ENHANCED HEATING MECHANISM BY MODIFYING THE SHAPE OF THE ELECTRIC METAL MELTING FURNACE IN TRADITIONAL FOUNDRY

BY

ZAIRUL AZRUL BIN ZAKARIA

A thesis submitted in fulfilment of the requirement for the degree of Master of Science in Manufacturing Engineering

Kulliyyah of Engineering
International Islamic University Malaysia

SEPTEMBER 2015

ABSTRACT

The cost to own a furnace to melt metals is very costly. Observations have been made in the melting industry and it has been found that the cost of a furnace is around RM 60, 000 for a 3 litre capacity diesel furnace; and may be higher depending upon the crucible capacity. Due to the high cost of raw material i.e. copper and aluminium, the metal industry has become an expensive industry and a burden, especially for the small operators. Thus, this project aims to modify the shape of the heat chamber in the electric furnace in order to improve efficiency and at the same time being affordable to support the traditional local foundry. These might reduce the cost of provision or purchase the furnace, in addition to encourage the small and medium entrepreneurs involved in the industry to be more productive and able to save operation time as well. The electric furnace is designed based on the induction concept and used the coil as the heater to melt the non-ferrous metals, namely an aluminium or brass. The conceptual design of the furnace using Solid Works took several important criteria that have been considered; that is the furnace efficiency, the commercial design, the cost involved, the furnace heating mechanism, the heat chamber shape, the internal combustion flow and the mobility of the furnace. The criteria are then analysed by using the Matrix Evaluation Method (MEM) to find the ultimate design that suits the criteria. From the computational simulation, it is found that the heat flow due to the induction accumulates the entire space in the furnace and is capable to melt the metal completely. Results from the repeated experiments show that the melting time for aluminium is only 45 minutes for the quantity of 1 kg at a temperature of 740°C. This design of induction furnace turned out to be reasonably efficient (78.53%) and is very economical RM 10,320. Therefore, this furnace can be successful in helping the traditional local foundry.

خلاصة البحث

إن امتلاء فرن صهر المعادن مكلفة جدا، بحيث تعد ثمن تكلفة للفرن الواحد حوالي 60 ألف رينجيت ماليزيا تقريبا، وهو ما يعادل سعة ثلاثة لترات من الديزل. ويرجع غلاء تكلفة الفرن اعتمادا على سعة قدرة الفر، وارتفاع تكلفة المواد الخام النحاس، والألومنيوم. حيث أصبحت صناعة المعادن صناعة مكلفة، ومرهقة خاصة لدي الشركات الصغيرة. لذا، يهدف إلى تعديل شكل غرفة حرارة الفرن الكهربائي لتحسين زيادة الكفاءة، بأسعار مناسبة من اجل دعم مسبك المعادن المحلية التقليدية في الوقت نفسه ويمكن خفض من تكلفة الفرن أو شرائه، وتشجيع الشركات الصغيرة والمتوسطة العاملة في هذه الصناعة؛ لتكون أكثر إنتاجية، وقادرة على توفير الوقت للقيام بالعملية. وقد صمم الفرن الكهربائي على أساس مفهوم الاستقرائي، واستخدمت اللفائف بوصفها سخانا لإذابة المعادن غير الحديدية، كالألمنيوم أو النحاس. ويتم استخدام التصميم الفرن في الأعمال الصلبية، وأن تستوفي المعايير اللازمة وهي: كفاءة الفرن، والتصميم التجاري، والتكاليف المترتبة، وآلية تسخين الفرن، وشكل الغرفة الحرارة، وتدفق الاحتراق الداخلي، وتنقلية الفرن. وقد تم تحليل المعايير باستخدام طريقة التقويم الرياضي (MEM) من أجل العثور على التصميم النهائي الملائم لمعايير الفرن. فمن المحاكاة الحاسوبية تبين تبين تدفق الحرارة علي كامل مساحة الفرن، والقدرة على صهر المعدن بشكل تام. أظهرت النتائج التجارب المتكررة أن مدة ذوبان 1 كيلوغرام من الألمنيوم هي 45 دقيقة فقط، تحت درجة حرارة 740 درجة مئوية. وقد تبينت فعالية تصميم هذا الفرن الاستقرائي بشكل معقول بنسبة (78.53٪)، واقتصادية للغاية بقيمة 10,320 رينجيت ماليزي. وبالتالي، بإمكان هذا الفرن النجاح في تقديم المساعدة لمسبك المعادن المحلية التقليدية.

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion, it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Master of Science in Manufacturing Engineering.

……………………………………….
Tasnim Firdaus Binti Mohamed Ariff
Supervisor

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Master of Science in Manufacturing Engineering.

………………………………………..
Mohammad Yeakub Ali
Examiner 1

………………………………………..
Irfan Hilmy
Examiner 2

This dissertation was submitted to the Department of Advanced Engineering and Innovation Centre (AEIC) and is accepted as a fulfilment of the requirement for the degree of Master of Science in Manufacturing Engineering.

……………………………………….
Md. Yusof Ismail
Head, Advanced Engineering and
Innovation Centre (AEIC)

This dissertation was submitted to Kulliyyah of Engineering and is accepted as a fulfilment of the requirement for the degree of Master of Science in Manufacturing Engineering.

………………………………………..
Md. Noor Bin Salleh
Dean, Kulliyyah of Engineering

DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

Zairul Azrul Bin Zakaria

Signature .... Date ....

INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA

DECLARATION OF COPYRIGHT AND AFFIRMATION OF FAIR USE OF UNPUBLISHED RESEARCH

ENHANCED HEATING MECHANISM BY MODIFYING THE SHAPE OF THE ELECTRIC METAL MELTING FURNACE IN TRADITIONAL FOUNDRY

I declare that the copyright holder of this thesis/dissertation is
Zairul Azrul Bin Zakaria

No part of this unpublished research may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise without prior written permission of the copyright holder except as provided below

1. Any material contained in or derived from this unpublished research may be used by others in their writing with due acknowledgement.

2. IIUM or its library will have the right to make and transmit copies (print or electronic) for institutional and academic purposes.

3. The IIUM library will have the right to make, store in a retrieval system and supply copies of this unpublished research if requested by other universities and research libraries.

Affirmed by Zairul Azrul Bin Zakaria.

……………………………. ………………..
Signature Date

To Norazida Binti Muda, Ariff, Azim, Auni and my mum, Habsah Binti Sulong

ACKNOWLEDGEMENTS

In the name of Allah, the Most Beneficient and the Most Merciful. With the blessings of Allah SWT, I have completed my research.

My deepest appreciation goes to my supervisor, Engr. Dr. Tasnim Firdaus Binti Mohamed Ariff from Department of Manufacturing and Materials Engineering, Kulliyah of Engineering, International Islamic University Malaysia, Kuala Lumpur who has given the unlimited commitment and provided guidance during the process of completing this thesis.

I would like to also thank all the Academic and Non-Academic of Department of Mechanical Engineering, Politeknik Sultan Haji Ahmad Shah Kuantan (POLISAS) for all the help and assistance given either directly or indirectly throughout my research particularly in the areas of Foundry Engineering.

Not to forget, special gratitude goes my beloved family for their boundless support, understanding and even assisting in matters related to my research topic.

Your commitment is highly appreciated. Thank you.

TABLE OF CONTENTS

Abstract ii
Abstract in Arabic iii
Approval Page iv
Declaration v
Copyright Page vi
Acknowledgements viii
List of Tables xi
List of Figures xii

CHAPTER ONE: INTRODUCTION 1
1.1 Background of the Study 1
1.2 Statement of the Problem 3
1.3 Research Objectives 5
1.4 Research Methodology 6
1.5 Research Scope 7
1.6 Research Structure 7

CHAPTER TWO: LITERATURE REVIEW 10
2.1 Overview of Metal Casting 10
2.2 Melting Process 15
2.3 Energy Efficiency of the Melting Process 16
2.4 Smelting Process 18
2.5 Induction Heating VS. Natural Gas Heating 19
2.6 Fabrication and Simulation 21
2.7 Summary 22

CHAPTER THREE: RESEARCH METHODOLOGY 24
3.1 Studying The Current Design of Furnace 24
3.1.1 Reference Concept 26
3.1.1.1 Advantages 28
3.1.1.2 Disadvantages 28
3.1.2 Design Concept and Criteria 28
3.2 Concept Evaluation and Selection 32
3.3 Design and Numerical Evaluation 37
3.3.1 Gambit (Solver: Fluent 5/6) Simulation Procedure 37
3.3.2 Fluent 6.3 Simulation Procedure 39
3.4 Summary 40

CHAPTER FOUR: FABRICATION, EXPERIMENTAL SETUP AND COST ANALYSIS 42
4.1 Furnace Fabrication 42
4.1.1 Bill of Materials (BOM) 42
4.1.2 Construction and Assembly Process 43
4.2 Experimental Run 46
4.3 Performance Test 47

4.4 Engineering Cost Analysis 49
4.5 Volume Analysis 50
4.6 Summary...51

CHAPTER FIVE: RESULT AND DISCUSSION 52
5.1 Design and Computional Simulation of The Furnace 52
5.2 Performance Test 54
5.2.1 Heat Input 54
5.2.2 Heat Output 55
5.2.3 Specific Energy Consumption 57
5.3 Experimental Run..58
5.4 Summary...60

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS 62
6.1 Conclusions 62
6.2 Recommendations 63

REFERENCES...64

APPENDIX I: CATALOGUE 68

LIST OF TABLES

Table No.		Page No.
3.1	List of Advantages and Disadvantages for Conceptual Design #1	29
3.2	List of Advantages and Disadvantages for Conceptual Design #2	30
3.3	List of Advantages and Disadvantages for Conceptual Design #3	30
3.4	The results of simulation on static pressure and temparature of various heat chamber shape	34
3.5	Comparison between the Conceptual Designs 1, 2 and 3 with the reference concept	35
4.1	Bill of Materials (BOM) for the Electric Furnace	43
5.1	The average temperature readings of the combustion chamber and crucible	58
5.2	Summary of the calculated values of efficiency, energy consumption and amount of heat loss in this electric furnace	60

LIST OF FIGURES

Figure No.		Page No.
1.1	Traditional furnace for crafts and arts in Terengganu	4
1.2	Brass product made by local craftsman by using traditional furnace	5
2.1	Process Energy Costs in Metal Casting (HuangFu, 2005)	13
2.2	Energy Source in Metal Casting (HuangFu, 2005)	14
2.3	The sequence of the smelting proces	19
2.4	(a) Natural Gas Heated Furnace (b) Electrical Induction Furnace (HuangFu, 2005)	19
2.5	Energy consumption of a natural gas and an induction furnace used in the manufacture of the same product	20
2.6	Summary of energy efficiency benefits of induction furnace versus a natural gas furnace (HuangFu, 2005)	21
3.1	Flow chart designed in conducting this research	25
3.2	Commonly used crucible of 3 liter capacity manufactured by Salamander Morgan Battersea, U.K	26
3.3	The existing electric induction furnace that was chosen as the reference concept (Robert et al., 2005)	27
3.4	Conceptual Design #1. The heating coil is located at the side of the furnace wall in staged design	31
3.5	Conceptual Design #2. The heating coil also is located at the side of the furnace wall in parallel design	31
3.6	Conceptual design # 3. The heating coil is wound around the crucible	32
3.7	Air flow inside the hexagon shape combustion chamber with static pressure 30 Pa and inside temparature 950°C	33
3.8	Air flow inside the square shape combustion chamber with static pressure 450 Pa and inside temparature 1250°C	33
3.9	Air flow inside the round shape combustion chamber with static pressure 25 Pa and inside temparature 1450°C	34

3.10 Top View of the electric metal melting furnace 36

3.11 Front view of the electric metal melting furnace 36

3.12 The model of crucible and combustion area inside the electric metal melting furnace by using Solid Works 37

3.13 The meshing process to setup the *Boundry Condition* by using Gambit 38

3.14 The modeling to determine the *fluid domain* by using Fluent 6.3 39

4.1 Heating coil with wind diameter 160 mm and coil diameter 8 mm 44

4.2 The fabrication process of the furnace (a) V-Cast powder used as the ceramic of the furnace (b) The lid of the furnace by ceramic and the fire bricks at the sidewall as the insulation (c) The body of the induction furnace (d) Fixing the wires and cables on the spray coated furnace 45

4.3 The completely fabricated electric metal melting furnace with the thermocouple (Type K) fixed at the bottom of the furnace 47

4.4 Quantity of Heat Release at Various Temperatures (Mathur, 2010) 48

5.1 The simulation at the combustion chamber of the furnace by using FLUENT 6.3 (a) Heat flow vector (m/s) inside the combustion chamber (b) Air flow (m/s) meeting the entire space in the furnace 53

5.2 The reading taken by Infra-red Thermometer (AR872A) (a) Outside and (b) Inside of the furnace body 54

5.3 Heating profile inside the combustion chamber measured by thermocouple and the crucible measured by infra-red thermometer while melting the Aluminum 59

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

In the iron and steel industry, there are four types of furnaces used to melt the metal. The furnace can be categorized as blast furnace, basic oxygen furnace, electric arc furnace and immersion furnace. The blast furnace still maintains its predominant position as mass producer of hot metal from last centuries (Chu et al., 2006). There are many experiments and simulation works which have been conducted to improve the performance of blast furnace (Yagi et al., 2003). Heat transfer analysis is one of the major studies to enhance the performance of the furnace (Wu et al., 2008). Blast furnace has a cone-shaped tower height from 20-30 m and a diameter of 5-7 m. It is divided into two parts; which is the combustion chamber and brick construction. Combustion chamber is the place where the gas and fresh air delivered to the furnace for combustion to take place. The blast furnace commonly used to melt iron or to melt steel ingots. For the basic oxygen furnace it uses pure oxygen in the steel or iron smelting. It can move horizontally and vertically. While the furnace is filled with liquid iron and 30% steel scrap to the furnace in a position tilted and then set up the furnace. This type of furnace could produce high-quality steel that is faster on average in terms of time (Song et al., 2005). For the electric arc furnace, it has a high capacity and easier to handle than the other furnaces because of the low oxygen level in the furnace, it is suitable for producing steel alloy from the mixed metal that does not react with the oxygen. This furnace is widely used and appropriate to the grade of steel and increase the production of tool steel and steel alloys without the aid of high-quality and expensive fuels (Chena et al., 2008). Regarding the immersion furnace, it can be divided into two; i.e. Low-Temperature Melting and High-Temperature Melting (Robert et al., 2005). For Low-Temperature Melting, immersion furnaces or heaters are currently used for low-temperature melting of zinc. The heat is generated by combustion or electrical resistance inside a tube submerged in molten material. The heat is efficiently transmitted to the molten material through the wall of the tube by conduction. Combustion gases are never exposed to the molten metal, reducing oxidation losses and enhancing heat transfer to the molten metal. The efficiency of a zinc immersion furnace is high at 63 to 67% and provides melting rates of up to 1,600 lbs. /hr. Immersion heat tubes are typically made of metallic materials that have high thermal conductivity and are coated with ceramic or cement materials to resist corrosive attack by the molten metal. When melting aluminium or other higher-temperature-melting materials, heavier ceramic coatings are applied because these molten materials act more aggressively on the tubes. The ceramic coatings, however, act as a thermal barrier and lower the productivity of the immersion heater. The mechanical demands on ceramic-coated metallic tubes are also very high. These tubes must be structurally strong to survive in an industrial environment and must be able to operate under frequent thermal cycling. A small crack in the coating can lead to rapid destruction of the tube and lost in productivity. Higher-temperature melting furnaces utilizing immersion tubes are still considered experimental, and efforts have been made to develop more robust and protective tubes. Although Immersion furnace is well established for melting zinc, it is currently not well-adapted for melting metals with higher melting points. The protective ceramic coatings pose thermal barrier, lowering the melting efficiency. In U.S.A, several Industrial Technologies Program's (ITP) Metal Casting projects are currently focusing on enabling this technology commercially. One ITP sponsored project addresses the critical need for advanced materials that are lighter, stronger, and more corrosion-resistant than metals. Work has been done to optimize the nitride-bonded, silicon-carbide-fiber-reinforced Continuous Fiber Ceramic Composite (CFCC) immersion tube burners for application in aluminium and other light metal melting. The project validated that CFCC materials are stable in molten aluminium and in combustion gas for long periods. When tested at an industrial site, the immersion tube survived over 1,000 hours and 31 cycles in an aluminium casting furnace. In another testing, the immersion tube successfully survived for 1,752 hours in the furnace. The trend in design of the electric furnace in the past decade had been toward top charge and larger furnaces, with increased transformer capacity for fast melting. In many of the older installations, transformer size is being increased to provide faster melting rates and higher temperatures for steels requiring special treatment. The maximum size of the electric furnace has not been reached, and the possibilities of the really large furnace remain to be proven. However, there is little doubt in most operators' minds that the large electric furnace is practical (McCurdy, 1951).

1.2 STATEMENT OF THE PROBLEM

In the metal industry, regardless of whether large, medium or small scale, the necessary equipment needed in the process of casting is the furnace. It works to melt the metal in the crucible before pouring into the casting mould to form the metal-based product required. The price of metal melting furnace is very expensive depending on the size and capacity of the melting metal. This causes the small-industry casting i.e. foundry to not having the ability to buy or fabricate a better furnace. They were only able to build or purchase a small furnace that need longer time to melt. Figure 1.1 shows the simple stove fired furnace made locally in

Terengganu to melt aluminium and brass. The tool is very primitive and needs longer time to melt the metal. There is a lot of energy and effort needed to complete the work due to un-ergonomically furnace. Besides, the working area is unsafe. It is covered by fume and noise. These are the reasons why the industry is slowly dying. Nowadays, no more youngsters are interested in working in areas like this.

Figure 1.1: Traditional furnace for crafts and arts in Terengganu

Figure 1.2 below shows some products produced by the craftsman. Through the details analysis of the local foundry, this research intended to study the new design of electric furnace to reduce the cost and increase the performance of the furnace. The furnace is powered by electric power. This type of source is chosen because it is easily available at the residence. The design of the furnace is thoroughly studied so that the better design of the furnace can be produced in order to support the traditional foundry.

Figure 1.2: Brass product made by local craftsman by using traditional furnace

In this study, nonferrous metal namely aluminium was chosen to be melted. Aluminium is a soft, lightweight metal, non-toxic and non-magnetic which is usually used in aeronautic, aerospace, automotive and other industries requiring lightweight but strong material. The material has an estimated melting temperature of 700 ºC (Keating, 2007). This material has a tensile strength up to 700 MPa, and is easily malleable, ductile and corrosion resistance and durable as a result of the protective oxide layer.

1.3 RESEARCH OBJECTIVES

The study aimed to achieve the following objectives:

1- To design a modified electric furnace with increased efficiency by improving the heating mechanism and shape of the heat chamber using Solid Works.

2- To simulate the heat distribution of the heat chamber in the furnace numerically using Computational Fluid Dynamics (CFD).

3- To fabricate, test and evaluate the performance of the modified electric furnace.
4- To produce an improved design of an electric furnace that can be used in the local foundry with better efficiency.

1.4 RESEARCH METHODOLOGY

The methodology starts with the process of studying the current design of the furnace. The traditional furnace of the local foundry will be studied and the problems faced by the craftsman will be defined. Besides, the existing electric furnace in the industry also will be considered by investigating of several parameters that can be used to increase the performance of the furnace. Conceptual analysis will be done so that the better design of the furnace can be produced.

Then it comes is to the designing and evaluating numerical stage. Here, the simulation model is used at the design stage to optimize the basic geometry of the furnace. The performance of the furnace and the heat distribution in the combustion chamber of the furnace are studied accordingly. The boundary conditions are determined by the design parameters given. In this process, there are several engineering software involved i.e. Solid Works, Fluent and Gambit. The simulation gives a very clear view of how the heat is distributed through the combustion chamber. It is very useful to determine where the complete combustion occurred in the combustion chamber.

Then, the fabrication work starts once the optimum design is defined. In this project, the Bill of Materials (BOM) indicates the list of materials needed in fabricating the induction metal melting furnace which includes raw material and accessories. It is discussed in detailed to give a clear view of many other options on high performance designing of the furnace. The electric furnace is tested virtually and the reading taken is analysed. On the result and analysis stage, the result obtained from the simulation is measured using the Fluent 6.3. Additionally, it also describes the results from the experimental runs used in melting aluminium. The performance and the efficiency of this furnace design are calculated and analysed.

1.5 RESEARCH SCOPE

Upon conducting the literature review on related furnaces, a theoretical study on the performance of the combustion area using Computational Fluid Dynamics (CFD) software was performed. Optimization process from the CFD analysis was focused mainly on the effect of the heater location and also the effect of combustion chamber shape. These parameters were determined earlier by using design concept analysis. Altogether, there were three design concepts listed up including a reference concept as a datum. The concepts were compared with the datum by giving the weighting mark of their interest criteria. By summing the total weighting mark, the best design on furnace shape and heater location was determined. Then, the experimental test was conducted and the evaluation on the performance test (Temperature vs. Time) was done together with the heat distribution in the combustion chamber. Finally, the furnace was fabricated, tested and evaluated for its performance.

1.6 REPORT STRUCTURE

As the introduction, the Chapter 1 gives a clear background of what this research is all about. The problem statement, research objectives and scopes are clearly explained in this chapter. Chapter 2 on the other hand, covers a wide range of literature review from the past researches done by researchers in the field of foundry from all over the world. In this chapter, details of discussion are done in terms of definition of furnace, type of furnace and design selection, design of experiments and finally on role of Computational Fluid Dynamics (CFD) on furnace design.

Chapter 3 discusses the research methodology used for this research. The path is properly arranged in order to ensure the success of the research. The methods are divided into two sections, design optimization and design of the furnace. In design optimization, the first step is done by studying the current design of the furnace. Then, it is followed by design concept and criteria. Here, the table of advantages and disadvantages on each design are listed. In second section i.e. design of the furnace, it starts with the concept evaluation and selection. The simulation on each heat chamber is done to determine the best shape. Then, the geometry of the best shape is done in 3D drawing. It is followed by meshing the geometry, simulation setup and then post-processing data. All are done by using software.

Chapter 4 discusses about fabrication, experiment and analysis. The fabrication work start after the optimum design is defined. Before, there were several factors needed to be considered while developing the furnace including the bills of materials (BOM). After construction and assembly processes, the experiment was conducted in consideration of several assumptions. Based on the data collected, the analysing is done in order to find the heat loss, the specific energy consumption and the efficiency of the furnace. The cost of fabrication and the volume of the specimen are analysed as well.

In chapter 5, the results and discussion are presented. The results on optimizing process from CFD analysis are determined. The parameters involved and what are taken into consideration are the fluid domain, the boundary condition, the initial guess, the meshing and the solver. During the experimental test, the data on performance test is recorded. By using the data, the graph Temperature, T (°C) versus Time, t (s) are plotted. In fact, the effect of heat flow and air flow is described here. Only then, the actual data is compared with the simulation results.

Finally, Chapter 6 concludes whether the research objectives are achieved or not based on the experimental runs, testing and evaluation performed in this research. In addition, the recommendations for future work are stated here as well.

CHAPTER TWO

LITERATURE REVIEW

2.1 OVERVIEW OF METAL CASTING

Casting is a process of melting metals in the furnace and placing it into a mold cavity. Upon solidification, the metal takes the shapes of the cavity. This process is capable of producing intricate shapes in a single, ranging in size from very large to very small, including those with internal cavities. Typical cast products are automotive components such as engine block, cylinder head, transmission housing, piston, and ornamental artifacts (Kalpakjian & Schmid, 2014). The source of the burning comes from charcoal, natural gas, diesel, LPG and electric. An alternative burning source from solar and hybrid energy have been considered (Suresh & Rohatgi, 1979; Funken et al., 2005; Ferguson, Coms & Bryden, 2010). However, the application is limited due to inconsistency of the sun and limitation to keep the energy.

Due to its availability, the use of electrical source should be considered as it is the ‘ready used power source’ and more safety among others. Unfortunately literature reviews are done regarding the application of electric arc furnace, electric induction furnace and induction melting furnace but their results on efficiency are very difficult to find. Economically, two case studies from two different statuses of countries can be used as reference and motivation in developing Malaysian foundry business. The two countries are the U.S.A and Nigeria. The very successful small casting manufacturers came from the U.S.A. In U.S.A, the small and medium casting manufacturers dominated about 80% of 2480 casting facilities. Nevertheless the successes are not easy since several issues arise. A study in the country had shown that small industries find it difficult to assume the high costs and the risk associated with R&D, particularly long-term R&D, to improve metal casting technology and process efficiencies. With the help from government and Institutions of Higher Learning (IHL), small manufacturers have managed to grow and contribute to strengthen the economics of the country (Robert et al., 2005).

The Nigerian, on the other is still making use a very traditional based foundry industry. The strategy has been formulated to improved policies and management of technology to assist the local foundry (Ibitoye & Ilori, 1998). The Nigerian believed the traditional casting business has good prospect and can be a basis for the development of indigenous technological capability building in metal casting. Being in the upper part of developing countries, strongly supported with expertise from local institutions, Malaysia has the advantage to further enhance its traditional foundry business. The industries have the potential to expand and become very established industries with niche products.

Melting of metals, glass, and other materials has been one of the crucial manufacturing processes for several thousand years, producing molten liquids that can be poured and solidified into useful shapes. Although the basic process continues to be the same, the utility of cast products has come a long way. The process that created tools and exotic goods for only a privileged few in the Bronze Age contributes to components used in over 90% of manufactured goods in our society today. Since the dawn of the industrial age, the tremendous progress in the melting process equipment, the range of molten materials, the chemistry and thermal controls, and the complexity of the finished products has enabled cast components in building a vast variety of products i.e. automobiles, power generators, railroad cars, oil pipelines, military hardware, medical instruments, etc.