"I hereby declare that I have read this report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor Mech. Eng. (Thermal-Fluids)"

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Date : 14 DECEMBER 2005

THE EFFECTS OF HEAT TREATMENT ON MILD STEEL AND ITS INDUSTRIAL APPLICATION

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A report submitted in partial in fulfilment of the requirement for the award of the degree of Bachelor of Mechanical Engineering
(Thermal-Fluids)

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"I declared that this report entitled ' The Effects of Heat Treatment on Mild Steel and Its Industrial Application' is the result of my own research except as cited in references."

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Date : 14 DECEMBER 2005

DEDICATION

Dedication to my parent and my loving family. Thank you for all your support

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ABSTRACT

This research covered mainly the effects of heat treatment on mild steel (A36). Three types of heat treatment are annealing, quenching and tempering. There are two types of specimen being used consisted of cylinderical with dimension of 25 mm x 50 mm and square shape, 320 mm x 40 mm x 3 mm. During annealing process, specimen are annealing at the 850°C at different time before taken out from furnace. These specimen then are quenched in oil and being reheated again for tempering process at 450°C. The quenching process is using three types of medium which are oil, air and water. The tempering process consists the two parameter are time and temperature will be considered. Both produces the different result as comparison. After the process completed, three types test will be conducted which are hardness, microstructure and tensile test on the specimen. The hardness test applied Rockwell (B) with the con diamond. In term of microstructure observation, Axoiskop 2 Mat and CCTV are used as the main medium to obtain the result. The tensile test applied the Universal Testing Machine (UTM) which are prepare two specimen for one data. These result then compare the related industrial result which are based on the handbook. The expected result for microstructure test for annealing, quenching and tempering are fine pearlite, lath martensit dan spherodite respectively.

ABSTRAK

Kajian ini meliputi kesan rawatan haba terhadap keluli lembut (A36). Tiga jenis rawatan haba tersebut ialah penormalan, sepuhlindap dan pembajaan. Bentuk spesimen yang digunakan adalah dua jenis iaitu silinder dan segiempat sama yang berukuran 25 mm x 50 mm dan 320 mm x 40 mm x 3 mm. Pada proses penormalan, spesimen dipanaskan pada suhu 850°C dan diambil bacaan masa yang berbeza sebelum dikeluarkan dari relau. Spesimen akan di sepuhlindap di dalam minyak dan dipanaskan semula pada suhu 450°C. Pada proses sepuhlindap menggabungkan tiga jenis medium yang berlainan iaitu minyak, air dan udara. Pada proses pembajaan menggabungkan dua parameter iaitu suhu dan masa sebagai perbandingan. Spesimen yang telah dirawat haba dikenakan ujian kekerasan, ujian mikrostruktur dan tegangan untuk mendapatkan data. Ujian kekerasan menggunakan penguji kekerasan Rockwell (B) dengan mata kon diamond dan Axoiskop 2 Mat serta CCTV digunakan untuk ujian mikrostruktur. Ujian tegangan menggunakan Universal Testing Machine (UTM) dengan menyediakan dua spesimen untuk satu data. Keputusan tersebut akan dibandingkan dengan keputusan yang diperolehi dalam industri yang berkaitan berdasarkan buku panduan piawaian Keputusan yang dijangkakan untuk mikrostruktur selepas proses penormalan, sepuhlindap dan pembajaan adalah *fine pearlite, lath martensit* dan *spherodite.*

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LIST OF SYMBOLS

SYMBOLS	DEFINITION
Al	Aluminum
AISI	American Iron AND Steel Institute
ASTM	American Standard Testing Material Standard
B	width
BISRA	The Corporate Laboratories of The British Steel
BCT	Body Centered Tetragonal
BCC	Body Centered Cubic Crystal Structure
C	Carbon
Cu	Cuprum
$CuFeO_2$	Cuprum Ferum Oxidation
D	Diameter
E	Young's
EL	Ductility, elongation
Fe	Ferum/Iron
Fe_3C	Ferum Cimentit
L	Length
Mn	Manganese
NaOH	Natrium Hydroxide
wt %	weight percent
%	Percentage
P	Pressure
RA	Ductility, reduction in Area
T	Temperature
TTT	Time Temperature Transformation
HRB	Hardness Rockwell B Scale
HRC	Hardness Rockwell C Scale

kg/f	kilogram per force
kgf/mm^2	kilogram force per milimeter square
kN	kilonewton
Min	Minute
MPa	Megapascal
mm	milimeter
N/mm^2	Newton per milimeter square
nm	Nanometer
°C	Degrees Celsius
°F	Degrees Fahrenheit
GPa	Gigapascal
Ex	Example
&	and
ISO	International Standard Organization
pcs	pieces
Std	Standard
UTM	Universal Tensile Machine

GREEK ABJAD	**DEFINITION**
μ	micro
γ	Phase Designations
α	Phase Designations (Ferrite)
ε	Strain
δ	Changes of elongation
σ	Stress
ϵ	Epsilon

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CHAPTER 1

INTRODUCTION

Heat treatment is defined as an operation or combination of operations, involving heating and cooling of a metal, alloy or for this case involving the mild steel in its solid state with the object of changing the characteristic of the material. The changing of the characteristic can be explored through the microstructure test with applying the microscope that was form various characteristic as pearlite, martensite, temper martensite and so on. An involved of the heat treatment process are annealing, quenching and tempering. This research used mild steel that have contain the carbon percentage up to 0.30 %.The mild steel (A36) used because before that a less research to study the mild steel compares others material like stainless steel, tool steel, alloy aluminum and so on. Thereby, many of the handbook or others journal is not state specify (A36) the standard value as the guide for this research. Moreover, this material many used in an industrial application mainly in construction and automotive sector as a main source to produce the products.

Heat treatment is generally employed for following purposes such as to improve mach inability, to change or refine grain size, to improve mechanical properties like tensile strength, hardness, ductility and so on. That way, this research concentrate on the tensile and Rockwell hardness test and microstructure test to obtain various collection data before it can be evaluated to determine the result compare with the standard data of mild steel as a comparison. The expected result (general mild steel) that included in this research is based from The Corporate Laboratories of the British Steel Corporation (BISRA) and other sources are

American Iron and Steel Institute (AISI) and America Standard for Testing Material standard data provided by (ASTM).

1.1 Problem Background

Referred the others thesis that featured the change in the carbon steel SAE 1045 hardness cause the heat treatment after cooling in the furnace, air and water (Lufti *et al*, 2000) concern about the temperature between 400-800°C during 4 to 8 hours and the cooling process in water was added with increased 7% bt NaOh. The specimen test was the microstructure and the hardness (Rockwell).On the other hand, the effect of heat treatment and composition to the mechanical characteristic and the microstructure alloy aluminum (Annadurai, 2001) using the method by changing the copper and magnesium composition to nine different compositions at 540°C and then through the quenching in hot water. The specimen test used is the Vickers hardness test and microstructure.

The journal related the heat treatment process was the effect of composition, particle size and heat treatment on the mechanical properties of AL-4.5 WT.% CU based on alumina particulate reinforce composites (Maxim *et al*, 2000). This journal discusses the results of a recent study in which composites reinforced with 55 vol.% alumina were cast using two sizes of alumina particulate and eight different matrix alloys based on Al-4.5 wt.% Cu with varying amounts of silicon and magnesium. Optimum heat treatments for each alloy were determined utilizing micro hardness studies. The tensile strength and fracture toughness were evaluated as a function of alloy chemistry, particulate size, and heat treatment. Besides that, the effects of heat treatment on interface properties of S45C steel/copper compound casting (Shin Ho *et al*, 2001). It represented the bonding of an S45C steel inserted into copper during cast welding and heat treatment was examined. The interface shear strength was made with a push-out test. After cast welding, a cast-welding layer formed between steel and copper. After marquenching, martempering and austempering heat treatment, there was a cast-welding layer near the steel matrix, an irregular layer near the copper matrix and between of them was a middle layer. Through X-ray diffraction analysis was used to determine that the interface layer consisted of carbon and $CuFeO_2$.

Although these journal and thesis not use the mild steel, however its still concern about the heat treatment process. For this research to improve the previous method which applied three type heat treatment are annealing, quenching and tempering. The specimen test applied the Rockwell hardness test, microstructure and tensile test to determine and observe the characteristic in the mild steel (A36).

1.2 Problem Statement

This research try to proof that the hardness after the heat treatment larger than before the heat treatment. On the other hand, it also perform microstructure which it described on it behaviours. These could be divided to mechanical properties as Young's Modulus, ultimate tensile strength and yield strength. Furthermore, this research is conducted to find the yield and maximum load occur on initial changes to another form characteristic. Besides, the strength of material had a difference before and after the heat treatment.

1.3 Objectives

The objectives of this research are:

a. To study the effect of heat treatment on mild steel (A36) and its application in field related industrial.

b. To observe the changes of microstructure after subjected three types heat treatment.

c. To determine the hardness, mechanical properties, strength and ductility on mild steel (A36) through the tensile test.

1.4 Scopes

The scopes of this research are:

a. Make comparison between heat treatment process at material structure lab and related industrial.

b. Specimen preparation for make heat treatment process on mild steel (A36).

c. Apply three type tests on the mild steel (A36) after heat treatment are Rockwell hardness test, microstructure and tensile test.

d. Analyze the experiments result and summarize the assumption from the research.