Quest Journals
Journal of Research in Mechanical Engineering
Volume 12 ~ Issue 3 (May. – June. 2026) pp: 25-28
ISSN(Online):2321-8185
www.questjournals.org

Research Paper

Investigation of the Effects of Temperature and Time on the Solution Treatment and Aging Processes of B95 Aluminum Alloy

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Abstract
B95 aluminum alloy (equivalent to 7075 according to U.S. standards) is a high-strength Al-Zn-Mg-Cu alloy widely used in aerospace, military equipment, and structural applications due to its excellent strength-to-weight ratio. However, the mechanical properties of B95 alloy after conventional processing are still limited for high-performance applications. In this study, the effects of artificial aging temperature, aging time, and thermomechanical treatment combining quenching, cold deformation, and aging on the mechanical properties of B95 aluminum alloy were investigated. Samples were solution-treated at 470°C, water quenched, cold rolled with different deformation levels, and artificially aged at temperatures ranging from 120°C to 160°C. The results showed that thermomechanical treatment significantly enhanced the hardness and tensile strength of the alloy.
Keywords
B95 aluminum alloy, thermomechanical treatment, artificial aging, precipitation hardening, Al-Zn-Mg-Cu alloy

I. Introduction

Aluminum alloys of the Al-Zn-Mg-Cu system are widely used in aerospace, military, and structural applications because of their high specific strength and good corrosion resistance [1,2,4,7,8]. B95 aluminum alloy, equivalent to 7075 according to U.S. standards, is one of the most widely used high-strength aluminum alloys. [12,20,4,9,16]

The strengthening mechanism of B95 alloy is mainly based on precipitation hardening. During solution treatment and quenching, alloying elements dissolve into the aluminum matrix to form a supersaturated solid solution. [3,7,11,18.20] During subsequent aging treatment, strengthening precipitates are formed, resulting in significant strengthening of the alloy.

In this study, the influence of artificial aging conditions and thermomechanical treatment on the mechanical properties of B95 aluminum alloy was investigated. [4,7,2,3,13,18,19]

II. Experimental Procedure

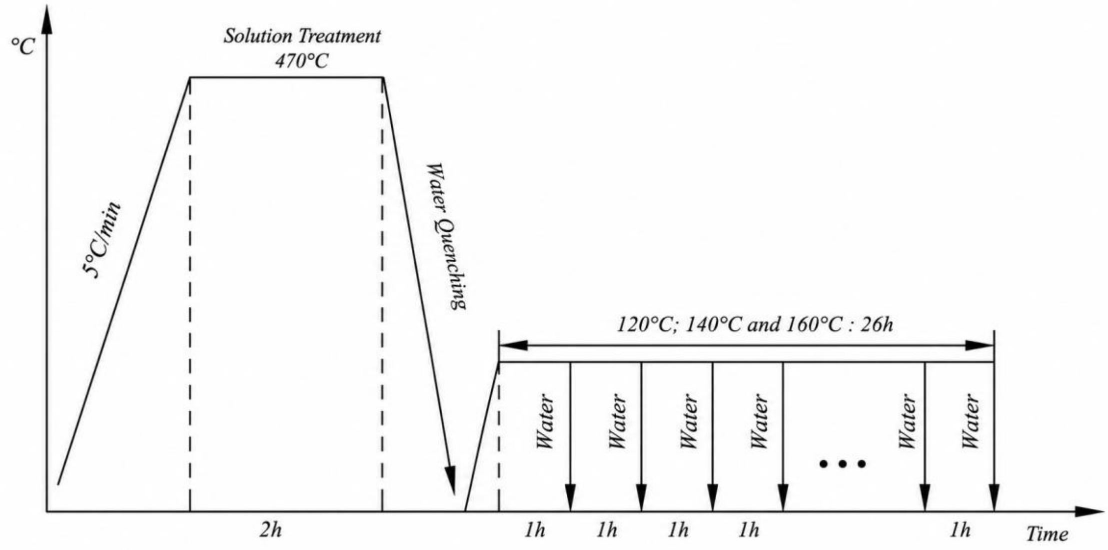
In this study, the chemical composition of the B95 aluminum alloy is shown in Table 1

Table 1. The chemical composition of B95 alloy (ГОСТ standard) and the chemical composition of the research sample.

Alloy	Aluminum alloy composition (%)									
	Al	Zn	Mg	Cu	Fe	Si	Mn	Ni	Cr	Ti
B95 (Rusia)	86,3-91,5	5,0-7,0	1,8-2,8	1,4-2,0	Max 0,5	Max 0,5	0,2-0,6	Max 0,1	0,1-0,25	Max 0,05
Research sample	89,286	5,668	2,103	1,836	0,338	0,094	0,390	0,006	0,181	0,023

The samples after being aged at 120°C, 140°C, and 160°C were studied over a period of 26 hours for each temperature, with samples taken every 2 hours to check hardness in order to construct the aging curve over time (a curve showing the change in hardness and strength depending on temperature and aging time) as per the technological process in Figure 1.

Figure 1. The technological process for chemical aging testing at 120°C and 160°C for B95.



For thermomechanical treatment, quenched samples were cold rolled with different deformation levels before artificial aging at 120°C.

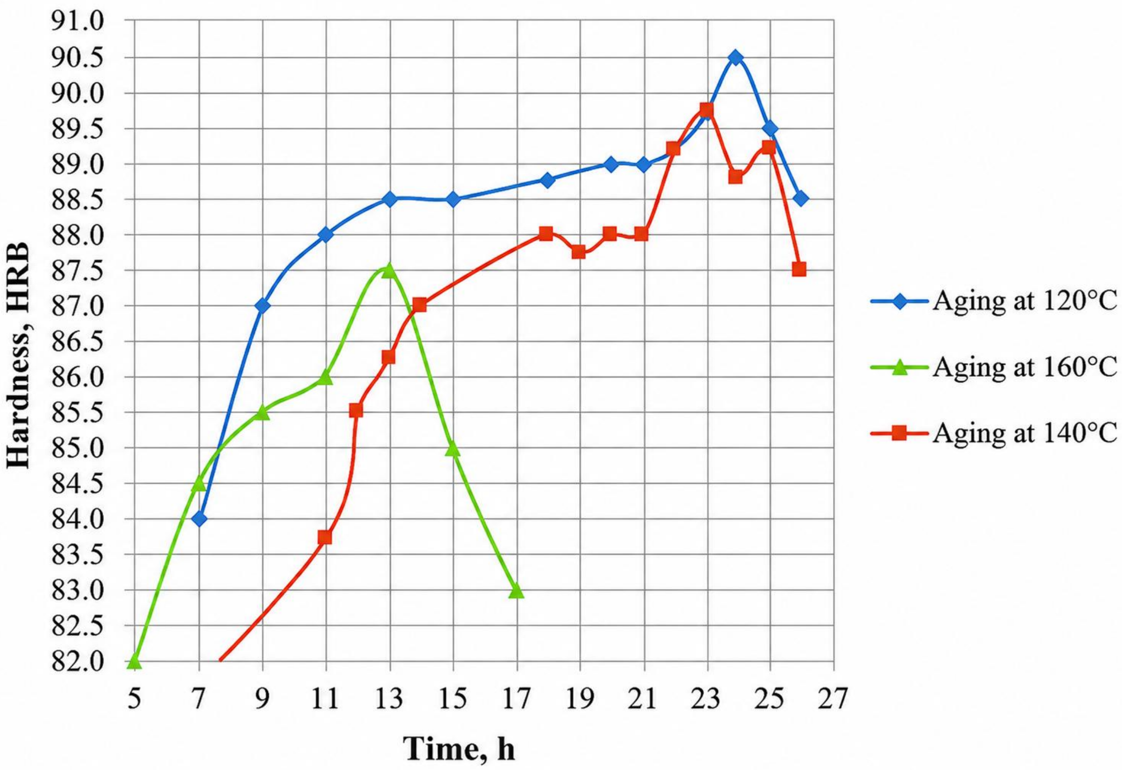
Microstructural observations were carried out using optical microscopy. Hardness measurements were performed using a Brinell hardness tester.

III. Results and Discussion

3.1. The effect of temperature and aging time on hardness

The samples were aged at 120°C, 130°C, and 160°C. The aging time was studied over 26 hours for each temperature, with samples taken every 2 hours to check hardness. From this, an aging curve over time was constructed, as shown in Figure 2.

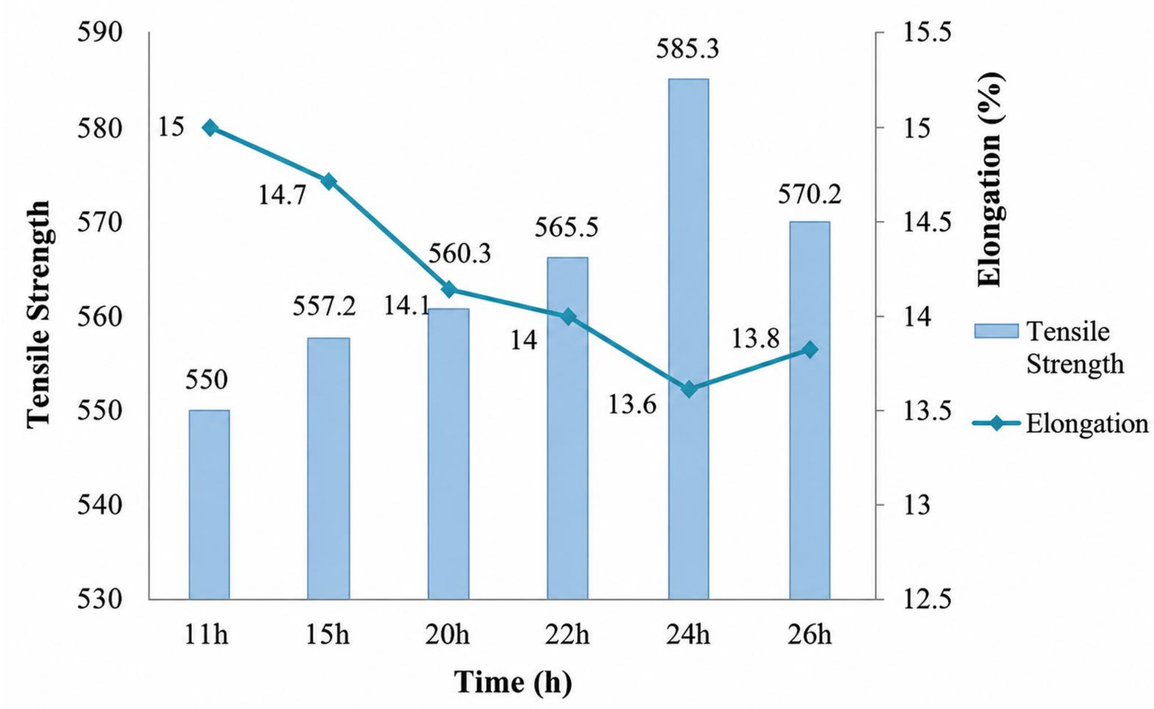
Figure 2. Aging curve at 120°C, 140°C, and 160°C.



3.2. The effect of aging time on durability

For high-strength aluminum alloys, the age hardening effect significantly contributes to increased strength and is a key objective of the research. The author investigated the changes in strength during aging at 120°C with different aging times over a period of 26 hours. The results of the strength and ductility values for samples aged for various durations are presented in the graph in Figure 3.

Figure 3. The relationship graph between tensile strength and ductility of the traditional aged sample (at 120°C) over aging time.



Experimental results indicate that increasing the aging temperature shortens the time required to achieve peak hardness. However, the maximum hardness obtained at 160°C was lower than that obtained at 120°C. Traditional aging at 120°C for 24 hours provided the highest hardness of 90.5 HRB and tensile strength of 585.3 MPa. When thermomechanical treatment was applied, deformation after quenching accelerated the aging process and increased the precipitation strengthening effect. The sample with 6% deformation and aging at 120°C for 20 hours achieved an optimal balance between strength and ductility, with a tensile strength of 640.4 MPa and elongation of 11.8%.

IV. Conclusion

The selected traditional quenching and aging technology used as a reference for the heat-treated sample with the process is:

- Quenching temperature is 470°C, held for 120 minutes, cooled in water;
- Aging temperature is 120°C, held for 24 hours.
- The maximum hardness reaches 90.5 HRB, the tensile strength is σb = 585.3 MPa, and the relative elongation is δ = 13.6%.

The research results show that this technology is of significant importance and can be applied in practical production to shorten manufacturing time, and improve the hardness and strength of B95 aluminum alloy compared to traditional technology.

Acknowledgment

This work is supported by Thai Nguyen University of Technology, Vietnam.

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