# EFFECTS OF ROLLING AND HEAT TREATMENT ON MILD STEEL PLATE

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This report submitted
in fulfillment of the requirements for the degree of
Bachelor of Mechanical Engineering (Plant and Maintenance)

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

MAY 2017

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## DECLARATION

I declare that this project entitled "Effects of Rolling and Heat Treatment On Mild Steel Plate" is the result of my own work except as cited in the references

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Date : 20/6/2017

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## APPROVAL

I hereby declare that I have read this project report and in my opinion this report is efficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Plant & Maintenance).

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## DEDICATION

To my beloved mother and father

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## ABSTRACT

Mild steel is one of the carbon steel which common and widely used in the construction due to its price is cheaper than others steel besides it is malleable. Next, the mild steel is easy to operate and useful material to create things such as bolt, nut, hinges and many more. Usually the mechanical properties of mild steel can be changed due to the aging and the method of keeping the mild steel. The material and mechanical properties of the mild steel can be altered to suit the requirement of any project. Past research have focused on the altering the mechanical properties of the mild steel using various type of heat treatment. In this paper present on the study of the mechanical properties of mild steel after undergoes the combination process of cold rolling and heat treatment (quenching) process. The mild steel plate was rolled before being heat treated using quenching method and followed by the determination of its new mechanical properties using tensile test which resulted in increasing and decreasing certain value of mechanical properties. The experiment resulted in the increasing of the ultimate tensile strength, increasing the value of yield strength and the reduction of percentage value of the elongation in area for the specimens which undergoes the combination process of cold rolling and heat treatment (quenching) process.




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## *ABSTRAK*

*Keluli lembut adalah salah satu keluli karbon di mana pengunaannya yang kerap dan meluas di dalam pembinaan disebabkan kos yang murah berbanding keluli lain selain sifatnya yang boleh ditempa. Seterusnya, keluli lembut juga mudah untuk digunakan dan sangat berguna untuk membuat barangan seperti bolt, nat, penyangkut dan lain-lain. Kebiasaannya, sifat mekanikal keluli lembut boleh berubah disebabkan masa dan cara simpanan keluli lembut itu. Sifat mekanikal keluli lembut boleh diubah untuk disesuaikan dengan permintaan sesuatu projek. Kajian terdahulu memfokuskan terhadap merubah sifat mekanikal menggunakan pelbagai jenis proses rawatan haba. Di dalam kertas kajian ini menyatakan kajian terhadap sifat mekanikal keluli lembut setelah melalui gabungan proses penggelekkan sejuk dan rawatan haba (pelindapkejutan) dan diikuti dengan menentukan sifat mekanikal keluli lembut yang baru menggunakan ujian keterikan di mana menghasilkan keputusan kenaikan dan penurunan beberapa nilai di dalam sifat mekanikal keluli lembut. Kajian dan eksperimen memberi hasil kenaikan nilai kekuatan tegangan maksimum, kenaikan nilai kekuatan yield dan penurunan nilai persen pemanjangan luas untuk spesimen yang telah melalui gabungan proses pengelekkan sejuk dan rawatan haba (pelindapkejutan).*



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## ACKNOWLEDGEMENT

First and foremost, I would like to express my acknowledgement and special thanks of gratitude to Dr. Omar Bin Bapokutty from Faculty of Mechanical Engineering Universiti Teknikal Malaysia Melaka (UTeM) for his guidance and essential supervision in order to complete this project.

Next, my deepest gratitude to the Mr. Mahader, Mr. Wan Saharizal Mr Habirafidi from laboratory at Kompleks Makmal Kejuruteraan, Faculty of Mechanical Engineering and Mr. Mohd Syafiq from Waterjet Laboratory, Faculty of Technology Engineering for their guidance, support, assistance and all the efforts from the preparation of specimens until conducting the test.

Special thanks to all my family members who keep giving the moral support in completing the degree in Bachelor of Mechanical Engineering (Plant & Maintenance). Last but not least, special thank you for those whose had been taken part of realization this project direct and indirectly.



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## LIST OF ABBREVIATION

| | |
|---|---|
| UTM | Universal Testing Machine |
| mm | Millimeter |
| ISO | International Organization for Standardization |
| GCI | Gray Cast Iron |
| MCI | Malleable Cast Iron |
| NCI | Nodular Cast Iron |
| CGI | Compact Cast Iron |
| ADI | Austempered Cast Iron |



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## LIST OF SYMBOL

| | | |
|---|---|---|
| $\sigma$ | = | Stress |
| $P$ | = | Load |
| $A_o$ | = | Original Area |
| $A_f$ | = | Final Area |
| $\varepsilon$ | = | Strain |
| $\delta$ | = | Gage Length of the Specimen |
| $L_o$ | = | Original Length |
| $L_f$ | = | Final Length |
| $\sigma_Y$ | = | Yield Strength |
| $\sigma_{ult}$ | = | Ultimate Tensile Strength |
| $P_{max}$ | = | Maximum Load |
| $\% EL$ | = | Elongation |
| $\% RA$ | = | Reduction in area |
| % | = | Percentage |



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# CHAPTER 1

# INTRODUCTION

## 1.1 Background

In this modern era, steel based material become one of the high demand material used especially in the developing countries. The construction of infrastructure, appliance and building are widely using steel based material (Kalpakjian, Schmid, & Sekar, 2014). Other than that, steel is based material also widely used in roads, railway and also can be found in the large structure modern structure. Steel also been used as reinforcement for the concrete structure (Kareem, 2011). The steel based material is made from iron ore where they need large thermal energy in the process and resulted in the reducing the iron to metallic form. In the general, the steel can be classified in three different categories which is low carbon steel, medium carbon steel and high carbon steel. Below is the main characteristic of this three types of steel:

Table 1.1: The main characteristic of three types of steel.

| Types of steel | Characteristic |
|---|---|
| Low carbon steel | 0.16 – 0.30 % carbon |
| Medium carbon steel | 0.30 to 0.60 % of carbon |
| High carbon steel | 0.60 to 1.70 % of carbon |



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The mild steel mechanical properties can be increased by doing heat treatment. Heat treatment can be classified into several types and the most suitable process is quenching since it can increase the hardness of the mild steel. Next, the rolling process is divided into two categories which is hot rolling and cold rolling. With the combination of cold rolling and annealing, it can resulted in ultrafine grain structure of the carbon steel (Ueji, Tsuji, Minamino, & Koizumi, 2002).

## 1.2 Problem Statement

Known that the mild steel has low tensile strength and the most commonly and widely being used in the construction due to the cheap price and malleable. Moreover, it also easy to operate and also being used as another important and useful material such as bolt, nut, hinges and many more. Usually this material mechanical properties can be changed due to the aging and the method of keeping the mild steel. The mechanical properties of mild steel, ultimate tensile stress and hardness, can be decreased along with time (Kareem, 2011). Therefore, a solution being proposed to increase the ultimate tensile stress (Hoshino, Ootsuka, & Yano, 2015) with the cold rolling and following by heat treatment process.

## 1.3 Objective

The objectives of this project:

1. To determine the mechanical properties of mild steel.
2. To determine the mechanical properties of as received mild steel after undergoes rolling and heat treatment process.



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3. To compare the mechanical properties between the mild steel which did not undergoes any process and the mild steel which undergoes combination process of cold rolling and heat treatment.

## 1.4 Scope of Project

The scopes of this project are as below:

1. To conduct laboratory testing for determining the mechanical properties of mild steel in both condition before and after rolling and heat treatment process.
2. Both result of the tensile test will be provided in this project.
3. Making a summary based on the result of the testing.

## 1.5 General Methodology

Below is the action that need to be conducted to achieve the objective of this project:

1. Start.

Proposed the title

2. Determine the problem statement, objective and scope of the project.

Doing research and study of journal on the mild steel properties, tensile test, heat treatment and cold rolling process.

3. Literature review

Review of journal, article and others related material that related on the experiment



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4. Methodology

All the necessary action that need to be conducted for this project. Determine mechanical properties of mild steel before and after cold rolling and heat treatment process. To perform this research, conduct a cold rolling process using rolling machine. Heat treatment process need the mild steel to be heated using furnace. To receive the mechanical properties of the mild steel, testing take place at universal testing machine to do tensile test

5. Fabricate specimen

The specimen need to be fabricated first before doing the testing. The specimen must follow the American Standard for Testing and Material.

6. Conducting experiment

Doing testing on mild steel and then tensile test. Conduct cold rolling and heat treatment and followed by tensile test.

7. Analyze the data

The result must be analyzed to determine whether the experiment need to be repeated or not.

8. Result and discussion

Final report will be written at the end of the project.

The general methodology of this study can be summarized into a flow chart and being shown in Figure 1.1:



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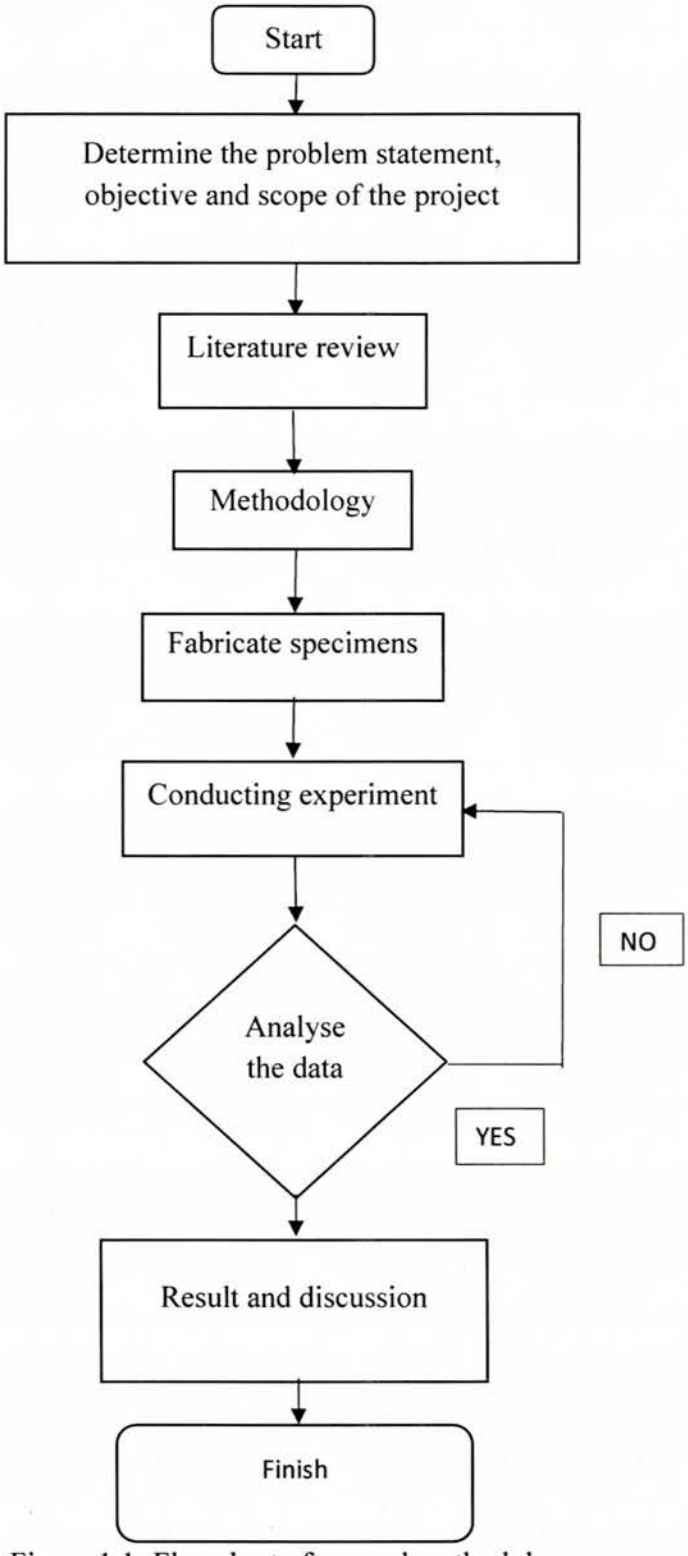

Figure 1.1: Flowchart of general methodology



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# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

In this chapter, the review of journal, article, patent, book and etc. was implied to collect the reliable information and summarize the theoretical base and helps determining the nature in this experiment.

## 2.2 Rolling

Rolling is one of the forming and shaping of material process resulted in improvement to the structure due to the refinement of grain (Van Der Winden, 2009) and also reducing its thickness while enhance their properties such as increasing the strength and hardness of the material which can be classified into two general types of rolling and those are flat rolling and shape rolling process that resulted in different finishing or end product (Kalpakjian et al., 2014) as shown in Figure 2.1 and all this result depends on several factor which are the shape and dimension of initial product, reduction of thickness, properties of metal, temperature while rolling, etc. (Hoshino et al., 2015). Figure 2.1 shows the difference of end product between flat rolling and shape rolling and along with that, rolling process can be divide into two type of operating condition which are hot rolling and cold rolling.



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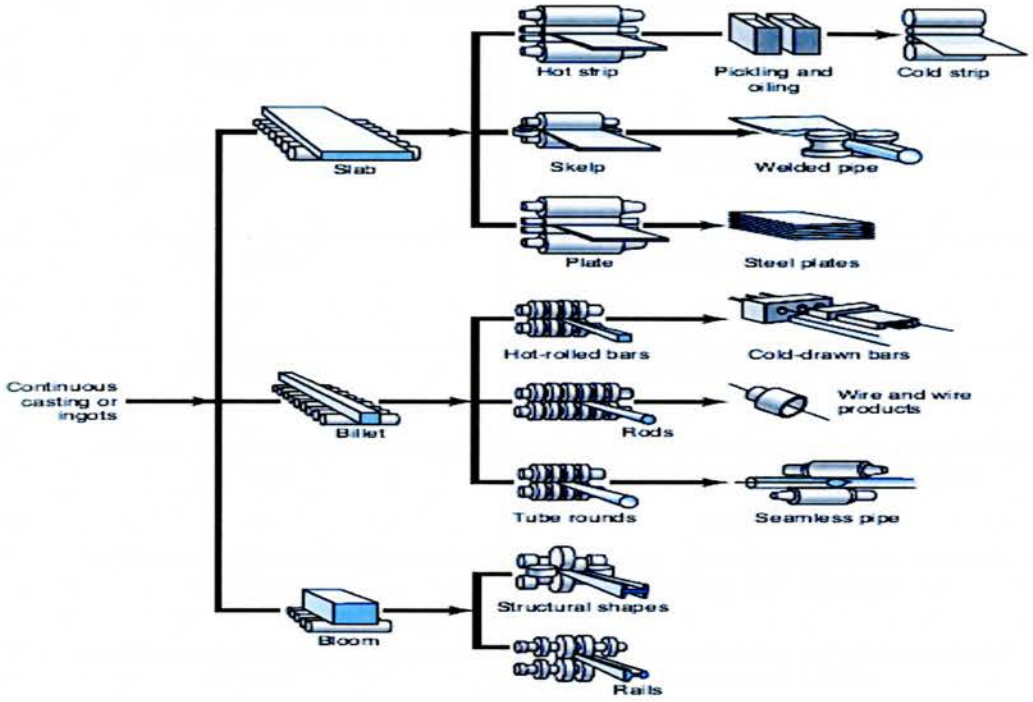


Figure 2.1: Schematic outline of various flat-rolling and shape rolling process. Source: Courtesy of American Iron and Steel Institute

### 2.2.1 Application of plates that undergoes rolling process

The rolling process that resulted in several thickness of plate that usually being made to make it suitable to use for various type of application in industry. Table 2.1 show the application of metal plate based on their respective thickness (Kalpakjian et al., 2014):



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Table 2.1: The application of metal plate based on their respective thickness

| **Thickness** | **Application** |
|---|---|
| 0.003 – 0.008 mm | Aluminum foils |
| 0.2 mm | Aluminum beverage cans |
| 0.7 mm | Automobile and appliance body |
| ≥ 1 mm | Commercial aircraft fuselages and trailer body |
| 1.8 mm | Boeing 747 fuselage |
| 1.9 mm | Lockheed L1011 |
| < 6 mm | Coils and wide variety of sheet metal products |
| > 6 mm | Ship hulls, boiler, bridges and heavy machinery |
| 100 – 125 mm | Machinery and warships |
| 150 mm | Reactor vessels |
| ≤ 300 mm | Large structural supports |



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### 2.2.2 Hot rolling

Hot rolling can be defined as the amount of deformation that a material can withstand without cracking and reach desirable deformed microstructures at a certain temperature and reduction (Y. Chen et al., 2017) while, from this process can resulted on scaling formed which is play important role (Vergne, Boher, Levaillant, & Gras, 2001). During the hot rolling process, the elevated temperature being used that resulted in a wrought structure, enhanced strength and hardness and also a better or finer grain. Compared to the metal that did not undergoes the hot rolling process, it consists of porous structure of the ingot, more brittle, and coarse-grain (Kalpakjian et al., 2014). While undergoes hot rolling process, the friction occurs between both strip and rolls resulted in redundant of shear and strain which the strain is inhomogeneous and inside the rolled strip will having a mark effect on the formation of metallographic (Sakai, Saito, Hirano, & KATO, 1988).

### 2.2.3 Cold rolling

Cold rolling is the process that being done after hot rolling process that carried out at room temperature condition which produce better surface finish, better dimensional tolerances while enhanced mechanical properties such as strength and hardness (Kalpakjian et al., 2014). The author (G. Chen et al., 2016) claim that after the cold rolling process, the bonding strength of the material being improved and increased as the reduction in thickness resulted from the cold rolling process. Regarding to all the benefits that resulted from the cold rolling process, the preferred orientation of mechanical fibering while doing the rolling process, they may produce a product that consist with anisotropic properties (Kalpakjian et al., 2014)



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