Research Progress in Mechanical and Manufacturing Engineering Vol. 3 No. 1 (2022) 632-637
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RPMME

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/rpmme
e-ISSN : 2773-4765

Analysis of Forming Limit Diagrams in Aluminum Sheet Alloy by Universal Tensile Testing

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DOI: https://doi.org/10.30880/rpmme.2022.03.01.066
Received 15 Nov. 2021; Accepted 15 April 2022; Available online 30 July 2022

Abstract: The increase of the demand in strengthening the material in over the years made many researchers and new technology and methods in hot press forming introduced. The heating process have potential to increase the strengthening material. In this study, the experimental method by conducted the tensile testing was made to study the effect of elevated heating temperature toward tensile testing result. The aluminium alloy AA6061 and AA7075 was selected as the material on this study. The experiment starts with workpiece preparation and then heated in furnace with different several temperatures. After that, the specimen moves to tensile testing process with tension test was applied. The result was obtained in load force-elongation graph and stress-strain graph was discussed and compared with the previous studies. Based on the previous study, the heating temperature increase effect the increase of load force and stress. The objective of this study was achieved.

Keywords: Hot Press Forming, Heating Temperature, Tensile Testing, Flow Stress Study

1. Introduction

The demand of lightweight and strengthening of the material have been increase over 30 years ago in aerospace and automobile industries. The increasing of this demand makes many engineers, designers, and researchers to develop many technologies and new methods to produce the product of materials that have high strength. Hot Press Forming is the new technology that have been introduced and used widely in many aerospace industries. Hot press forming is the combination of several process to produce material with high strength and lightweight from raw material. Heating process is one of the main process involved in hot press forming. In heating process, the specimen heated with specific temperature. The range of temperature can be heated must above recrystallisation temperature not to high temperature to prevent grain growth sample metal surface burned. There is much research related

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to heating process. It is essential to understanding the relationship between formations of austenite and heating conditions to optimise the thermal cycle to decide the final properties of the parts.

Therefore, The development of the model has been made to describe the austenite formation in boron steel [1]. First, the new model was created of austenitization by using simulation. Then, the results were compared to temperature profiles heated within a laboratory-scale furnace [2]. Besides, there are several kinds of the heating process that have been developed in recent years by researchers. Resistance heating by local pre-heating was developed to study the temperature distribution of a non-rectangular blank. The pre-heating process can entirely transform the blank microstructure into austenite under appropriate temperature [3]. Quick heating created using resistance and furnace heating on A2024, and A6061 alloys eliminate the cold sizing process and the solution treatment [4]. Tensile test is one of the mechanical tests that have used widely in engineering field especially in hot press forming. Tensile test is used to determine the strength of materials after the specific parameters in experimental method was done. After tensile testing was done, the results were obtained from computer in graphical analysis. In this paper, the experimental method was conducted to study the hot deformation behavior of hot press forming in tensile testing. The aluminum alloy AA6061 and AA7075 was used as the materials on this study.

2. Materials and Methods

2.1 Aluminum Alloy AA6061 and AA7075

The experiment begins with data collection made based on the sources of journal articles, books, and internet articles. After that, the process continued with workpiece preparation. In workpiece preparation, the chemical composition was determined as shown in Table 1. The sample of aluminum alloy AA6061 and AA7075 was cut and trimmed at Fabrication Laboratory UTHM using the Hydraulic Cutter Machine based on the standard procedure ASTM E8. Then, the samples were evaluated using the Vernier Caliper to make sure the dimension of the sample was valid to do tensile testing.

Table 1: The Chemical Composition of Aluminium Alloy AA6061 and AA7075

Element	Al	Si	Zn	Mg	Mn	Cr	Cu	Fe	Ti	Zr
6061 Al	95.85 – 97.90 %	0.40 – 0.80 %	0.00 – 0.25 %	0.80 – 1.20 %	0.00 – 0.15 %	0.04 – 0.35 %	0.15 – 0.40 %	0.00 – 0.70 %	0.00 – 0.15 %	-
7075 Al	86.90 – 91.40 %	0.00 – 0.40 %	5.6 – 6.10 %	2.1 – 2.50 %	0.00 – 0.30 %	0.07 – 0.23 %	1.20 – 1.60 %	0.00 – 0.50 %	0.00 – 0.2 %	0.00 – 0.25 %

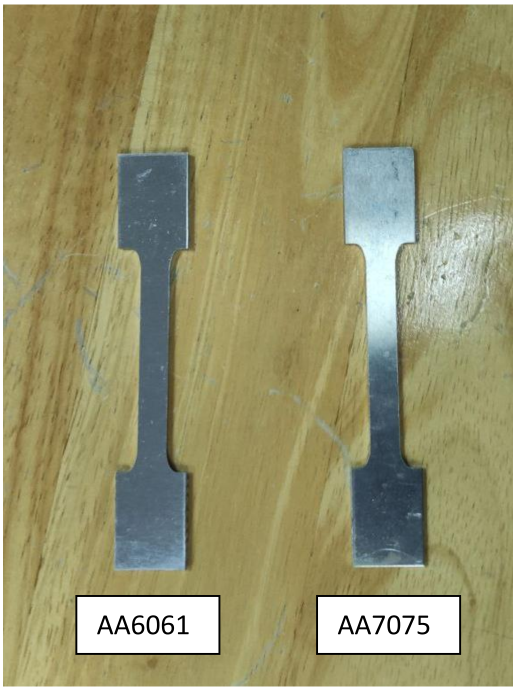

Figure 1: the samples of Aluminium Alloy AA6061 and AA7075 after trim process

2.2 The Heating Process and Tensile Testing

The specimen then move to heating process after the specimen was evaluated. In heating process, the specimen was heated in The Muffle Low Temperature Furnace. Five pieces of each aluminium alloy AA6061 and AA7075 was placed pair with the heating temperature that is room temperature, 100°C, 200°C, 300°C and 400°C, respectively.

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Figure 2 : a) the sample moved inside the Furnace. b) The Muffle Low Temperature Furnace (the range of temperature is 0 into 1300°C)

Tensile testing was conducted after the heating process. The Shimadzu Tension Testing Machine was used to conduct the tension test. The specimen first was grip with fix and moveable arm. Then, the perpendicular force was applied until the specimen breaks. The raw data was process, and the result was generated by the Shimadzu Gluon Test Execution software in graphical analysis.

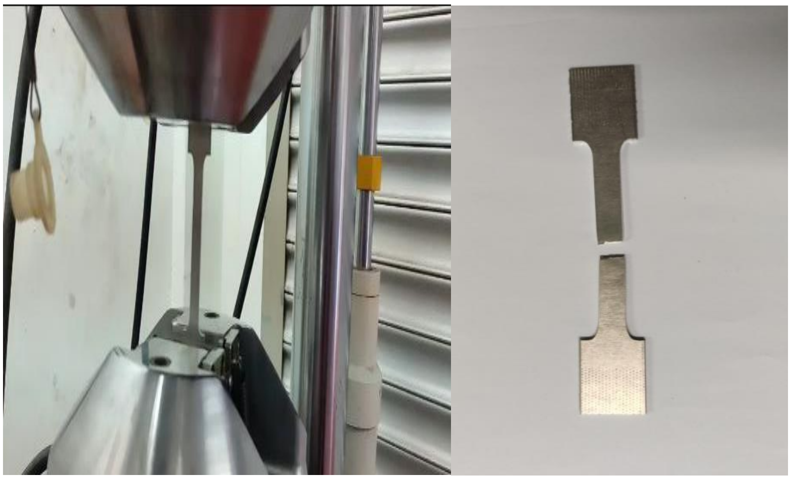
a)  b)

Figure 3: a) the sample was gripped with fix and moveable arm b) the condition of sample after break

3. Results and Discussion

3.1 The Graph of Load Force-elongation

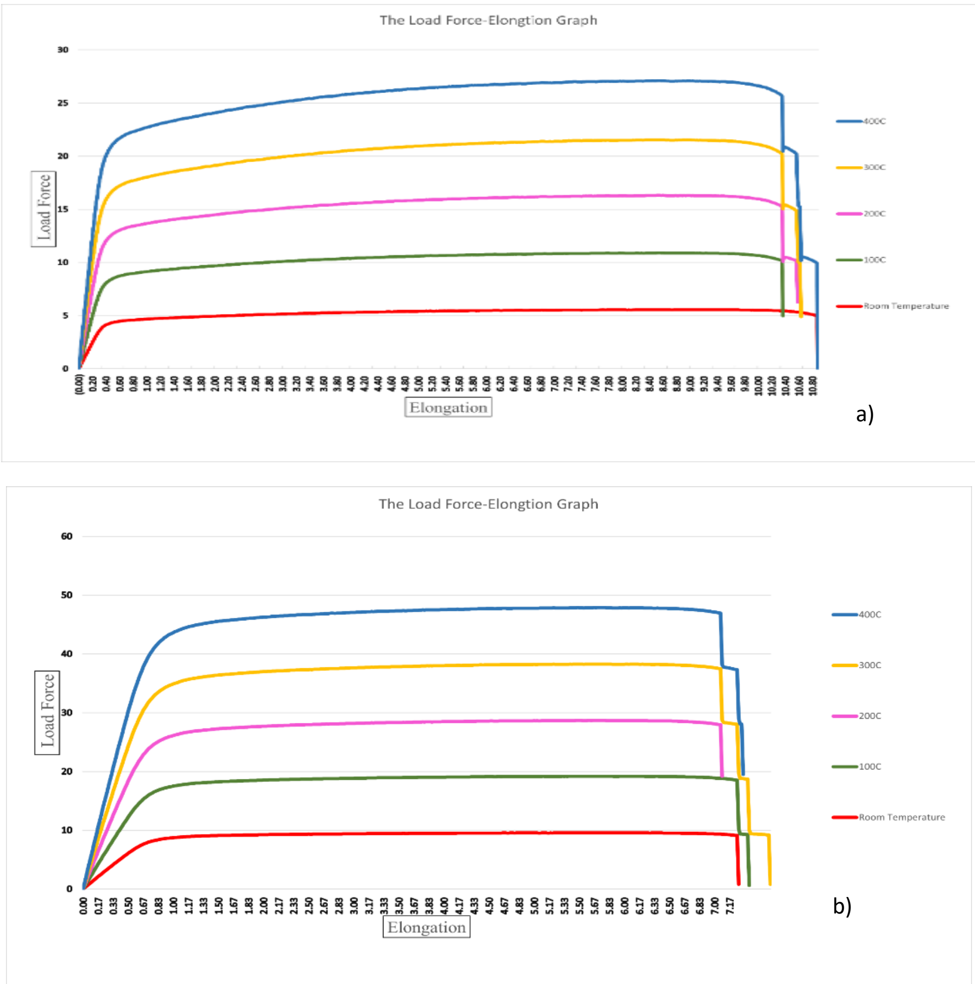


Figure 4: the graph of Load Force-Elongation a) AA6061 b) AA7075

The graph of Load Force-elongation of AA6061 and AA7075 was obtained after tensile testing shown in figure 4. From figure 4, the curve of aluminum alloy AA6061 and AA7075 rise with to the heating temperature increase. The curve reached and approached the maximum load force. The maximum load force of AA6061 and AA7075 is 5.238MPa and 9.5025MPa at room temperature and increase into 5.7055MPa and 9.63225MPa respectively at 400°C. the curve continues with negative gradient until fracture point. The fracture point of aluminium alloy AA6061 and AA7075 is 4.6305MPa and 9.11925MPa increase to 5.11925MPa and 9.27775MPa from room temperature until final temperature.

3.2 The Graph of Stress-Strain

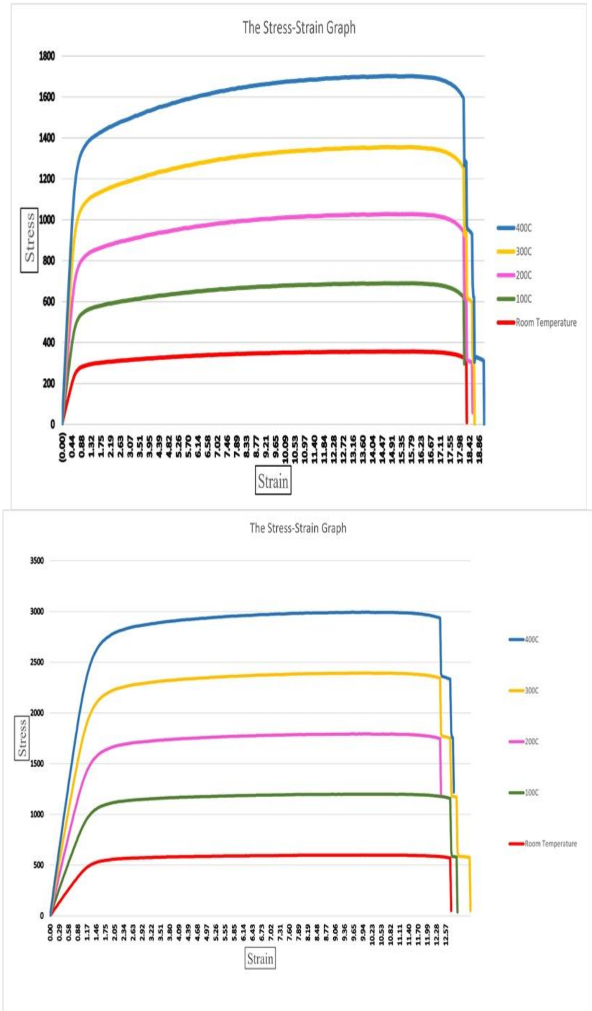


Figure 5: The Stress-Strain Graph for a) AA6061 and b) AA6061

The graph of stress-strain of AA6061 and AA7075 was obtained after tensile testing shown in figure 5. From the figure 5, the elastic modulus, yield strength, ultimate tensile strength, and breaking point of aluminum alloy increase as the heating temperature increase. the curve rises linearly as elastic modulus. Elastic modulus is the slope line of stress-strain. The elastic modulus of aluminum alloy AA6061 and AA7075 is 43284.2MPa and 44284.2MPa at room temperature increase into 46222.3MPa and 47222.3MPa at 400°C. the curves move until the yield strength. the yield strength of aluminium alloy AA6061 and AA7075 is 248.234MPa and 498.984MPa increase into 276.875MPa and 513.234MPa respectively at final temperature. The curve then approaches to the Ultimate Tensile Strength (UTS) point. The UTS of aluminium alloy AA6061 and AA7075 increase from room temperature to final temperature with the value of 327.375MPa and 593.906MPa into 356.594MPa and 602.016MPa, respectively. After UTS reached, the curve moves with negative slope until fracture point. The fracture point of aluminium alloy AA6061 and AA7075 also increase as the heating temperature increase with 289.406MPa and 569.953MPa into 319.953MPa and 579.859MPa. the results then were compared with the previous study. Mu (2018) studied several parameters that is heating temperature, deformation temperature and soaking time of 30MnB5 and 22MnB5. After heating temperature increase from 800 °C to 1000 °C, the tensile strength of 30MnB5 and 22MnB5 increase from 620MPa and 580MPa and reach the peak value of 1946 MPa and 1596MPa, respectively.

4. Conclusion

The demand of light weighting and strengthening of material in aerospace and automobile industries increase every year. This demand makes many researchers to develop the advanced method to produce the high strength of material. The Aluminium Alloy have been used in most aerospace industries. To increase the strength of this material, the study of hot deformation behaviour in tensile testing have been made. The aluminium alloy AA6061 and AA7075 was selected as the material on this study. The experimental method of heating process and tensile testing was selected. The specimen was heated with different the heating temperature that is room temperature, 100°C, 200°C, 300°C, and 400°C. after heated, the specimen was transferred to tensile testing to determine the strength of specimen. The results were obtained, justified, and discussed in graphical analysis. The results then compared with the previous studies.

Acknowledgement

The authors wish to thank to the Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia that has supported on the accomplishment of research activity.

References

[1] N. Li, J. Lin, D. S. Balint, and T. A. Dean, “Modelling of austenite formation during heating in boron steel hot stamping processes,” *J. Mater. Process. Technol.*, vol. 237, pp. 394–401, 2016, doi: 10.1016/j.jmatprotec.2016.06.006.

[2] B. Zhao, C. Chiriac, and K. J. Daun, “Evaluation of 22MnB5 Steel Austenitization Sub-Models for Simulating the Heating Phase of Hot Stamping,” *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 967, p. 012076, 2020, doi: 10.1088/1757-899x/967/1/012076.

[3] Y. Nakagawa, K. Mori, and M. Nishikata, “Hot stamping of non-rectangular steel sheets using resistance heating by local preheating,” *Procedia Manuf.*, vol. 50, no. 2019, pp. 298–302, 2020, doi: 10.1016/j.promfg.2020.08.055.

[4] T. Maeno, K. ichiro Mori, and R. Yachi, “Hot stamping of high-strength aluminium alloy aircraft parts using quick heating,” *CIRP Ann. - Manuf. Technol.*, vol. 66, no. 1, pp. 269–272, 2017, doi: 10.1016/j.cirp.2017.04.117.

[5] Y. hong Mu, B. yu Wang, J. Zhou, X. Huang, and J. ling Li, “Influences of hot stamping parameters on mechanical properties and microstructure of 30MnB5 and 22MnB5 quenched in flat die,” *J. Cent. South Univ.*, vol. 25, no. 4, pp. 736–746, 2018, doi: 10.1007/s11771-018-3778-8.