12th International Foundry Congress
19-21 September / Eylül 2024
Istanbul Expo Center, Istanbul - Türkiye
12. Uluslararası Döküm Kongresi
12th International Foundry Congress
TÜDÖKSAD
tüdöksad akademi

«Düşük Basınçlı Reçine Kumda Dökülmüş A201 Alaşımının Isıl İşlemi ve Mikroyapı Karakterizasyonu»

«Heat Treatment and Microstructure Characterization of Low Pressure Resin Sand Cast A201 Alloy»

Yunus Emre Dağıstanlı & Abay Tekkol & Alihan Özsarı & Prof. Dr. Ali Kalkanlı
(ODTÜ & Altun Döküm)

7.Oturum / 7th Session

Oturum Başkanı / Session Chairman: Erkin KOÇ
(Ay Döküm)

TÜDÖKSAD
tüdöksad akademi

Outline

- Introduction
- Objective
- Experimental Parameters
- Procedure
- Results
- Conclusion
- Recommendations

Introduction

- Low density and high strength engine block materials
- A201

Elements	Si	Fe	Cu	Mn	Mg	Ag	Al
Composition(% wt.)	0.72	0.033	4.80	0.29	0.28	0.46	Bal.

- Low-pressure die casting used
  - To decrease porosity
  - To prevent bifilm formation
- Incipient melting to be avoided

Objective

- The aim of this work is to investigate the effect of solidification parameters, alloying elements and heat treatment conditions to achieve sound and defect free cast components,
- To reveal the benefit of multiple T6 heat treatments to achieve higher strength values,
- To optimize heat treatment conditions to modify intermetallic morphology to improve mechanical properties.

Experimental Parameters

- Effect of alloying elements: By addition of Ag to improve high temperature performance.

- Effect of heat treatment cycle: By changing temperature and time of solutionizing and aging steps.

- Effect of number of T6 heat treatment cycle: By applying one time, two times, three times.

Procedure

Elements	A-201+	A-201	Literature
Al%	90,6	92,4	Bal.
Si%	0,449	0,0081	0,05-0,72
Fe%	0,0864	0,0831	<0,15
Cu%	6,55	6,21	4,5-4,97
Mn%	0,642	0,203	<0,35
Mg%	0,575	0,149	0,24-0,55
Ag%	1,1	0,701	0,46-0,63
Ti%	0,288	0,184	0,20-0,25

Casting parameters;

Mold Temp: 110°C-120°C

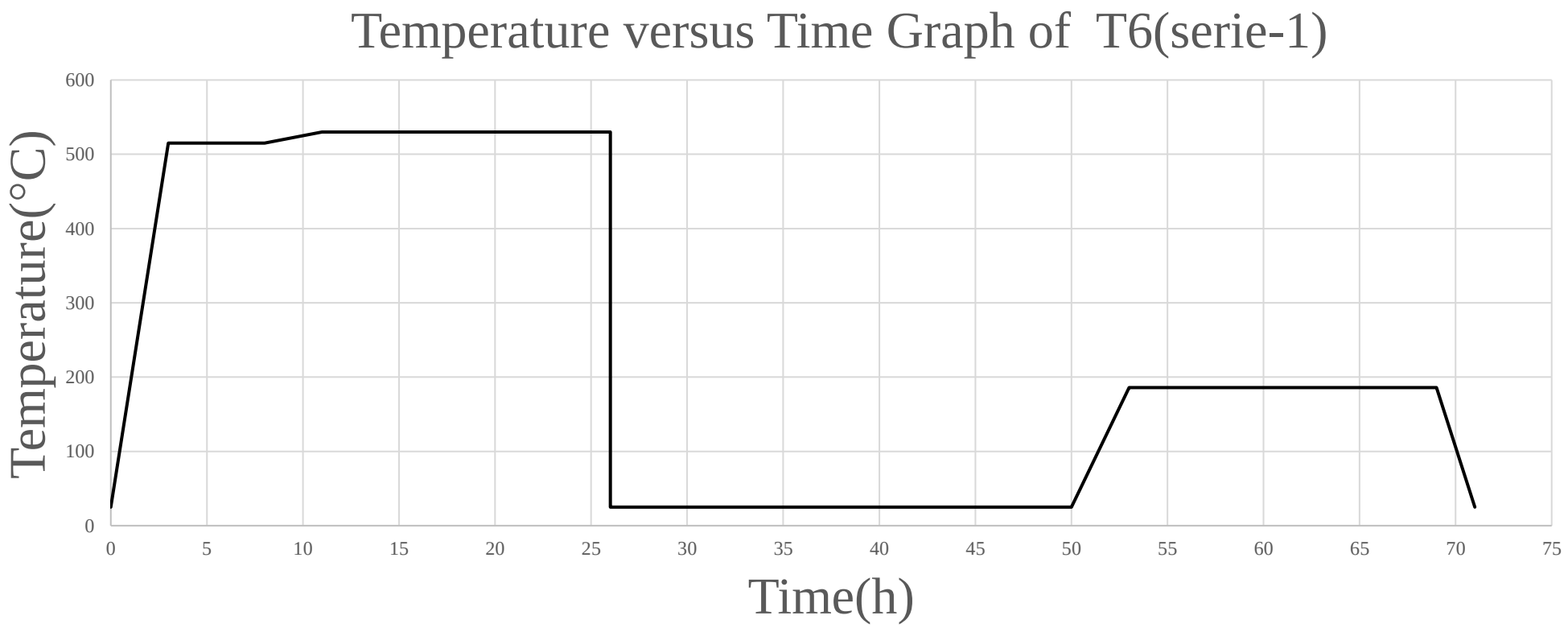
Casting Temp: 730°C-750°C

Pressure: 350-400 mbar

Procedure

- The first T6 heat treatment (here-after T6(serie-1));
- 5 hours at 515°C to prevent incipient melting
- 15 hours at 530°C for solutionizing
- Water quench
- 24 hours rest at room temperature
- 16 hours aging at 186°C for precipitation hardening

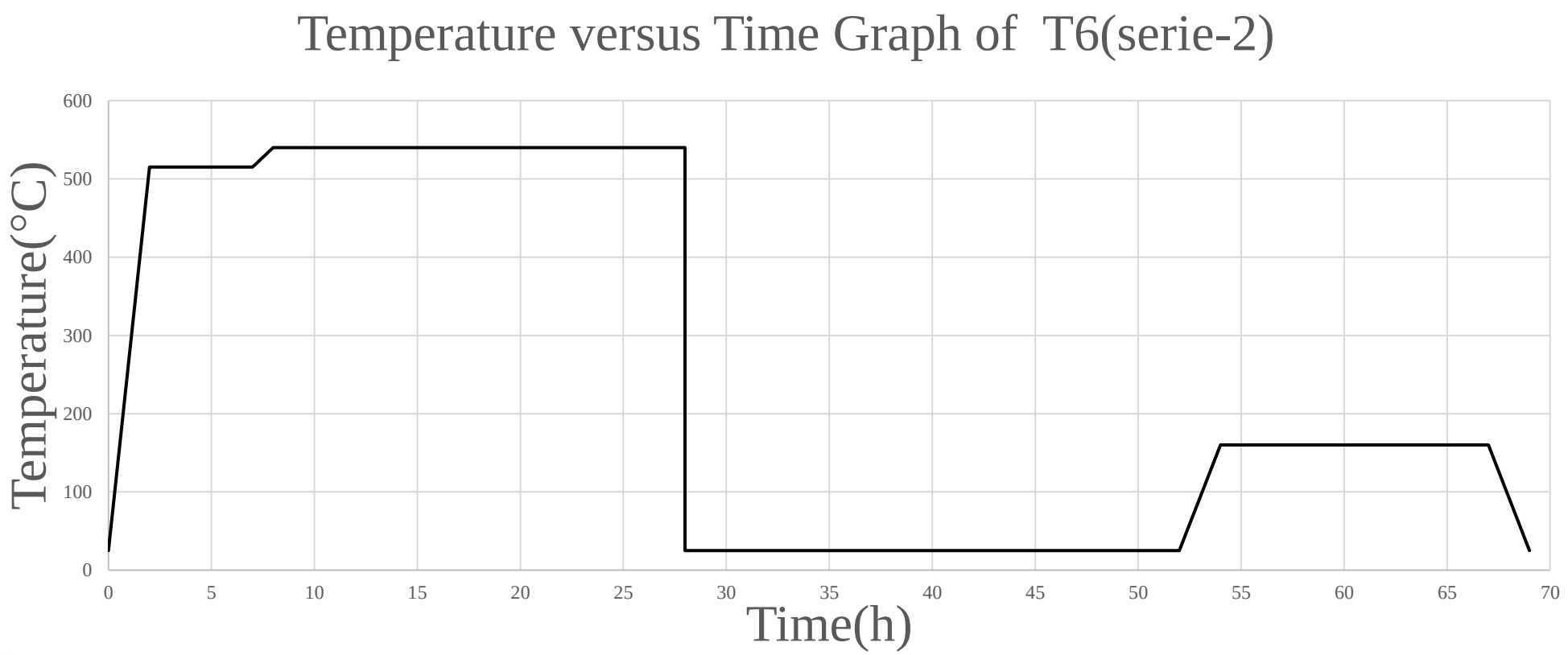
Procedure


Temperature versus Time Graph of T6(serie-1)
Temperature(°C)
600
500
400
300
200
100
0
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
Time(h)

Procedure

- The second T6 heat treatment(here-after T6(serie-2));
- 5 hours at 515°C to prevent incipient melting
- 20 hours at 540°C for solutionizing
- Water quench
- 24 hours rest at room temperature
- 13 hours aging at 160°C for precipitation hardening

Procedure


Temperature versus Time Graph of T6(serie-2)
Temperature(°C)
600
500
400
300
200
100
0
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
Time(h)

Procedure

- Tensile test
- Hardness test
- Optical analysis
- SEM analysis

Results

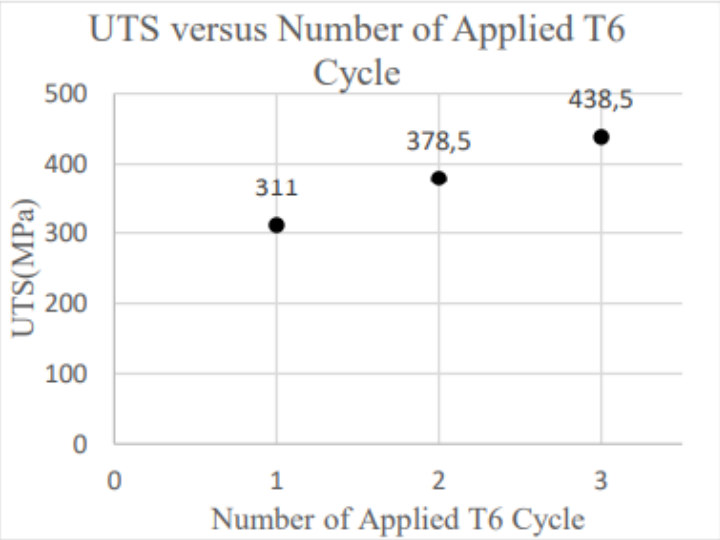
	A201	A201+
UTS(MPa)	280	312
Hardness(MPa)	110	128

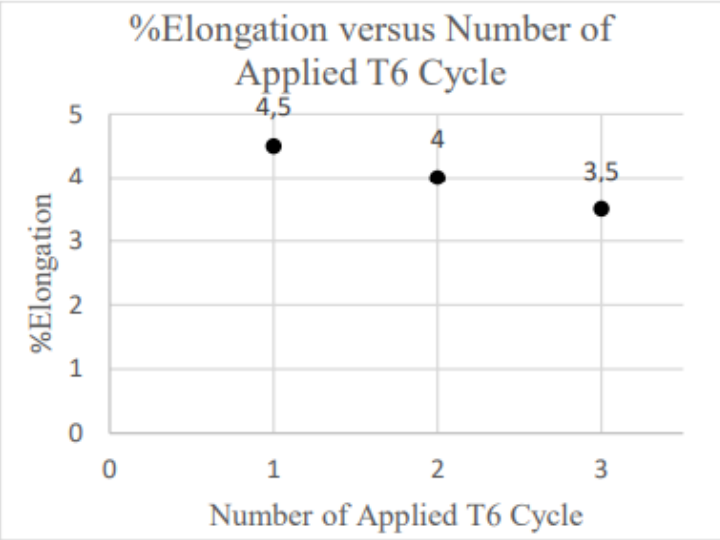
- As a result of the increase in alloying elements, the amount of second phase particles increased.

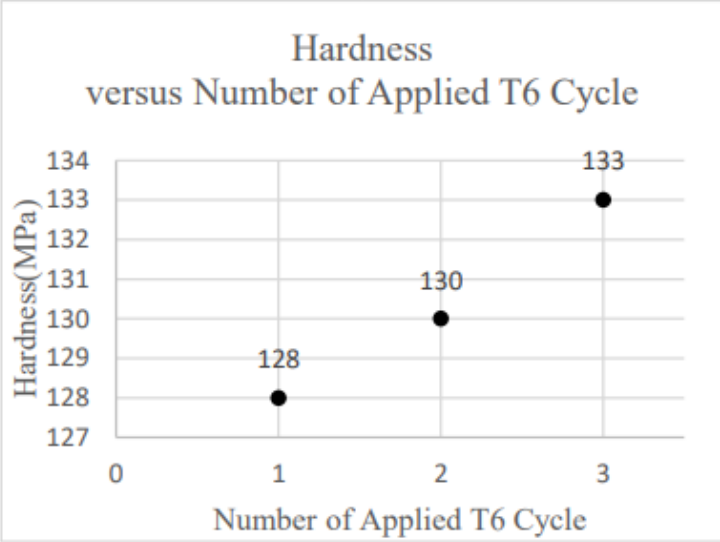
Results

	T6(serie-1)	T6(serie-2)
UTS(MPa)	312	270
Hardness(MPa)	128	125

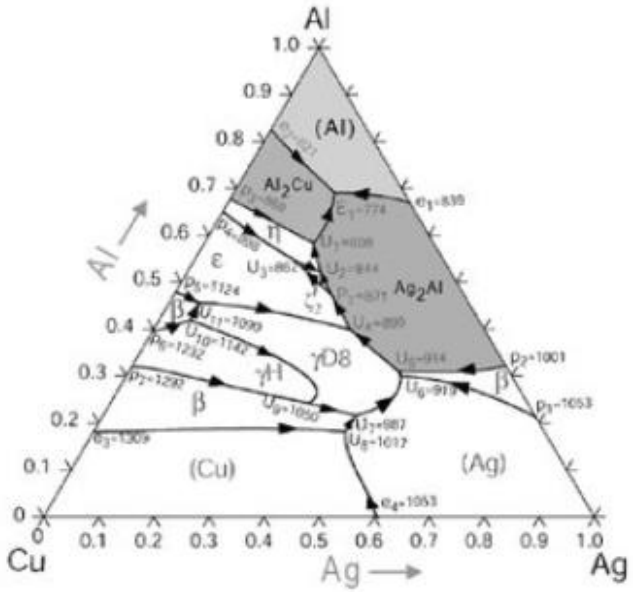
- Low solutionizing temperature caused less grain growth, high aging temperature caused more second phase particle formation.





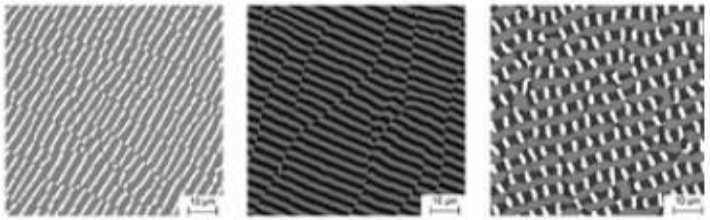


- As the amount of T6 applied increased, the amount of second phase particles increased.
- Some stable primary phases are not dissolved and some intermetallics may precipitate after the second or third T6 heat treatment.



(Hecht et al., 2014)

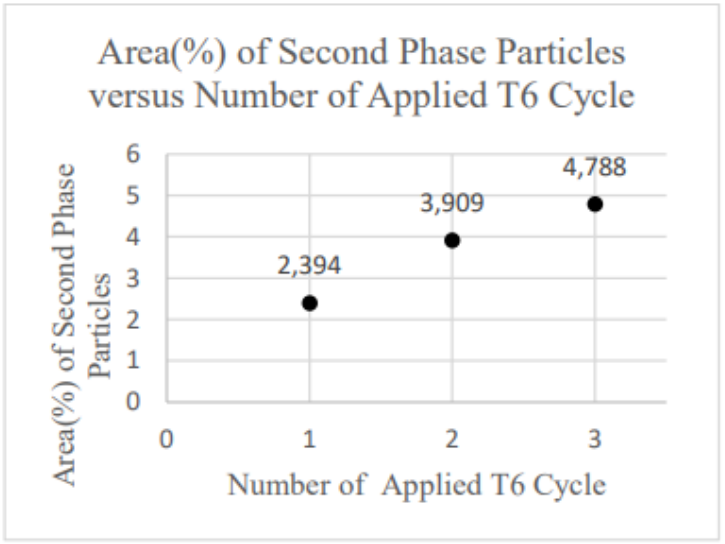
Nonvariant eutectic reactions	Eutectic point °C, at.%	
Liq. → Al+Al_2Cu	548.2	17.7 Cu
Liq. → Al+Ag_2Al	566.0	33.0 Ag
Liq. → Al+Al_2Cu+Ag_2Al	501.0	12.4 Cu 18.6 Ag

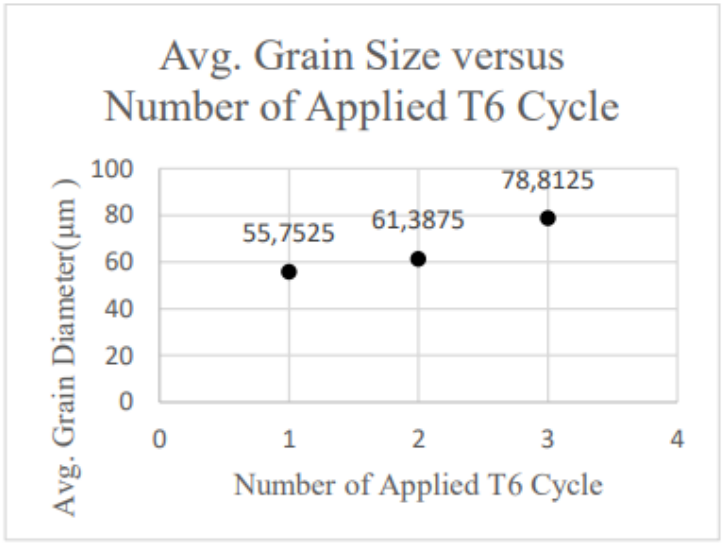


Al-Ag_2Al Al-Al_2Cu Al-Al_2Cu-Ag_2Al

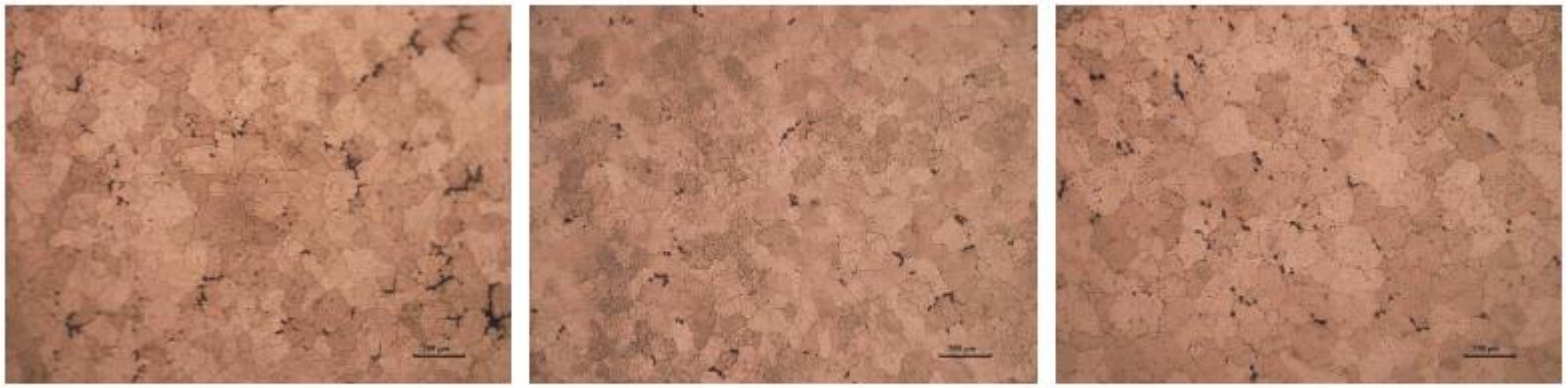
Reaction No.	Reactions	Suggested Temperature, °C
1	Development of a dendritic network	651 - 649
2	Liq. – Al + Al_6(MnFeCu)	649
3	Liq. + Al_6(MnFeCu) – Al + $Al_{20}Mn_3Cu_2$	616
4	Liq. – Al + Al_2Cu + $Al_{20}Mn_3Cu_2$ + Al_7FeCu_2	537
5	Liq. – Al + Al_2Cu + Al_2MgCu + Mg_2Si	500

(Bäckerudet al., 2014)

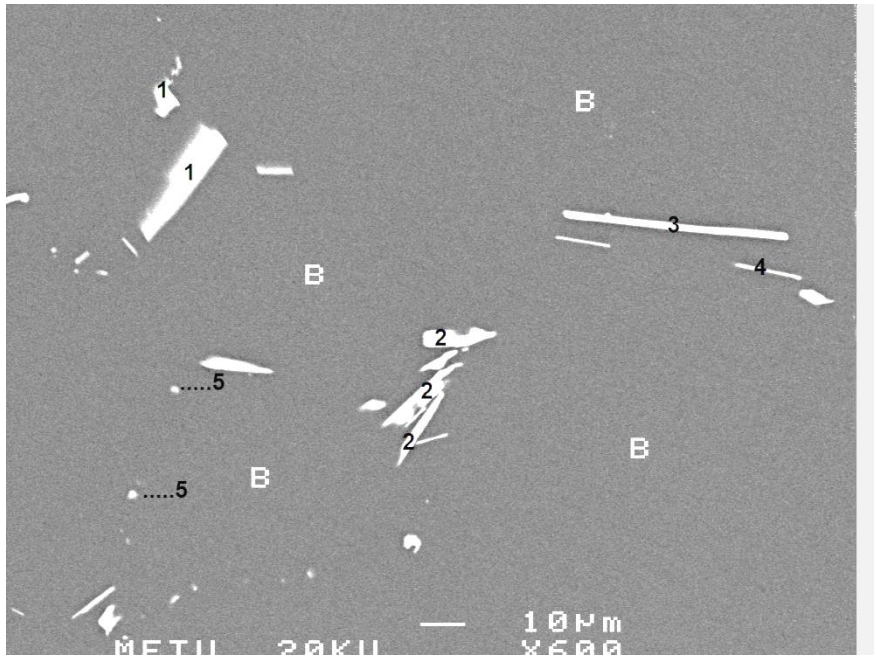




- Since the growth is thermally activated process, after each T6 cycle grain diameter was observed to be increased.

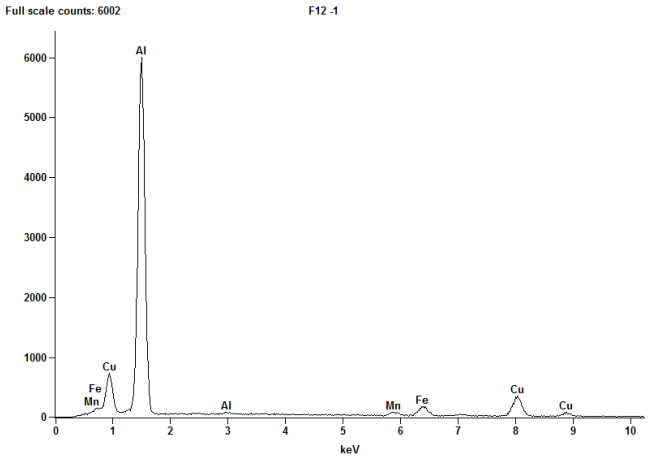


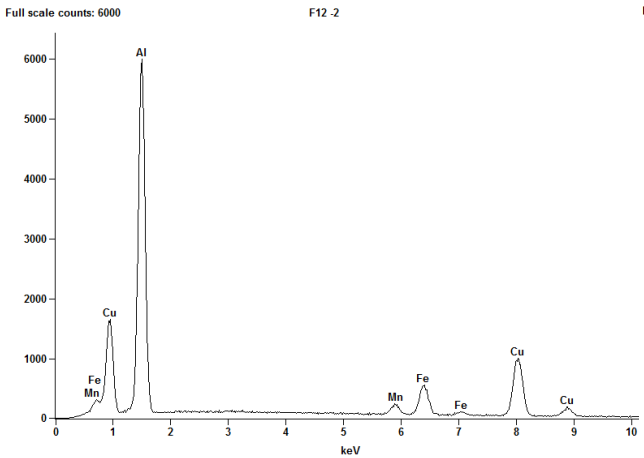
(1x) (2x) (3x)

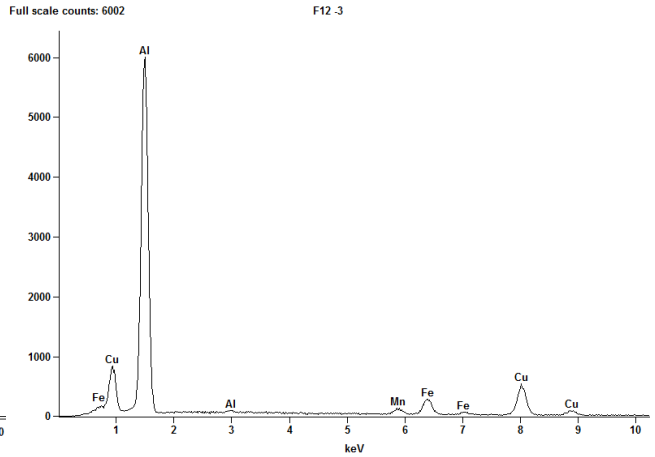


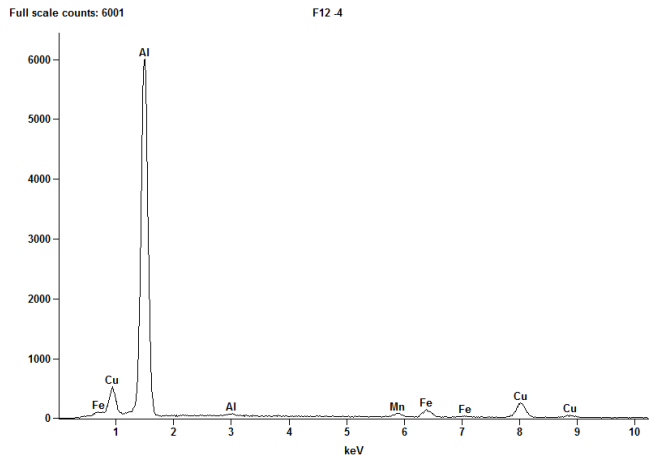
- These primary phases' morphologies are not rounded or spherical but rod-like and stress raising nature.

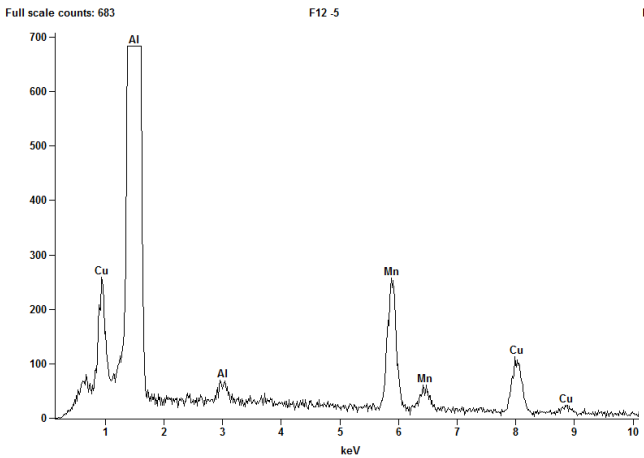
	1	2	3	4	5	B
Al	-	-	-	-	-	95,37
Mn	5,32	6,47	6,44	7,29	51,97	-
Cu	77,34	17,94	19,45	74,28	48,03	4,63
Fe	17,34	75,59	74,1	18,43	-	-

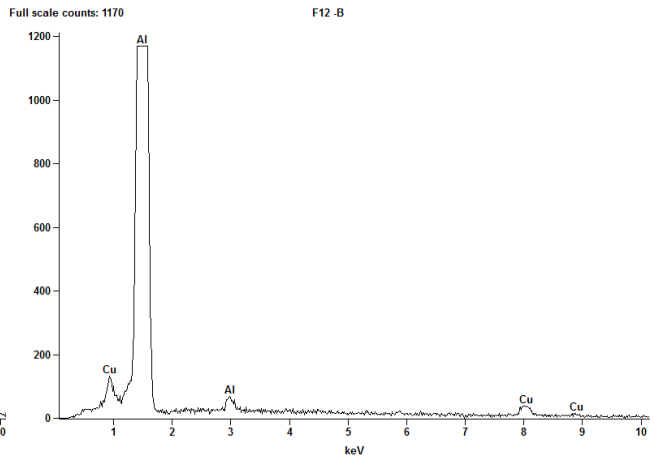












Heat Treatment and Microstructure Characterization of Low Pressure Resin Sand Cast A201 Alloy

Abay Tekkol, Yunus Emre Dağıstanlı, Prof. Dr. Ali Kalkanlı

Conclusion

1. Tensile strength increased from 280MPa to 312MPa with increase in Ag and Ti content.
2. Tensile strength increased from 312MPa to 432MPa after third times T6 heat treatment.
3. The volume fraction of second phase precipitates were found to increase from 2.394% to 4.788% after there times of T6 heat treatment.
4. The sharp morphology of iron containing intermetallics became more rounded with three times of T6 heat treatment.

Recommendations

- To achieve higher %elongation such as 7-15% with higher tensile strength values of 380-420MPa is to be investigated in the future to reveal the effect of morphological modification of intermetallics by heat treatments
- Iron content is critical and more experiments must be carried out with the lowest iron content.
- Various section thicknesses and cooling rates must be studied to include primary solidification parameters.

THANK YOU ALL FOR LISTENING!

Thanks to Altun Döküm and Kenan Polat for Their Support