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Tüdöksad Akademi 10. Uluslararası Döküm Kongresi / 10th International Foundry Congress by Tudoksad Academy
In conjuction with ANKIROS / ANNOFER / TURKCAST fairs

«Düşük Manganlı Küresel Grafitli Dökme Demirlerde Östemperleme Sıcaklık ve Sürelerinin Çekme Özelliklerine Etkileri»

«The Effects of the Austempering Temperature and Duration On Tensile Properties of Low Manganese Austempered Spheroidal Graphite Cast Iron»

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1.Oturum / 1st Session

Oturum Başkanı / Session Chairman: Seyfi Değirmenci (Tüdöksad Akademi)

TÜDÖKSAD

tüdöksad akademi

THE EFFECTS OF THE AUSTEMPERING TEMPERATURE AND DURATION ON TENSILE PROPERTIES AND FRACTURE BEHAVIOR OF LOW MANGANESE AUSTEMPERED SPHEROIDAL GRAPHITE CAST IRON

Utku Can KUMRU

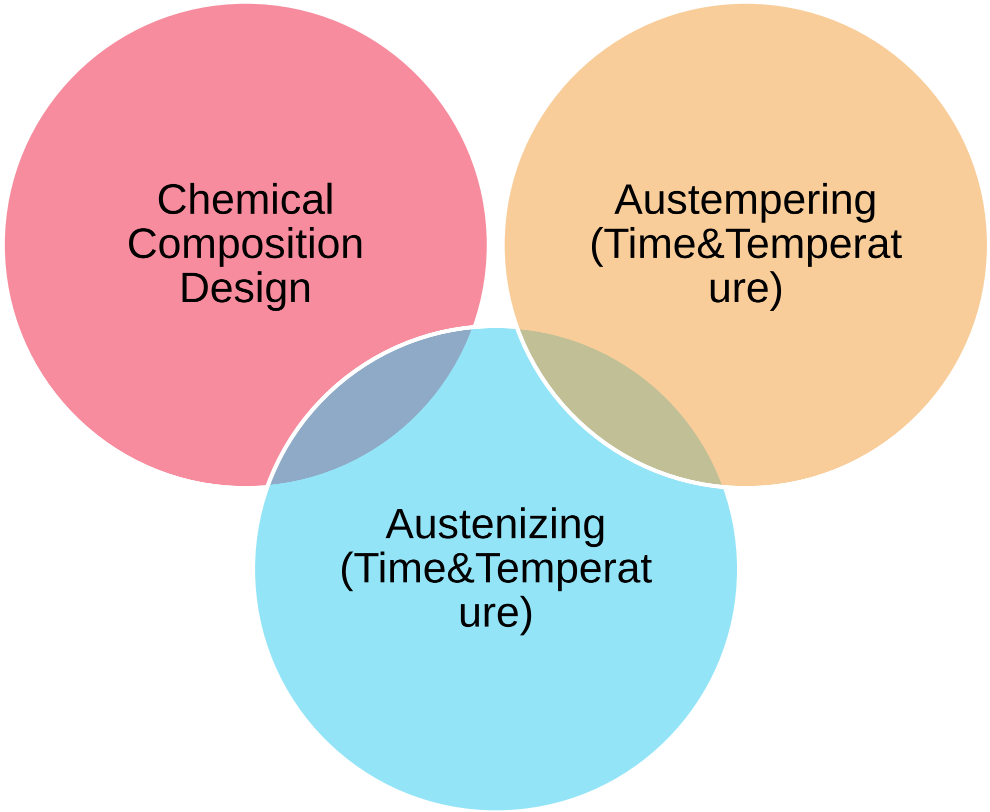
Tofaş Türk Otomobil Fabrikası A.Ş.

25/10/2018

INTRODUCTION

- In this study, the effects of the austempering temperature and duration on tensile properties and fracture behavior of low manganese austempered spheroidal graphite cast iron were investigated.

- The objectives of this study were to identify the optimum austempering temperature&time that results in enhanced mechanical properties, such as strength and elongation.



EXPERIMENTAL METHODS

Chemical Composition (%weight)

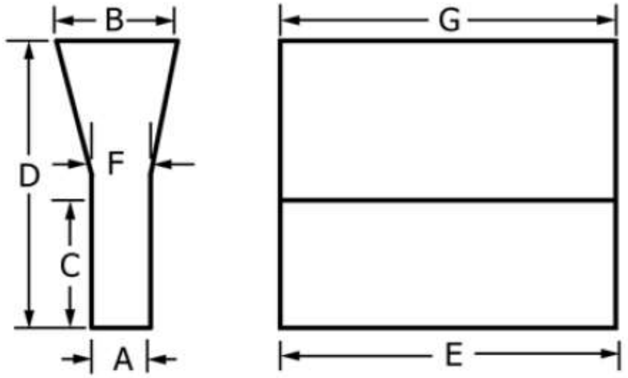
C	Si	Mn	P	S	Mg	Fe
3,62	2,53	0,167	0,043	0,014	0,047	Kalan

- The aim here is to improve the austemperability by preventing pearlite, and ferrite formation before austempering by preventing the cutting of pearlite nose of CCT curve during cooling to austempering temperature by providing sufficient hardenability with alloying.

- Avoid segregation in the microstructure especially thick parts for increase toughness **for fatigue life.**

EXPERIMENTAL METHODS

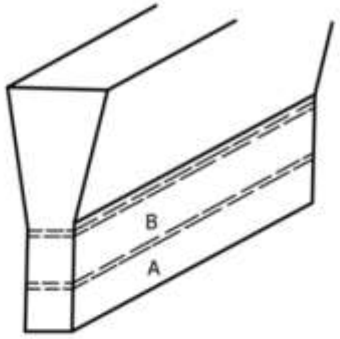
Y Block Castings were done for test specimens between **13 – 38 mm** thickness according to **ASTM A897**
The section thickness of the Y-block with 20 mm was chosen based on the casting section thickness.



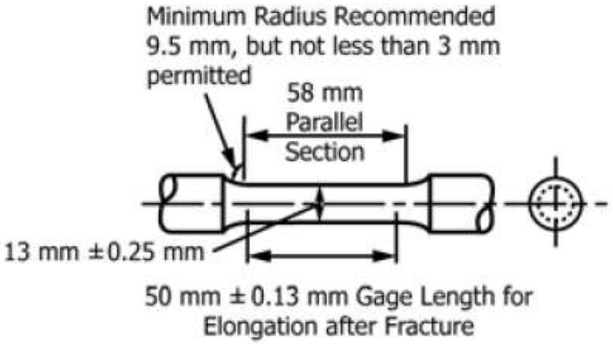
Dimensions	"Y" Block Size: For Castings of Thickness Less Than ½ in. [13 mm]	For Castings of Thickness ½ to 1½ in. [13 to 38 mm]	For Castings of Thickness of 1½ in. [38 mm] and Over
	in. [mm]	in. [mm]	in. [mm]
A	½ [13]	1 [25]	3 [75]
B	1⅝ [40]	2⅛ [55]	5 [125]
C	2 [50]	3 [75]	4 [100]
D	4 [100]	6 [150]	8 [200]
E	7 [175] approx	7 [175] approx	7 [175] approx
F	9⁄16 [14]	1 1⁄16 [27]	3 1⁄16 [78]
G	7 ⅛ [180] approx	7 ⅛ [180] approx	7 ⅛ [180] approx

FIG. 2 Y-Blocks for Test Coupons

Test specimens were machined from Position A (preferred).
The test bars were machined before heat treatment

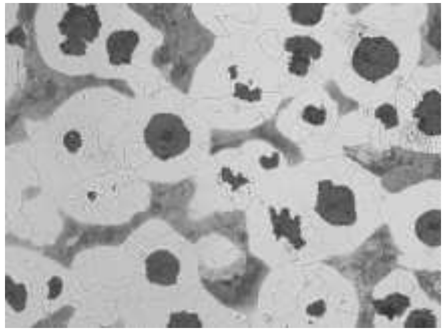


1-in. [25-mm] Y-Block—Two blanks for 0.50-in. [13-mm] diameter tension test specimens.



TARGET

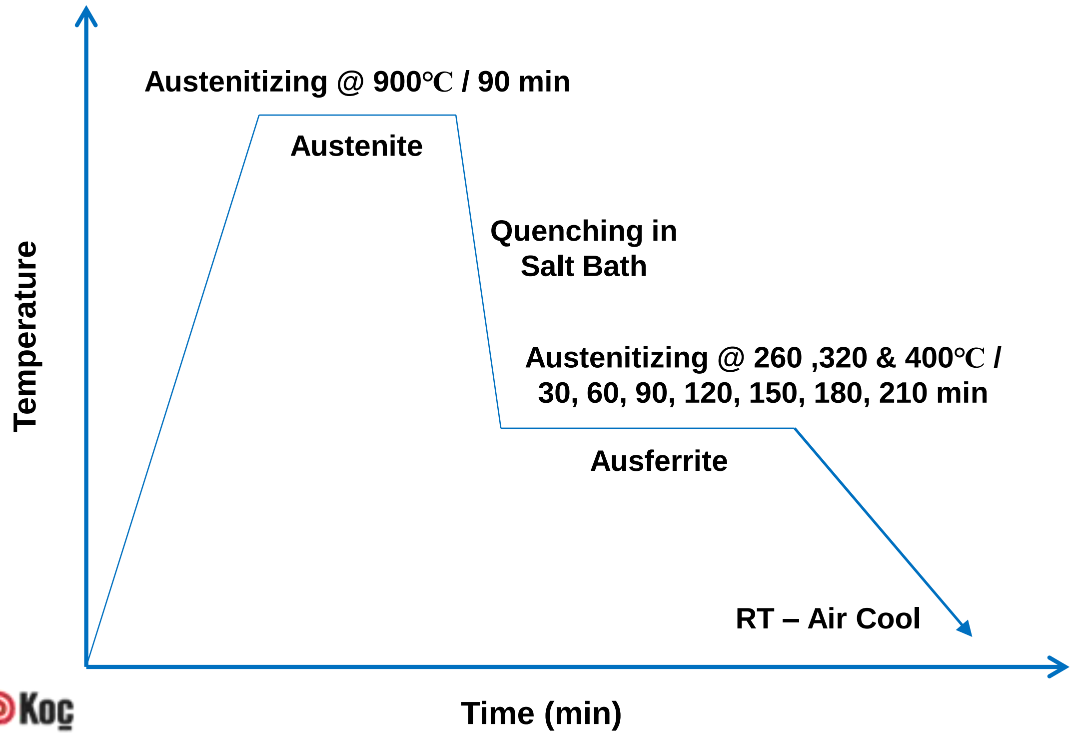
After Casting (starting microstructure for heat treatment next step):
pearlite + ferrite + graphite (max.%10) – without carbide



EXPERIMENTAL METHODS

Compositional Design → Casting → **Heat Treatment**

Austempering Temperature 260 °C							Austempering Temperature 320 °C							Austempering Temperature 400 °C						
Austempering Times (minutes)							Austempering Times (minutes)							Austempering Times (minutes)						
30 minute	60 minute	90 minute	120 minute	150 minute	180 minute	210 minute	30 minute	60 minute	90 minute	120 minute	150 minute	180 minute	210 minute	30 minute	60 minute	90 minute	120 minute	150 minute	180 minute	210 minute



TARGET

(with optimizing process window)

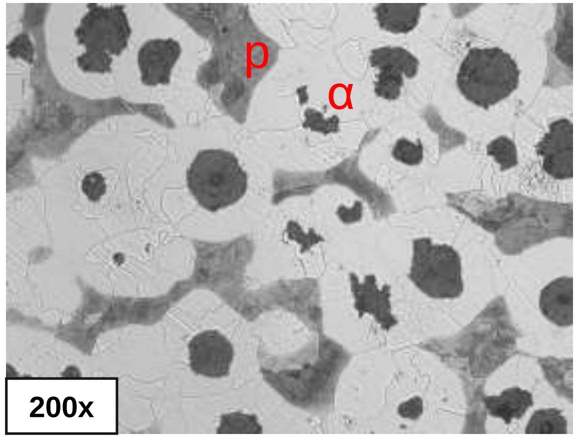
After Heat Treatment (final microstructure):
high carbon ferrite + austenite

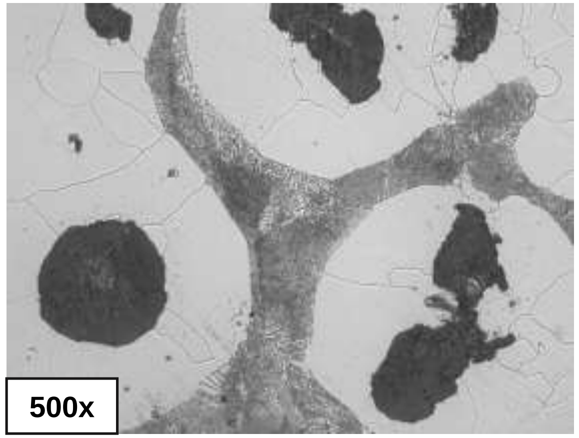
WHICH MEANS HIGHER MECHANICAL PROPERTIES WITH MODERATE ELONGATION

Sınıflandırma : Genel

EXPERIMENTAL FINDINGS AND EVALUATION

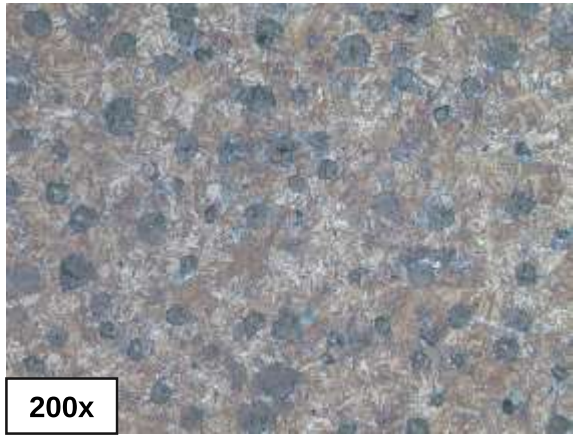
As Casted Microstructure

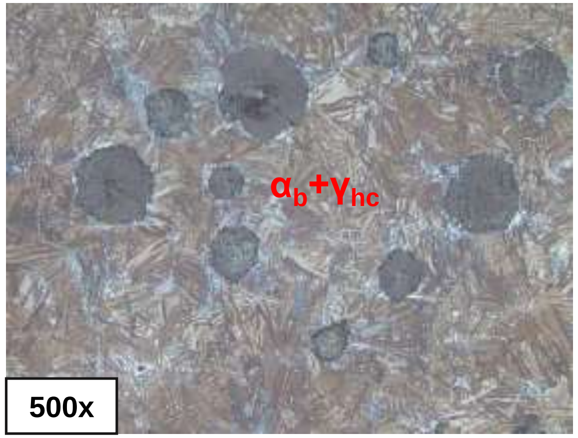




Achieved

Heat Treated Microstructure



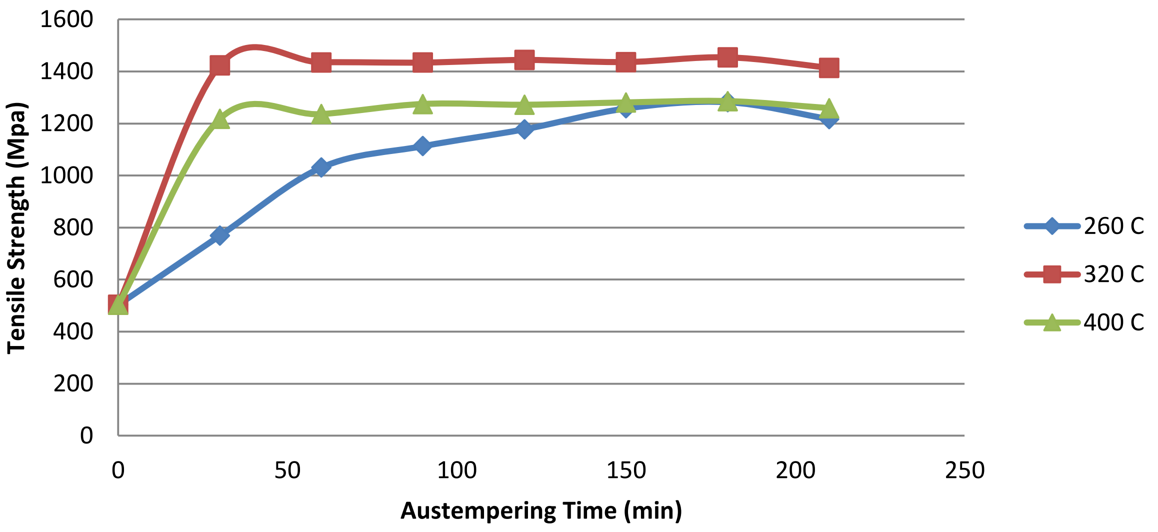


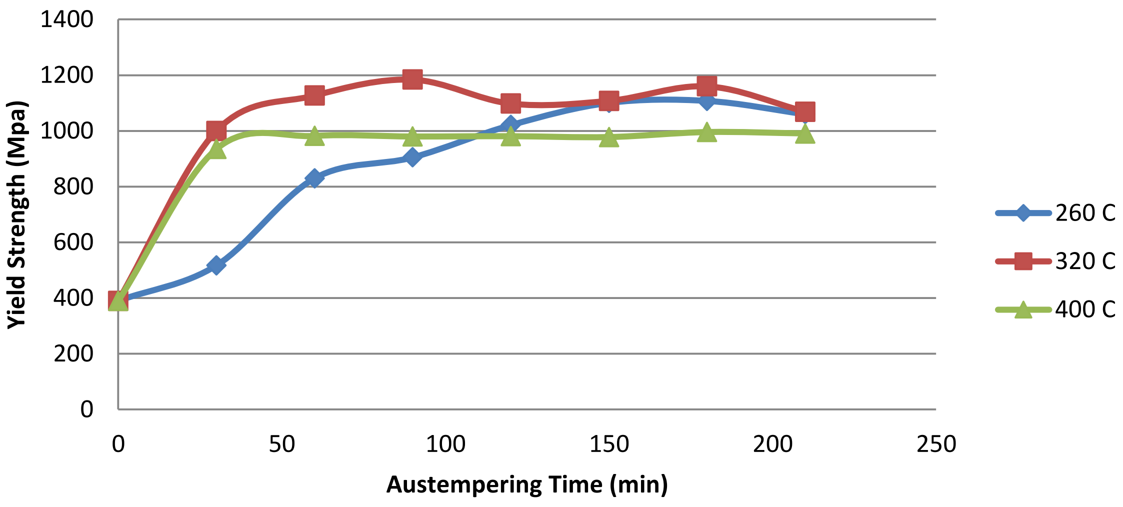
Achieved

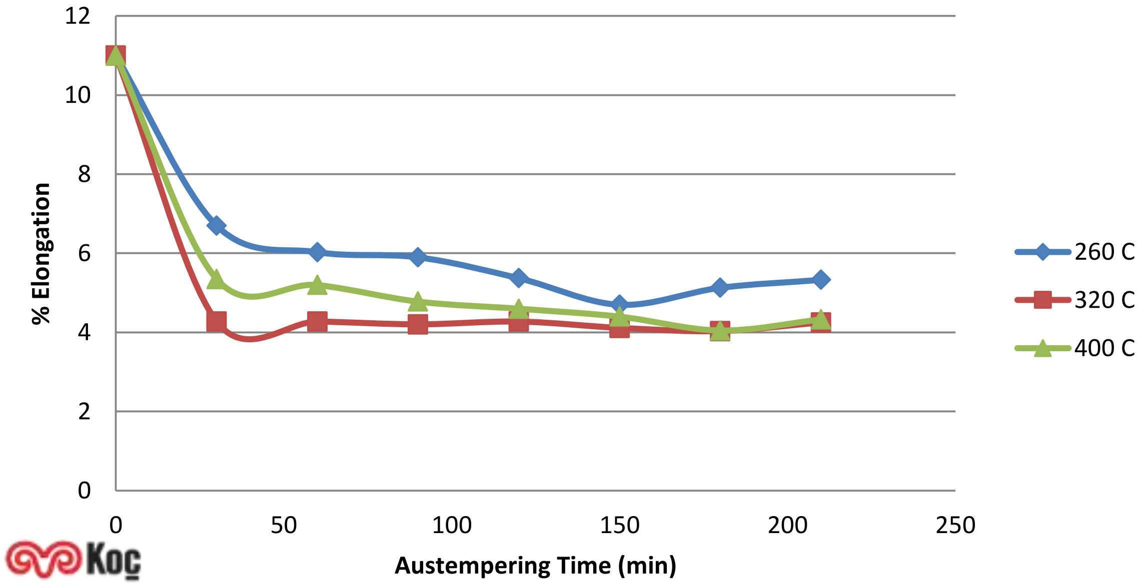
Metallography results of as-casted microstructure

Nodularity (%)	Nodule Count (mm2)	Nodule Size (mμ)	Graphite Volume Ratio (%)	Ferrite Volume Ratio (%)	Pearlite Volume Ratio (%)
89	286	19,21	13,86	56,59	29,55

EXPERIMENTAL FINDINGS AND EVALUATION



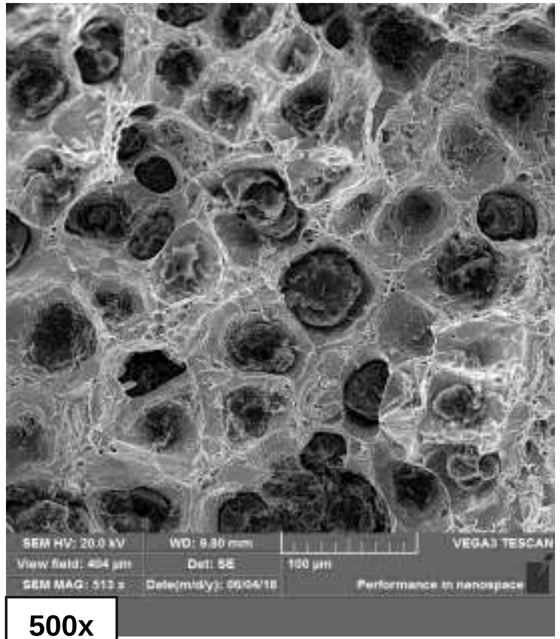




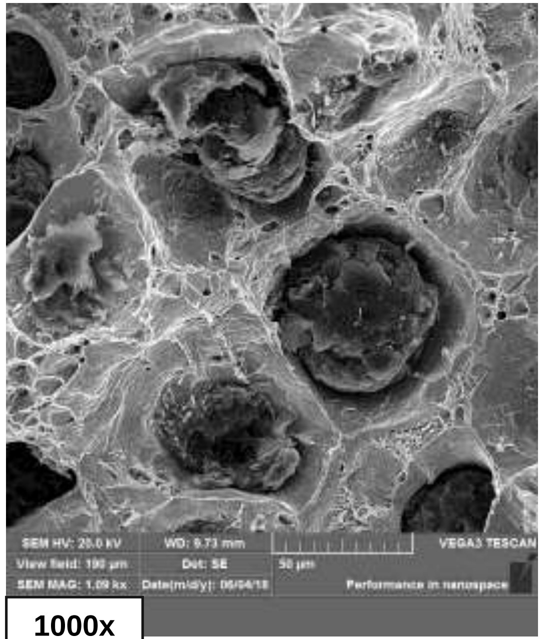
The yield and tensile strengths of the austempered samples were increased **three times** compared to the samples in as-casted conditions.

EXPERIMENTAL FINDINGS AND EVALUATION

SEM images of the fracture surface of the sample in as-casted conditions



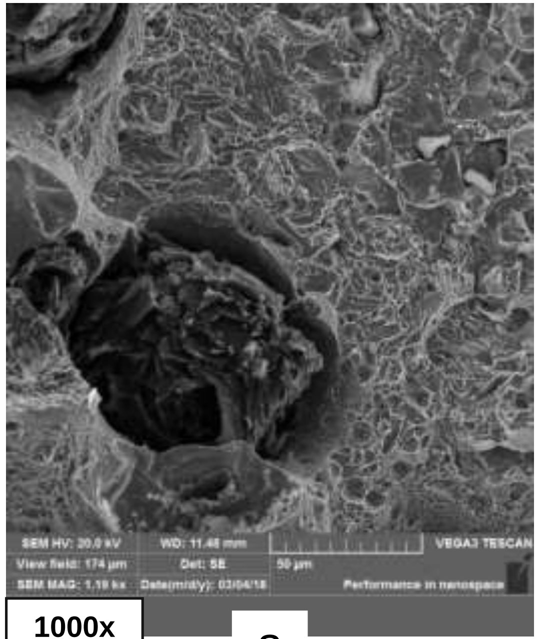
500x



1000x

Microvoids (dimples) proves that the fracture ise **ductile overload**

SEM images of the fracture surface of the sample in;
a) Austempered at 320 ^{0}C / 30 min b) Austempered at 320 ^{0}C / 180 min



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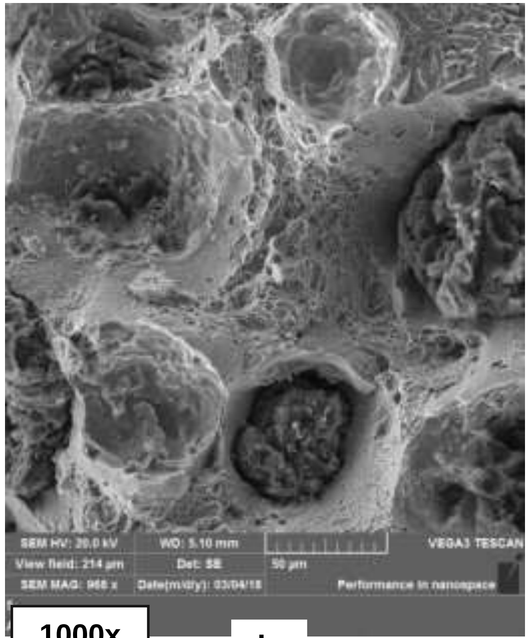
a



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b

30-minute austempered specimen shows **cleavage** fracture and for 180 minutes exhibited a **partially dimpled** ductile, and **partially cleavage** fracture mode

As the austempering time increases, the reason for the fracture mode to partially pass from brittle to ductile can be attributed to the displacement of the microstructure by martensite as the austempering time increases.

EXPERIMENTAL FINDINGS AND EVALUATION

Conclusion

1. The yield and tensile strengths of the austempered samples were increased three times compared to the samples in as-casted conditions.
2. The experimental results showed that the best strength-ductility combination results of the samples exhibited austempering at 320 ° C for 180 minutes.
3. It was observed that the fracture mode was passed from the brittle to ductile as the austempering time increased.


THANK YOU