CONTROL HEATING OF SMALL FORGING USING OXY-ACETYLENE FLAME

EMILIA SHANDER ANDREW ABE

This Report Is Submitted In Partial Fulfillment Of Requirement For The Degree of Bachelor In Mechanical Engineering (Design and Innovation)

Fakulti Kejuruteraan Mekanikal
Universiti Teknikal Malaysia Melaka

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“I hereby declared that I have read through this report and found that it has comply the partial fulfillment for awarding the Bachelor Degree of Mechanical l Engineering (Design and Innovation)”

Signature	:..
Supervisor’s Name	: P.M. IR Mustafar Abd Kadir
Date	: 08.05.07

"I hereby declared that this report is a result of my own work except for the excerpts that have been cited clearly in the references"

Signature :..

Name : EMILIA SHANDER ANDREW ABE

Date : 08.05.2007

A venture of this sort does not come without its pain.
The pain is usually felt by other people. But I really want to dedicate this report to
My beloved parents for providing moral support and encouragement.

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Last but not least, without all of your supports, it would not have been possible for me to meet the strong demands placed on my time by this project n report. Thank you all!

ABSTRACT

My bachelor degree project comprises of designing and fabricating process. The chosen title is 'Control Heating of Small Forging Using Oxy-Acetylene Flame'.

This project requires me to come out with a new idea of designing and fabricating a small furnace for Ø25mm x L75mm steel bar using oxy-acetylene flame. The existing furnace is the distinctive feature of the furnace and consist of fire-brick flues filled with bricks set on edge and arranged in such a way as to have a great number of small passages between them. The bricks absorb most of the heat from the outgoing waste gases and return it later to the incoming cold gases for combustion. This furnace operates at a high temperature by using regenerative preheating of fuel and air for combustion. In regenerative preheating, the exhaust gases from the furnace are pumped into a chamber containing bricks, where heat is transferred from the gases to the bricks. The flow of the furnace is reversed so that fuel and air pass through the chamber and are heated by the bricks.

This project requires designing and inventing a small furnace for carbon steel bar forging with controllable heating distribution using oxy-acetylene flame. The design involves heat distribution on carbon steel for forging using oxy-acetylene flame. A small furnace needs to be designed in order to get the uniform heating on the particular carbon steel bar. The right temperature of oxy-acetylene flame produces uniform heating and the particular temperature should be before melting point (~900°c - 1200°c).

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CHAPTER 1

PROJECT INTRODUCTION

1.0 Introduction

Projek Sarjana Muda (PSM) is one of the knowledge research that related to student's discipline. This particular final year project is vital and compulsory as to meet the Bachelor Degree's requirements. The task has to be accomplished completely and the objectives of this final year project must be successfully achieved. The project has been divided into three categories, design project, technical/concept analysis and case study.

1. Design project should be base on certain design and finally could end with product or design.
2. Technical and concept analysis that relates to student's discipline their selves.
3. The case study project is more on study research on certain case or topic.

By the end of this project, student should come with solution of the problem.

My chosen final year project title is "Control heating of small forging using oxy-acetylene flame". So, by the end of this project, I should have come out with my design of a small furnace using oxy-acetylene flame which will work to fire on a steel bar uniformly, specially designed for forging work.

1.1 Objectives

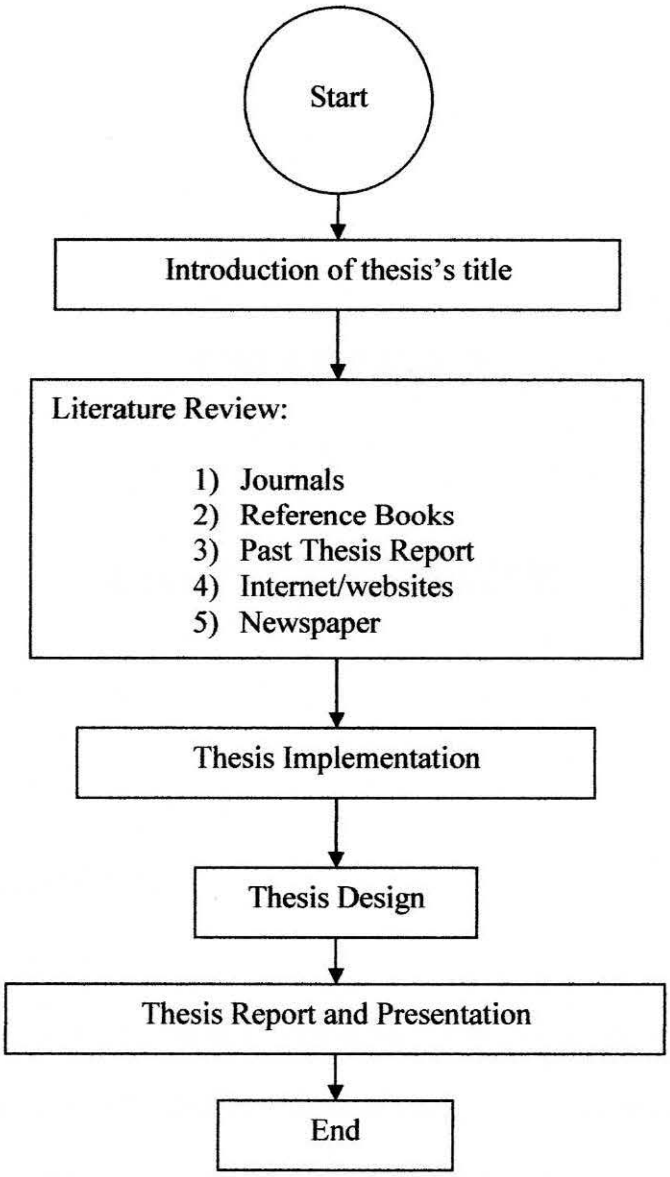
The objectives of this research are:

1) To design a small furnace with controllable heating for carbon steel forging using oxy-acetylene flame.
2) To study the material characteristics of the carbon steel bar to achieve uniform heating for forging.
3) To identify and study the heating flow in order to perform distribution heat on steel bar.
4) To study the properties of heat resistant clay for furnace construction.
5) To design and fabricate the furnace prototype.
6) To test, troubleshoot and improve the final prototype.

1.2 Scope of project

The scope of this project is to design a small controllable heating furnace for steel forging using oxy-acetylene flame. Next, is to identify and study the heating flow in order to perform distribution of heat on steel bar. Research on the oxy-acetylene flame's behaviors will also be undertaken in order to get the controllable uniform heating on the steel bar. Duration time for heating will be experimentally studied in order to get a perfect uniform heating on the steel bar.

1.3 Flow Chart of Final Year Project Management (PSM I)



CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Before getting all started and implemented, this chapter begins with the overall studies; theoretically on the heating fundamental, uniform heating and controllable heating of the small furnace for steel forging. Apart from that, the basic elements and the characteristics of carbon steel are also being studied and explained besides of general descriptions of furnace living, heat resistant clay and oxy-acetylene flame which are also being discussed in this chapter.

2.2 HEATING FUNDAMENTAL

Specifically, heat is a form of energy not associated with matter and in transit between its source and destination point. Furthermore, heat energy exists as such only between these two points. In other words, it exists as heat energy only while flowing between the source and destination.

So far this description of heat energy has been practically identical to that of work energy, the other form of energy in transit not associated with matter. The distinguishing difference between the two is that heat energy is energy in transit as a result of temperature differences between its source and destination point, whereas work energy in transit is due to other, non-temperature factors.

British Thermal Unit

Heat energy is measured by the British thermal unit (Btu). Each thermal unit is regarded is regarded as equivalent to one unit of heat (heat energy).

Since 1929, British thermal units have been defined on the basics of 1 Btu being equal to 251.996 IT (International Steam Table) calories, or 778.26 foot-pounds of mechanical energy units (work). Taking into consideration that one IT calorie equals $^{1/860}$ of a watt-hour, 1 Btu is then equivalent to about $^{1/3}$ watt-hour.

Relationship Between Heat and Work

The relationship between work and heat is referred to as the mechanical equivalent of heat; one unit of heat is equal to 778.26 ft-lb. This relationship (i.e., the mechanical equivalent of heat) was first established by experiments conducted in the nineteenth century. In 1843 Dr. James Prescott Joule (1818-1889) of Manchester, England, determined by numerous experiments that when 772 ft-lb of energy had been expended on 1 lb of water, the temperature of water had risen 1°F and the relationship between heat and mechanical work was found. The value 772 ft-lb is known as Joule's equivalent. More recent experiments give higher figures and the value 778 (1 Btu = 778.26 ft-lb).

2.3 FURNACE LIVING

In American English, the term *furnace* on its own is generally used to describe household heating systems based on a central furnace (known either as a boiler or a heater in British English), and sometimes as a synonym for kiln, a device used to fire clay to produce ceramics.

In British English the term *furnace* is used exclusively to mean industrial furnaces which are used for many things, such as the extraction of metal from ore (smelting) or in oil refineries and other chemical plants, for example as the heat source for fractional distillation columns.

The term *furnace* can also refer to a direct fired heater, used in boiler applications in chemical industries or for providing heat to chemical reactions for processes like cracking, and is part of the standard English names for many metallurgical furnaces worldwide.

The heat energy to fuel a furnace may be supplied directly by combustion of some fuel, or electric furnaces such as the electric arc furnace or induction furnace use remotely generated electric power.

2.4 FORGING

Forging is a metal forming process used to produce large quantities of identical parts, as in the manufacture of automobiles, and to improve the mechanical properties of the metal being forged, as in aerospace parts or military equipment. The design of forged parts is limited when undercuts or cored sections are required. All cavities must be comparatively straight and largest at the mouth, so that the forging die may be withdrawn. The products of forging may be tiny or massive and can be made of steel (automobile axles), brass (water valves), tungsten (rocket nozzles), aluminum (aircraft structural members), or any other metal. More than two thirds of forging in the United States is concentrated in four general areas: 30 percent in the aerospace industry, 20 percent in automotive and truck manufacture, 10 percent in off-highway vehicles, and 10 percent in military equipment. This process is also used for coining, but with slow continuous pushes.

The forging metal forming process has been practiced since the Bronze Age. Hammering metal by hand can be dated back over 4000 years ago. The purpose, as it still is today, was to change the shape and/or properties of metal into useful tools. Steel was hammered into shape and used mostly for carpentry and farming tools. An ax made easy work of cutting down trees and metal knives were much more efficient than stone cutting tools. Hunters used metal-pointed spears and arrows to catch prey. Blacksmiths used a forge and anvil to create many useful instruments such as horseshoes, nails, wagon tires, and chains.

Forging changes the size and shape, but not the volume, of a part. The change is made by force applied to the material so that it stretches beyond the yield point. The force must be strong enough to make the material deform. It must not be so strong, however, that it destroys the material. The yield point is reached when the material will reform into a new shape. The point at which the material would be destroyed is called the fracture point.

In forging, a block of metal is deformed under impact or pressure to form the desired shape. Cold forging, in which the metal is not heated, is generally limited to relatively soft metals. Most metals are hot forged; for example, steel is forged at temperatures between 2,100°F and 2,300°F (1,150°C to 1,260°C). These temperatures cause deformation, in which the grains of the metal elongate and assume a fibrous structure of increased strength along the direction of flow. (See Figure)

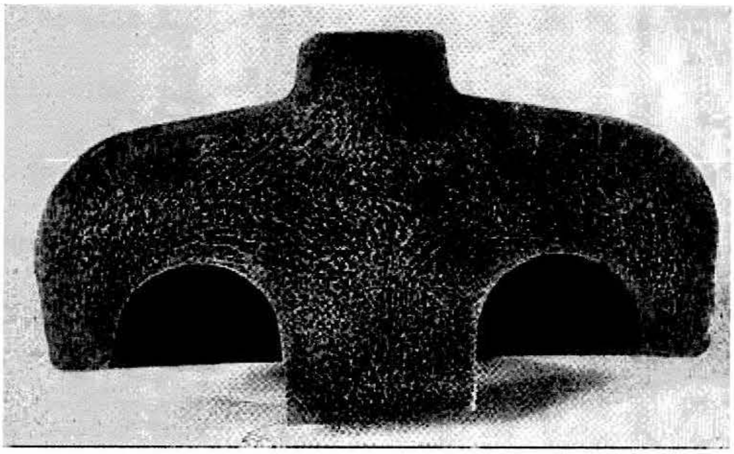


Figure 1: Flow lines in a forged part

Normally this results in metallurgical soundness and improved mechanical properties. Strength, toughness, and general durability depend upon the way the grain is placed. Forgings are somewhat stronger and more ductile along the grain structure than across it. The feature of greatest importance is that along the grain structure there is a greater ability to resist shock, wear, and impact than across the grain. Material properties also depend on the heat-treating process after forging. Slow cooling in air may normalize workpieces, or they can be quenched in oil and then tempered or reheated to achieve the desired mechanical properties and to relieve any internal stresses. Good forging practice makes it possible to control the flow pattern resulting in maximum strength of the material and the least chances of fatigue failure. These characteristics of forging, as well as fewer flaws and hidden defects, make it more desirable than some other operations (i.e. casting) for products that will undergo high stresses.

In forging, the dimensional tolerances that can be held vary based on the size of the workpiece. The process is capable of producing shapes of 0.5 to >50.0 cm in thickness and 10 to <100 cm in diameter. The tolerances vary from ± $^{1}/_{32}$ in. for small parts to ± ¼ in. for large forgings. Tolerances of 0.010 in. have been held in some precision forgings, but the cost associated with such precision is only justified in exceptional cases, such as some aircraft work.

Types of forging:

Forging is divided into three main methods: hammer, press, and rolled types.

(1) *Hammer Forging (Flat Die)*: Preferred method for individual forgings. The shaping of a metal, or other material, by an instantaneous application of pressure to a relatively small area. A hammer or ram, delivering intermittent blows to the section to be forged, applies this pressure. The hammer is dropped from its maximum height, usually raised by steam or air pressure. Hammer forging can produce a wide variety of shapes and sizes and, if sufficiently reduced, can create a high degree of grain refinement at the same time. The disadvantage to this

process is that finish machining is often required, as close dimensional tolerances cannot be obtained.

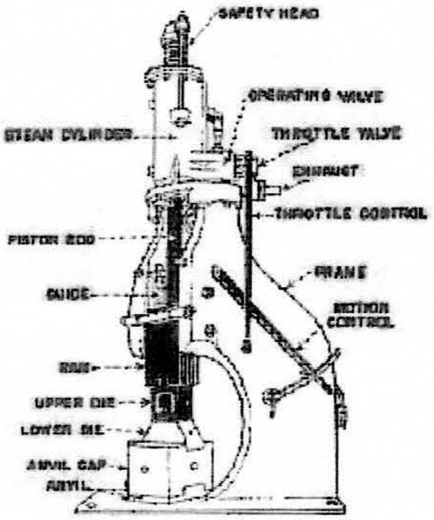


Figure 2: Press Forging

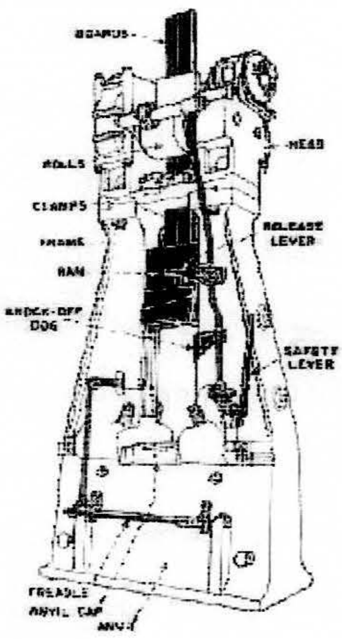


Figure 3: Die forging

(2) *Press Forging*: This process is similar to kneading, where a slow continuous pressure is applied to the area to be forged. The pressure will extend deep into the material and can be completed either cold or hot. A cold press forging is used on a thin, annealed material, and a hot press forging is done on large work such as armor plating, locomotives and heavy machinery. Press Forging is more economical than hammer forging (except when dealing with low production