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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
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November 2005

“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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DEDICATION

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

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In the name of Allah, The Most Gracious, The Most Merciful. First and foremost, I thank to Allah giving me the opportunity to complete my thesis successfully.

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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 cylindrical 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*.

LIST OF CONTENTS

CHAPTER	TITLE	PAGES
	Declaration	ii
	Dedication	iii
	Acknowledgement	iv
	Abstract	.v
	Abstrak	vi
	List of Contents	vii
	List of Tables	.x
	List of Figures	xii
	List of Symbols	xvii
	List of Appendix's	xx
1	INTRODUCTION	1
	1.1 Problem Background	2
	1.2 Problem Statement	3
	1.3 Objectives	4
	1.4 Scopes	4
	1.5 The Important of the Research	5
	1.6 Expected Outcomes	5
2	LITERATURE REVIEW	7
	2.1 The background of steel	7
	2.2 Carbon Steel	8
	2.3 The characteristic of mild steel.	9
	2.4 The advantage of mild steel	10
	2.5 The application of mild steel.	10

2.6	Heat treatment	11
2.6.1	Annealing	12
2.6.2	Quenching	13
2.6.3	Tempering	14
2.7	Microstructure theory	14
2.8	Hardness test theory (Rockwell)	15
2.9	Tensile test theory	17
2.10	Heat Treating at industry.	18
2.10.1	Heat Treating Other than Case Hardening	18
3	METHODOLOGY	21
3.1	Material Composition	22
3.2	Preparation of specimen	23
3.3	Types of methodology test	23
3.4	Heat Treatment	24
3.4.1	Annealing	24
3.4.2	Quenching	25
3.4.3	Tempering	25
3.5	Microstructure Test.	28
3.5.1	Sample preparation	28
3.5.2	Microstructure analysis	28
3.5.3	Material and apparatus	29
3.5.4	Procedures	29
3.6	Hardness Test	31
3.6.1	Apparatus	31
3.6.2	Procedures	31
3.7	Tensile Test	32
3.7.1	Objectives	32
3.7.2	Equipments	33
3.7.3	Procedures	34
3.8	Limitation	39
3.9	Research Planning	39

4	RESULT AND DISCUSSION	40
4.1	HARDNESS ROCKWELL TEST	40
4.1.1	Annealing Process	40
4.1.2	Quenching Process.	47
4.1.3	Tempering Process.	51
4.2	MICROSTRUCTURE TEST	55
4.1.3	Fractography of Mild Steel (A36) in Annealing (SoakingTime).	55
4.2.2	Fractography of Mild Steel (A36) in Quenching.	60
4.2.3	Fractography of Mild Steel (A36) in Tempering.	64
4.3	TENSILE TEST	71
4.3.1	Annealing Process	71
4.3.2	Quenching Process	82
4.3.3	Tempering Process	88
5	CONCLUSION	102
	References	106
	Appendix's	108

LIST OF TABLES

NO. TABLES	TITLE	PAGES
1.6	Standard properties for mild steel (A36) (Everett,1994)	6
2.5	Application of mild steel based on carbon contain (Raj Put,2000)	11
3.1 (a)	Composition of mild steel (A36). (ASM Handbook,2000)	22
3.1 (b)	Simplified average basic properties (Everett, 1994)	22
3.2	Description data of specimen	23
4.1 (a)	Data collections for hardness value at differences soaking time in HRC	40
4.1 (b)	Data collections for hardness value at differences soaking time in N/mm^2	41
4.1 (c)	Data collections for hardness value in differences medium in HRC	47
4.1 (d)	Data collections for hardness value in differences medium in N/mm^2	47
4.1 (e)	Hardness effect when changing the tempering time at 500 °C in HRC	52
4.1 (f)	Hardness effect when changing the tempering time at 500 °C in N/mm^2	52
4.1 (g)	Hardness effect when changing the tempering temperature at 30 minute in HRC	52
4.1 (h)	Hardness effect when changing the tempering temperature at 30 minute in N/mm^2	52

4.3 (a)	The fatigue specimens at various soaking time annealing	71
4.3 (b)	Mechanical properties of mild steel (A36) for annealing	73
4.3 (c)	The strength data specimens for annealing	74
4.3 (d)	The ductility data specimens for annealing	75
4.3 (e)	The overall result for annealing process in case changes on soaking time	77
4.3 (f)	The fatigue specimens on three types quenching medium	82
4.3 (g)	Mechanical properties of mild steel (A36) for quenching	83
4.3 (h)	The strength data specimens for quenching	84
4.3 (i)	The ductility data specimens for quenching	84
4.3 (j)	The overall result for quenching process in case different mediums	85
4.3 (k)	The fatigue specimens at 500°C on tempering	88
4.3 (l)	The fatigue specimens at 30 minutes on tempering	89
4.3 (m)	Mechanical properties of mild steel (A36) for tempering	90
4.3 (n)	The strength data for tempering	91
4.3 (o)	The ductility data specimens for tempering	92
4.3 (p)	The overall result for tempering process in case changes in time	93
4.3 (q)	The overall result for tempering process in case changes in temperature	93
5 (a)	Composition of mild steel (A36). (ASM Handbook,2000)	104
5 (b)	Standard properties of mild steel (A36). (ASM Handbook,2000).	104

LIST OF FIGURES

NO FIGURES	TITLE	PAGES
2.1	The group of steel. (Lovatt & Shercliff, 2002)	7
2.2	Carbon steel classification (Ginzel, 1995)	8
2.3	The microstructure of mild steel (A36)	9
2.6	TTT- Diagram for steel. Path I- Complete formation of martensite. Path II – Formation of pearlite and bainite (Alberg, 2003)	13
2.8	Rockwell-Scale Hardness Tester Impressions (Hayden <i>et al</i> , 1965).	16
3.0	Flow of methodology process.	21
3.4 (a)	The graph circle of heat treatment process at various soaking time annealing.	24
3.4 (b)	The graph circle of quenching process.	25
3.4 (c)	The graph circle of tempering at various tempering soaking time	26
3.4 (d)	The graph circle of tempering at various tempering temperature.	26
3.4 (e)	Gas furnace for heat treatment process	27
3.5 (a)	The microscope (Axioskop 2 Mat) and CCTV.	29
3.5 (b)	The manual grinding machine with 4 grades sand paper	30
3.6	Rockwell Hardness Testing Machine.	32
3.7 (a)	Universal testing machine (UTM) brand INSTRON- Model 6500 where it able to support the maximum load until 200 kN	33
3.7 (b)	Extensometer	33
4.1 (a)	The increase of average of hardness proportion with	

	soaking time in HRC	41
4.1 (b)	The increase of average of hardness proportion with soaking time in HRC	42
4.1 (c)	The distribution of hardness after 10 minutes soaking time in HRC	42
4.1 (d)	The distribution of hardness after 40 minutes soaking time in HRC	43
4.1 (e)	The distribution of hardness after 100 minutes soaking time in HRC	43
4.1 (f)	The distribution of hardness after 160 minutes soaking time in HRC	44
4.1 (g)	The Brinell and Rockwell hardness as a function of carbon concentration for group in plain carbon steel having fine and coarse pearlite as well as spheroidite microstructure. (Masseria, 1981)	45
4.1 (h)	Ductility (% RA) as a function of carbon concentration for plain carbon steels having fine and coarse pearlite as well as spheroidite microstructures (Masseria, 1981)	46
4.1 (i)	Comparison hardness in difference quench medium.	48
4.1 (j)	Percentage of hardness in different quenching medium.	48
4.1 (k)	The rate of hardness distribution in quenching oil	49
4.1 (l)	The rate of hardness distribution in quenching air	49
4.1 (m)	The rate of hardness distribution in quenching water	50
4.1 (n)	The effect of tempering time on the hardness value	53
4.1 (o)	The effect of tempering temperature on the hardness value.	53
4.2 (a)	Fracture surface of mild steel (A36) in 50x (above) and 100x magnification (below), annealing at 850°C for 10 minutes soaking time.	55
4.2 (b)	Fracture surface of mild steel (A36) in 50x (above) and 100x magnification (below), annealing at 850°C for 40 minutes soaking time.	56
4.2 (c)	Fracture surface of mild steel (A36) in 50x (above)	

	and 100x magnification (below),annealing at 850°C for 100 minutes soaking time.	57
4.2 (d)	Fracture surface of mild steel (A36) in 50x (above) and 100x magnification (below),annealing at 850°C for 160 minutes soaking time.	58
4.2 (e)	Composition carbon concentration related with percent of F ₃ C. (Masseria, 1981).	59
4.2 (f)	Experiment for following the microstructure changes that occur during the isothermal transformation of a eutectoid plain carbon steel (Smith, 1981).	59
4.2 (g)	Fracture surface of mild steel (A36) in 50x (above) and 100x magnification (below), quench in oil.	60
4.2 (h)	Fracture surface of mild steel (A36) in 50x (above) and 100x magnification (below), quench in air.	61
4.2 (i)	Fracture surface of mild steel (A36) in 50x (above) and 100x magnification (below), quench in water	62
4.2 (j)	Effect of carbon content on the martensite transformation start temperature, M _s for mild steel (less than 0.3% C). (Marder & Krauss, 1987)	63
4.2 (k)	Fracture surface of mild steel (A36) in 50x (above) and 100x magnification (below), tempered at 500°C for 10 minutes soaking time.	64
4.2 (l)	Fracture surface of mild steel (A36) in 50x (above) and 100x magnification (below), tempered at 500°C for 30 minutes soaking time.	65
4.2 (m)	Fracture surface of mild steel (A36) in 50x (above) and 100x magnification (below), tempered at 500°C for 60 minutes soaking time.	66
4.2 (n)	Fracture surface of mild steel (A36) in 50x (above) and 100x magnification (below), tempered at 300°C for 30 minutes soaking time.	67
4.2 (o)	Fracture surface of mild steel (A36) in 50x (above) and 100x magnification (below), tempered at 600°C for 30 minutes soaking time.	68

4.2 (p)	Fracture surface of mild steel (A36) in 50x (above) and 100x magnification (below), tempered at 800°C for 30 minutes soaking time.	69
4.2 (q)	(a) The shape of the precipitate is rodlike (Speich <i>et al</i> , 1972) and (b) Spheroidite. (Vilella <i>et al</i> , 1966).	70
4.3 (a)	The changes of Young's Modulus due the various time on annealing.	76
4.3 (b)	The ultimate tensile strength due the various soaking time on annealing.	77
4.3 (c)	(a) Typical stress-strain behavior for a metal showing elastic and plastic deformations and (b) Representative stress-strain behavior found for some steel demonstrating the yield point phenomenon	78
4.3 (d)	The yield strength proportional to annealing soaking time.	78
4.3 (e)	Typical engineering stress-strain behavior to fracture, point F. The tensile strength TS is indicated at point M. The circular insets represent the geometry of the deformed specimen at various points along the curve.	79
4.3 (f)	The comparison strength of mild steel (A36) on annealing.	80
4.3 (g)	The percent of elongation mild steel (A36) related the ductility behavior.	81
4.3 (h)	Comparison the mechanical properties for mild steel (A36) on annealing.	85
4.3 (i)	Comparison the strength of mild steel (A36) at quenching.	86
4.3 (j)	Distribution percentage of elongation mild steel (A36) at annealing.	87
4.3 (k)	The change of Young's Modulus on tempering.	94
4.3 (l)	The Young's Modulus proportional temperature on tempering	94
4.3 (m)	The ultimate tensile strength over the different time on tempering	95

4.3 (n)	The change of ultimate tensile strength over the different temperature on tempering.	96
4.3 (o)	The change of yield strength due the different time on tempering.	97
4.3 (p)	The change of yield strength due the different time on tempering	97
4.3 (q)	The comparison strength of mild steel (A36) due time on tempering	98
4.3 (r)	The comparison strength of mild steel (A36) due temperature over the tempering	99
4.3 (s)	The percent of elongation mild steel (A36) related the ductility behavior for changing on time.	100
4.3 (t)	The percent of elongation mild steel (A36) related the ductility behavior for changing on temperature.	101

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 ₃ C	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

μ

γ

α

ε

δ

σ

ε

DEFINITION

micro

Phase Designations

Phase Designations (Ferrite)

Strain

Changes of elongation

Stress

Epsilon

LIST OF APPENDIXS

APPENDIXS	TITLE	PAGES
A	Flow of implementation PSM I	107
B	Flow of implementation PSM II	108
C	Schedule for planning activities in PSM I	109
D	Schedule for planning activities in PSM II	110
E	Graph for standard mild steel	111
F	Graph for tensile test on annealing.	112
G	Graph for tensile test on quenching.	120
H	Graph for tensile test on tempering.	126
I	Example of tensile test data for specimen 1.1 (annealing)	138

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 American 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% by 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.