Improvement of Mechanical Propeties and Fatic Resistance on ASSAB Steel 705 M Through The Austempering Process

Helmy Alian, Qomarul Hadi, Sugiarto

Abstract: Austempering is the process of isothermal transformation of steel at temperatures between the pearlite phase and the martensite phase. The austempering time must ensure that the formation of bainite ferrite is sufficient for the remaining austenite with carbon which allows most of it to be maintained to room temperature. Austempering is intended to form strong and resilient material. To determine the effect of temperature variations on the austempering process, the tests conducted are tensile testing, fatigue testing and microstructure observation. Tensile test values after undergoing austempering at temperatures of 320 ° C, 350 ° C and 380 ° C are 119.47 kgf/mm^2, 127.86 kgf/mm^2 and 134.34 kgf/mm^2. While the strain value is 1.39%, 1.74 %, 2.43 %. The cycle produced by fatigue testing in the process at temperatures of 320 ° C, 350 ° C and 380 ° C, namely 130600 cycles, 166200 cycles, 185700 cycles.

Keyword: Austempering, Mechanical Properties, Fatigue

1 INTRODUCTION

Iron and steel are the most widely used sources as industrial materials. From the elements of iron and steel, the shapes of metal structures can be changed, this is the reason why iron and steel are called materials that are rich in various properties. The microstructure of iron and steel, the main alloying element is carbon [1]. Heat treatment (heat treatment) is a process in which the material is heated and cooled to change the microstructure of the material, this is related to the mechanical properties that will change with changes in the microstructure of the material. One of the heat treatment processes commonly used to change the microstructure of a material is austempering [2]. The purpose of the austempering process is to produce a strong metal and still maintain its tenacity. Austempering consists of two stages. Namely austenisasi and austempering [3]. The phase diagram is a diagram showing the relationship between temperature and the process of phase changes during the heating process and the slow cooling process with a certain carbon content. This diagram is the basis for understanding all heat treatment operations. The function of the phase diagram is that it makes it easy to choose the appropriate heating temperature for each heat treatment process, both annealing, normalizing and hardening processes [4]. Carbon is a very significant variable in its effect on Ms. Other chemical elements have little effect compared to the effect of carbon on Ms. The estimated Ms temperature can be calculated using the following formula: [3]

$$Ms = 538 - (361 \times\% C) - (39 \times\% Mn) - (19 \times\% Ni) - (39 \times\% Cr)$$

The austmpering process on ASSAB 705 M steel is carried out with an acetation temperature of 850 ° C and austempering temperature variations of 320 ° C, 350 ° C and 380 ° C with holding time of 60 minutes. The austempering process itself is carried out using the pending media KNO3 and NaNO3 solution. The purpose of this study was to determine the effect of temperature variations on the austempering process on tensile strength, fatigue and microstructure of the material.

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2. METHODOLOGY

2.1 Flow diagram

The research steps from start to finish are shown in the flow chart below:

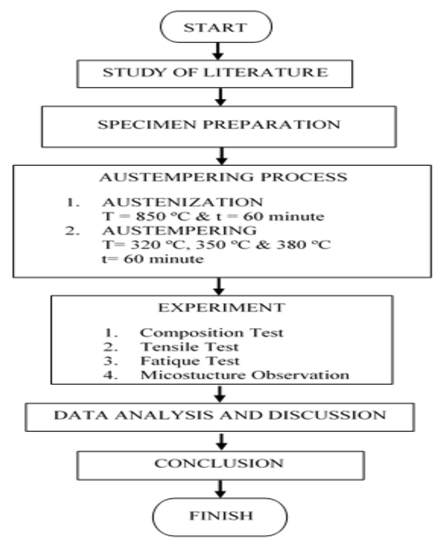

Figure 2. *Research Flow Diagram*

2.2 Test Material

The material used in this study is ASSAB 705 M steel specimens which have dimensional specifications:
Length: 352 mm and 296 mm
Diameter: 19 mm and 12 mm

2.3 Metallographic Testing

Microstructure observations in this study aim to determine changes in the microstructure of ASSAB 705 M steel, because this greatly influences mechanical properties.

Gambar 3. *Measuring Microscop STM6-LM*

2.4 Tensile Testing
Tensile testing is carried out using a hydraulic universal material tester tensile testing machine with a standard JIS B 7721 machine, which standard specimen used is JIS Z 2201.

Figure 4. *Universal Hydraulic Tensile Testing Machine*

2.5 Fatigue Testing
Fatigue testing machine with the JIS machine standard.

***Figure 5**. Mechanical Engineering Fatigue Testing Machines*

3 RESULTS AND DISCUSSION

3.1 Chemical Composition Testing Results
Testing the composition of ASSAB 705 M steel material used in this study using a portable x-ray fluorescene analyzer (XRF).

TABLE 1

ASSAB 705 M steel Chemical Composition

Elemental Composition	*(%)*
Fe	*97,33*
C	*0,42*
Mn	*0,729*
Mo	*0,179*
Cr	*1,05*
LEC	*0,135*

3.2 Tensile Test Results
To get the results of the amount of stress and strain that worked at the time of the tensile test used the following equation:

Engineering stress

$$\sigma_n = P/A_0$$

Engineering Strain

$$\varepsilon = (Li - Lo)/Lo$$

Remaks:

σ_n = nominal tensile stress (MPa)

P = tensile load (kgf)

A_o = initial cross-sectional area (mm^2)

ε = strain (%)

L_i = specimen length after tensile test (mm)

L_o = specimen length initially (mm)

TABLE 2

Tensile Testing Results for ASSAB 705 M

Parameter	*NT*	*Austempering Temperature (°C)*		
		320	*350*	*380*
σ_y (kgf/mm^2)				
σ_u (kgf/mm^2)	*97,66*	*119,47*	*127,86*	*134,34*
σ_f (kgf/mm^2)	*84,14*	*105,18*	*114,16*	*122,41*
ε (%)	*6,58*	*1,39*	*1,74*	*2,43*

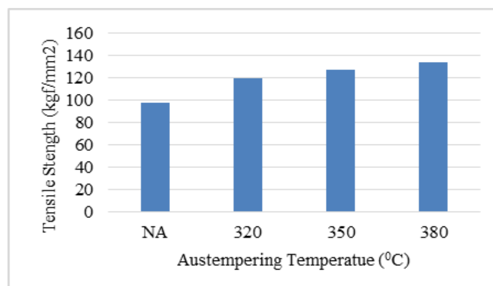

Figure 6. *Ultimate stress vs. austempering temperature*

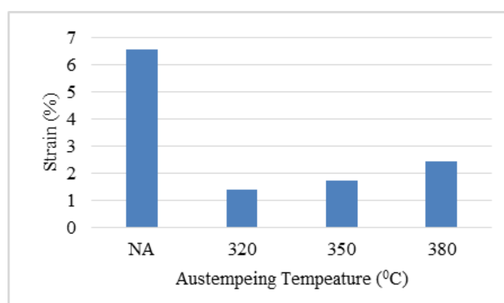

***Figure 7**. Strain vs austempering temperature*

TABLE 3

Fatigue Testing Results for ASSAB 705 M

Austempering temperature (°C)	*Time (sec.)*	*Rotation (rps)*	*Cycle*
(Non-Treatment)	*20500*	*50*	*1025000*
320	*2612*	*50*	*130600*
350	*3324*	*50*	*166200*

380	*3714*	*50*	*185700*

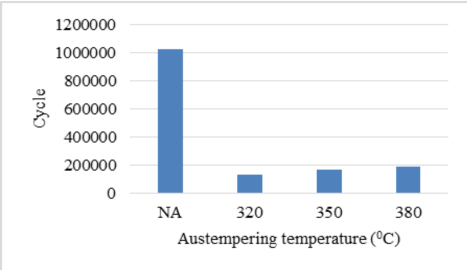

Figure 8. *Cycle of fatik vs austempering temperature*

Judging from the results of ASSAB 705 M steel fatigue tests that undergo austempering process will decrease fatigue resistance, the lower the austempering temperature, the lower the fatigue resistance value. The magnitude of the cycle value resulting from fatigue testing shows that the fatigue resistance of ASSAB 705 M steel is better before undergoing austempering process. This is caused because after undergoing the heat treatment process austempering steel will tend to experience a decrease in fatigue resistance.

3.4 Results of Observation of Micro Structure

Micro testing is a test carried out to see the condition or internal structure of ASSAB 705 M steel. The area observed in this micro structure testing is the surface of ASSAB 705 M steel before and after undergoing austempering process with several temperature variations, namely 320 0C, 350 0C and 380 0C. The solution used to look at the microstructure of carbon steel is a 3% nital solution (with a composition of 3 ml of nitric acid and 97 ml of alcohol). Below is the result of microstructure testing on specimens that have been etched and which have not been etched.

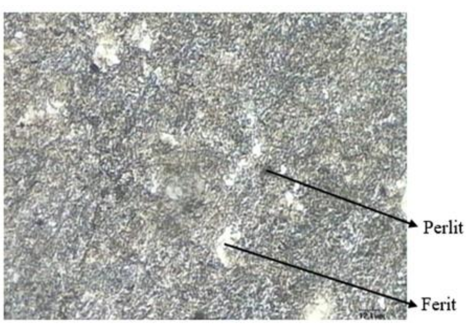

Figure 9. *ASSAB 705 M Steel Before Austempering Process*

Figure 10. *ASSAB 705 M Steel After Austempering Process at 320 ° C*

Figure 11. *ASSAB 705 M Steel After Austempering Process at 350 ° C*

Figure 12. *ASSAB 705 M Steel After Austempering Process at 380 ° C*

Based on observations of existing microstructure, the percentage of bainite phase formed during the austempering process can indicate the strength of a material, the greater the percentage of the existing bainite phase, the material will be stronger. The greatest strength value occurs after the austempering process at a temperature of 380 ° C with a percentage of 68.82%, and the smallest strength value occurs when the austempering process at a temperature of 320 ° C with a percentage of 27.07%. So based on observations of existing chemical composition, the best strength value of HQ 705 steel occurs after the austempering process at a temperature of 380 °.

4 CONCLUSIONS

Based on the analysis and discussion that has been carried out, it can be concluded that:

1. Based on testing the chemical composition of steel HQ 705 obtained a percentage of carbon content of 0.42%, the ASAB 705 M steel is classified as medium carbon steel or can also be classified as low alloy steel.
2. The maximum stress value at the time of ASSAB 705 M steel before undergoing austempering process is 97.66 kgf / mm2. The higher the austempering temperature used, the higher the tensile strength of the steel will also be higher. After undergoing the austempering process the highest tensile strength value occurs when ASSAB 705 M steel is processed at 380 ° C with a maximum stress of 134.34 kgf / mm2 and the lowest tensile stress value occurs when ASSAB 705 M steel is processed at 320 ° C ie at 119.47 kgf / mm2.
3. The tenacity of ASSAB 705 M steel after experiencing the austmpering process will decrease compared to before experiencing the austempering process. The greatest toughness after the austempering process occurs at austempering temperature of 380 ° C.
4. Before experiencing the austempering cycle process that occurred in ASSAB 705 M steel which was tested using fatigue testing, it obtained a cycle value of 1,025,000 cycles. After experiencing the austempering process, the largest cycle value occurs when the austempering process at 380 ° C is 185,700 cycles and the smallest cycle value occurs at austempering temperature 320 ° C, which is equal to 130,600 cycles.
5. The percentage value of bainite phase formed after undergoing austempering process at 380 ° C of 68.82% has the greatest strength value compared to other austempering temperatures.

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