis data yang dikumpul daripada penyelidikan uji kaji ini. Kesan parameter kimpalan seperti kelajuan arus, voltan dan perjalanan secara langsung terjejas geometri dimensi daripada besi tuang bahan pelapisan. Akhir sekali , cadangan untuk meningkatkan pengoptimuman parameter dalam proses pelapisan juga telah dibincangkan.

ABTRACT

The purpose of this study was to find the heat flow that effect cladding parameter of Nickel based alloy deposited on the cast iron substrate. The main objective was to study the effect of variable factor which is current, voltage and travel speed on the clad dimension or bead clad geometry. The cladding process was conducted using metal inert gas (MIG) weld method. Background knowledge about metal deposition including form of materials, heat sources or heat input that carry the thermal energy to form the molten pool. The application in industry that relate to its cladding process is mostly on the heavy application for example create boiler steam using welding or cladding technique. This experimental method involved manipulating one variable (cladding parameter) to determine if changes in this variable cause changes in another variable (geometry dimension). This method relies on controlled methods and the manipulation of variables to test a hypothesis. Finally, the geometry dimension of cladding tungsten carbide nickel based alloy on the cast iron was generating using Smart Weld Software. In addition, Minitab 16.1 Software that implemented full factorial technique has been used in order to make sure the optimization of parameters while conducting this experimental research. This research had successfully analyzed the data collected from this experimental research. The effect of welding parameters such as current, voltage and travel speed is directly affected geometry dimension of cast iron cladding material. Finally, the suggestion to enhance the optimization of parameter in cladding process also had been discussed.

DEDICATION

To my beloved father, Khairudin bin Haji Mohyi, my mother, Satinah binti Haji Daud, siblings and friends, your love is my driving force.

To my supervisor, Dr Nur Izan Syahriah binti Hussein, your guidance is enlightenment to me.

Thank you everyone for every guidance, support, help, cooperation, directly or vice versa.

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In the name of Allah, the most gracious, the most merciful,

Alhamdulillah, praise to Allah S.W.T. for giving me the chance to complete my Final Year Project from the very beginning until the very end. It was a winding road in completing this project, but due to the help gained by God and people close to me, this burden is lightened. First of all, a million thanks are dedicated to my supervisor, Dr Nur Izan Syahriah binti Hussein for his guidance, concerns and patients. Through the completion of this project, she has been my major supporter and reference. A countless thanks is also dedicated to both of my parents who has been very supporting and understanding in every single moment since I was born. Without their blessing, I won't be able to make it up to this level of achievement. Special thanks are also delivered to the technicians and staff of Faculty of Manufacturing Engineering, Universiti Teknikal Malaysia Melaka (UTeM), for helping willingly whenever needed at any time. Last but not least, thank you also to the all my friends for being supportive and for the help given. Thank you to all of you.

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Nowadays, surface cladding is a popular non-traditional coating technology. This is because of the superior surface uniqueness of the coat in which the surface with resistance to wear, corrosion and hardness can be resulted. In fact, from the application point of view, the coating on any component produced by laser is highly comparable to other coating processes such as plasma coating and spray coating.

Cladding is similar with welding concept which is one of the thermal type techniques using a heat source to deposit a thin layer of a desired metal (by melting) on the substrate surface. Basically, the first thing that want to know is cladding is made from the laser cladding. Laser cladding using powder can be performed in two distinct ways. In the first process, powder is pasted on the surface by some adhesive and then the clad is formed by laser beam.

According to the Vollertsen (2005) said that the characteristic of laser cladded surfaces is a comparably small dilution zone of substrate and clad material. In order to realize a low dilution zone the process parameters and material combinations have to be fitted to the geometrical boundary conditions of the work piece.

Partes (2005) said that the when used cladding process it only focus on the surface of the substrate and it will change the performance of the base metal properties. Hardening and cladding it both performances for any production created and repair of structural parts. Generally, the effect of laser cladding process performance is evaluated on the basic of clad bead dimension such as clad height, clad width and depth of penetration.

1.2 Problem Statement

Nowadays, the cladding techniques are being utilized in a wide range of industries such as automotive part. Based on the previous research on the Miyazu Sdn Bhd, the problem occurs on the stamping mold when it produces high production. When the mold operates in continuously work process, the effect of wear will occur. The weld cladding technique is regularly applied in various types of industries, either for the purpose of maintenance or manufacturing new component.

According to Buchanan et al., (2009) the cladding technique is used to reduce wear of grey cast iron mill rollers in the sugarcane industry. Reducing the wear of the rollers helps in the use of greater extraction loads and better movement of the crushed cane through the rollers. From the problem issues, clad need to attach on the stamping mold to reduce the several effect on that case. So, the best parameter which is current, voltage and speed of clad must be selected to overcome this situation.

1.3 Research Objective

The main objectives of this study are:

i. To study the effect of cladding parameters which are current, voltage and travel speed on the clad dimension.
ii. To suggest the optimization of parameter using design of experiment (DOE).
iii. To verify the result of clad dimension with the analysis and explanation.

1.4 Research Scope

The scope of this project is to examine the effect of heat flow by deposited nickel based alloy on the cast iron substrate during cladding process. The response variable for this study is focus on the melting efficiency and bead clad geometry consists of dimension of length, width and depth of penetration. This project will start with the design the number order of cladding variable using Minitab Software as shown on the methodology chapter. Then, analyses the data with the different parameter based on the number of the order into the Smart Weld Software. The data result will be getting from that software followed by analysis into the Minitab Software again. When the data obtained, the result of the geometry size will be compared to the actual experiment to see the different performances of geometry size error.

1.5 Research Organization

This project is organized into five chapters:

Chapter 1 is the introduction of the report. In this chapter, it includes the background, problem statement, research objectives and research scope of the project. Chapter 2 describes the findings of the project as well as theoretical or methodological review before the experimental works. The literature review must relate to the project issues. Chapter 3 explains the methodology used in the experiment including flow chart, equipment's, procedures and data analytical technique required for the study. Chapter 4 shows the testing and data results together with discussions. In this chapter, the data result would be to compare to each other to collect more analysis data in formation. Chapter 5 will conclude the whole project and recommend for further study to be done for this related title.

CHAPTER 2

LITERATURE REVIEW

2.1 Cladding Process

Cladding is an established process used in a variety of industries for improving the surface and near surface properties of a part, or to resurface a component that has become worn through use. There are currently quite a number of different techniques for performing cladding, each with its own specific characteristics in terms of the materials employed, the quality of the clad layer, and various practical issues, including throughput speed, process compatibility, and cost.

Cladding by powder injection is a surface engineering method to produce high quality, metallurgical bonded and thick coatings on deficient substrates with a minimal heat input into the work piece. By referring Oliveira (2006) has stated the main objective of cladding is to improve wear, impact and corrosion resistance properties of surfaces, by generating a protective layer of a different material.

In this process, Boer (2006) said that the nickel filler metal is used to form the clad under the heat input power while it scans the surface of the substrate generating a melt pool with a depth that corresponds to the thickness of a single clad generated in one single step. Several others process parameters play also a role, such as amount of shielding and carrier gas, size, speed and feeding direction of electric arc power input.

2.1.1 Principle of Cladding Process

Current cladding technologies can be broadly classified into three categories; these are arc welding, thermal spraying and laser-based methods. Each of these methods has advantages and limitations, and, as a result, there are certain types of applications for which each is best suited.

According to Vollertsen (2005) said that, the aim of laser cladding is the deposition of a cladding onto surfaces of work pieces in order to generate functional layers or regenerate the natural shape of parts. The material is deposited by powder injection, pre-placed powder or by wire feeding. In combination with the laser beam generating a melt pool the additional material is melted.

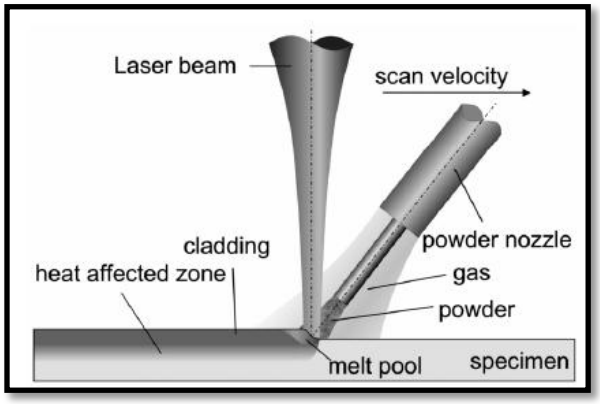

Figure 2.1: Principle of cladding process (Partes, 2005)

The process is schematically shown in Figure 2.1, Partes (2005) has reported the powder flow can be off-axis or co-axial. In both cases the powder travels some distance through the laser beam causing the particles to be preheated or even melted before they reach the melt pool. To protect the optical components a cross jet is usually applied in order to avoid damage caused by heated powder particles. Another characteristic of laser cladded surfaces is a comparably small dilution zone of substrate and clad material. In order to realize a low dilution zone the process parameters and material combinations have to be fitted to the geometrical boundary conditions of the work piece.

2.1.2 Heat Source for Cladding Process

The successful of welding is about the source of heat which is performing of making the good weld pool. Basically, this fusion weld pool is place on the joint line. Figure 2.2 below shows that the schematic of weld pool on the workpiece.

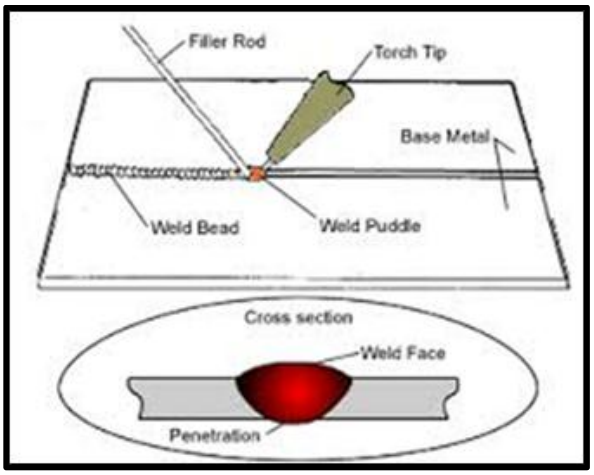

Figure 2.2: The cross section of weld pool on the parent metal. (Vollertsen, 2003)

The weld pool area heated with heat source to be usable in welding conditions which is:

a) The small heat source directly to the area of weld pool because of the size of weld pool can be limited to change. When the heat source is large, it is not suitable to use in cladding process because it make the properties and the microstructure of parent metal change.
b) The heat source must operate at a higher temperature than the low heat transfer and the heat will spread over the area of weld pool.
c) The total amount of heat flow is depend on the physical properties of the substrate choose and the dimension of arc length.