INSTITUTO DE PESQUISAS TECNOLÓGICAS

COMUNICAÇÃO TÉCNICA

Nº 179291

Effects of heat treatment time on the microstricuture and some mechanical properties of C36000 BRASS

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Palestra apresentado no CONGRESSO ANUAL DA ABM, 77., 2024, São Paulo.
Anais... *14 slides.*

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EFFECTS OF HEAT TREATMENT TIME ON THE MICROSTRUCUTURE AND SOME MECHANICAL PROPERTIES OF C36000 BRASS

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September 5, 2024

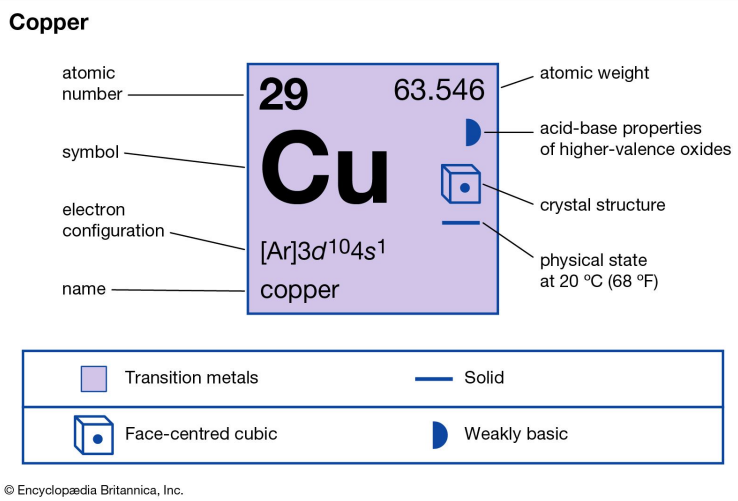
Introduction

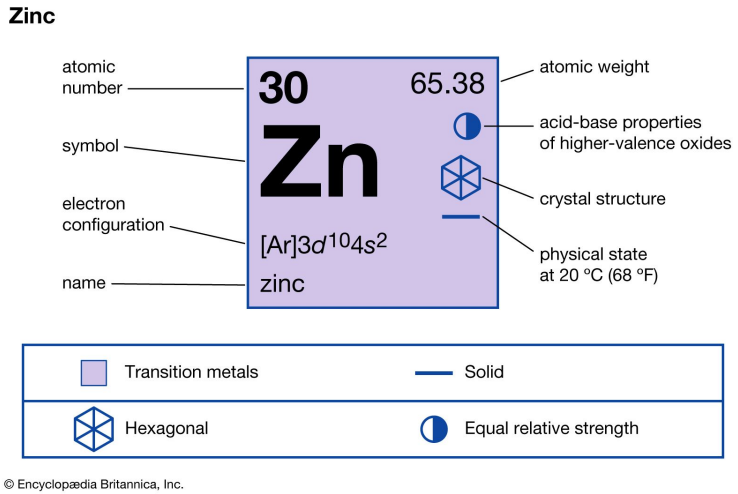
What is Brass and why is it used?

- ✓ Copper + Zinc alloy
- ✓ Excellent combination of physical and mechanical properties
  - ✓ Corrosion resistance
  - ✓ Thermal and electrical conductivity,
  - ✓ Conformability, and machinability

Main commercial alloys

- ✓ α brass alloys
- ✓ Dual phase brass alloys (α + β brasses)
- ✓ β brass alloys





Introduction

Dual phase brass alloys

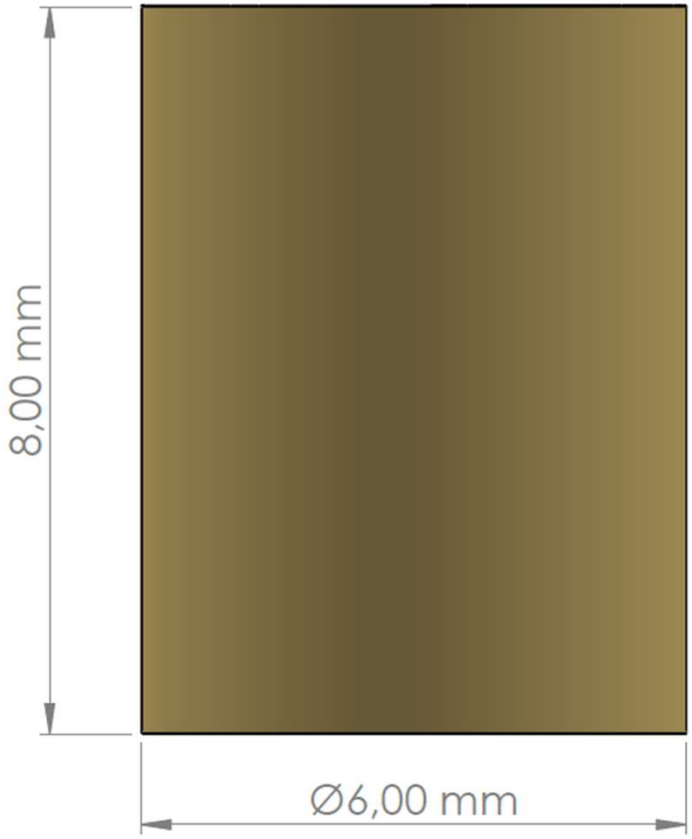
- ✓ Complex Mechanical behavior
  - ✓ α phase → better cold formability, corrosion resistance
  - ✓ β phase → harder phase, excellent hot plasticity

Brass Alloy UNS-C36000

- ✓ Dual phase brass alloys with 3%Pb
  - ✓ α matrix
  - ✓ β phase
  - ✓ Lead nodules
- ✓ Effect of lead presence
  - ✓ Better machinability
  - ✓ Possible deleterious effects on formability

Experimental procedure

Specimens preparation and Heat treatment



Geometry of the specimens intended for mechanical and microstructural characterization

Material

- ✓ Extruded wires of C36000 brass alloys
- ✓ 2 specimens per condition: Microestrutural characterization and Mechanical characterization

Heat Treatment

- ✓ Muffle-type electric resistance furnace
- ✓ Air atmosphere
- ✓ Times at 790 °C → 30 min, 90 min, 150 min, 270 min and 480 min
- ✓ Water quenching

Experimental procedure
Microstructure and Mechanical Characterization

Microstructure Characterization

- ✓ Optical Microscopic
- ✓ SEM Analyses

} Phases analyses and quantification

- ✓ XRD Analyses
- ✓ EDS Analyses

} Phases identification

Mechanical Characterization

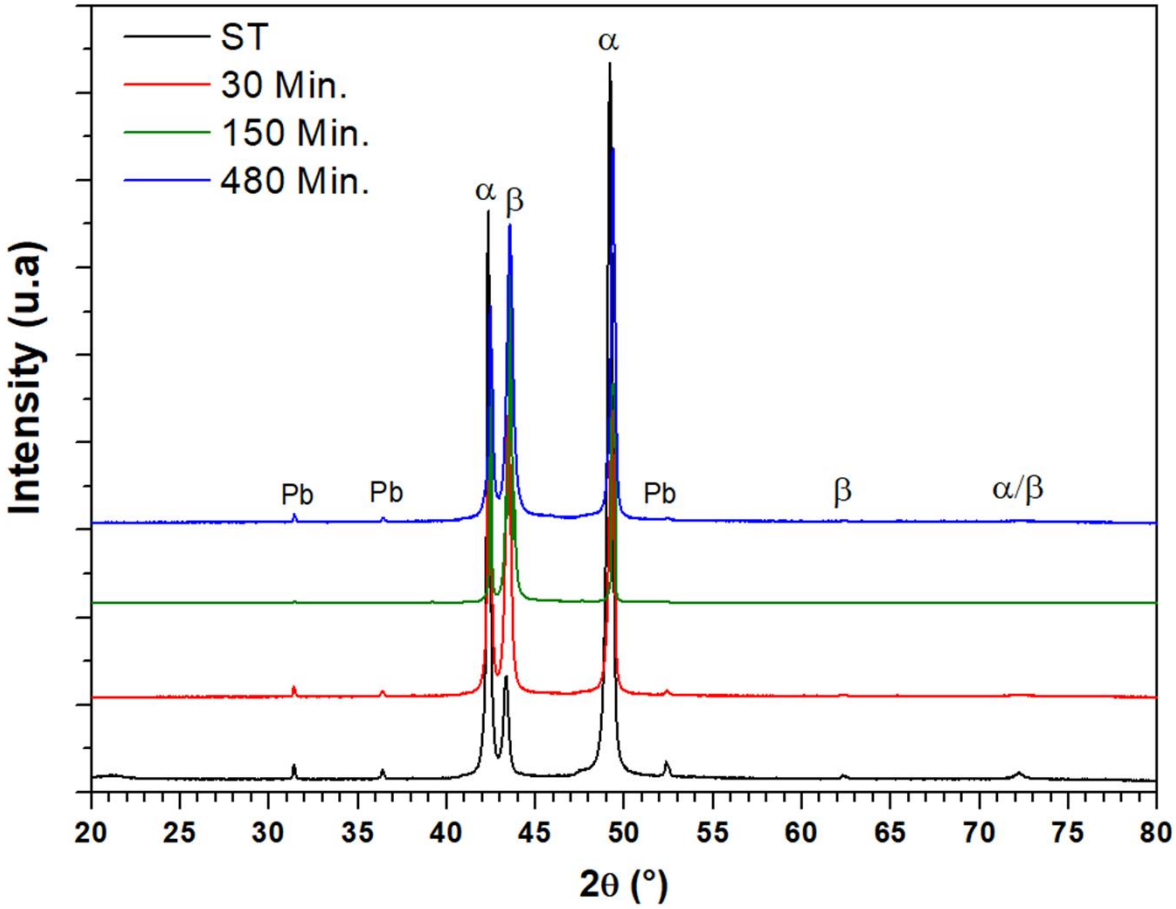
- ✓ Vickers Hardness test
  - ✓ ASTM E384-17
- ✓ Compression tests
  - ✓ ASTM E9-19

Results and Discussion

Microstructural Characterization

Phases identified with XRD:

- ✓ α phase
- ✓ β phase
- ✓ Pb peaks



XRD diffractograms of the as-received specimen and specimens annealed for 30, 150, and 480 minutes at 790°C of the C36000 Brass.

Results and Discussion
Microstructural Characterization

SEM-EDS analysis:

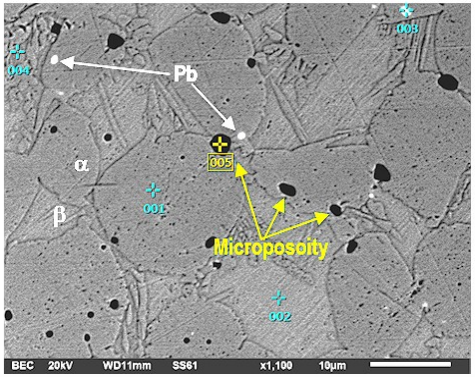
- ✓ Biphasic microstructure:
  - ✓ $\alpha + \beta$
- ✓ Chemical composition difference between phase
  - ✓ α phase → ~ 34.4% Zn
  - ✓ β phase → ~ 39.5% Zn

Shorther annealing times (30 min)

- ✓ Presence of dendrites and secondary α phase lamellae

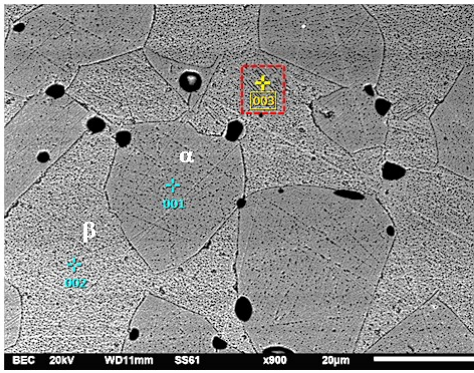
Analysed point	% wt / EDS-SEM				Phase
	Cu	Zn	Pb	Sn/Fe	
+001	65,7	34,3			α
+002	60,3	39,6		0,1	β
+003	54,5	31,5	12,0	0,3	Pb
+004	58,5	41,2			β
+005	57,8	32,9		Others (O, Al, Si, P, S, Ca)	porosity

specimens: 790 °C / 30 min – Center
(a)



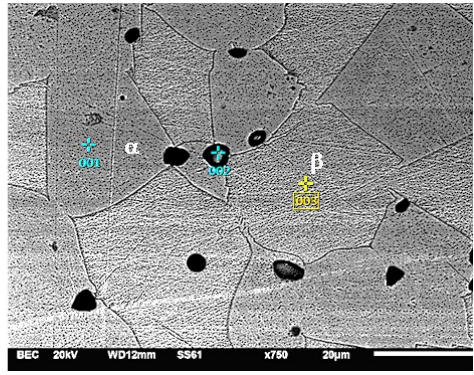
Analysed point	% wt / EDS-SEM				Phase
	Cu	Zn	Pb	O/Si/Sn	
+001	65,3	34,7			α
+002	60,6	39,2		0,2	β
+003	60,2	39,5		0,2	α Phase lamellae in β

specimens: 790 °C / 150 min – Center
(b)



Analysed point	% wt / EDS-SEM				Phase
	Cu	Zn	Pb	O/Si/Sn	
+001	65,4	34,6			α
+002	64,3	35,4		Others	porosity
+003	60,5	39,3	0,2		β

specimens: 790 °C / 480 min – Center
(c)



SEM (backscattered electron mode) images of C36000 brass: (a) Central region annealed for 30 minutes, (b) Central region of specimen annealed for 150 minutes, and (c) Central region of specimen annealed for 480 minutes, all at 790°C.

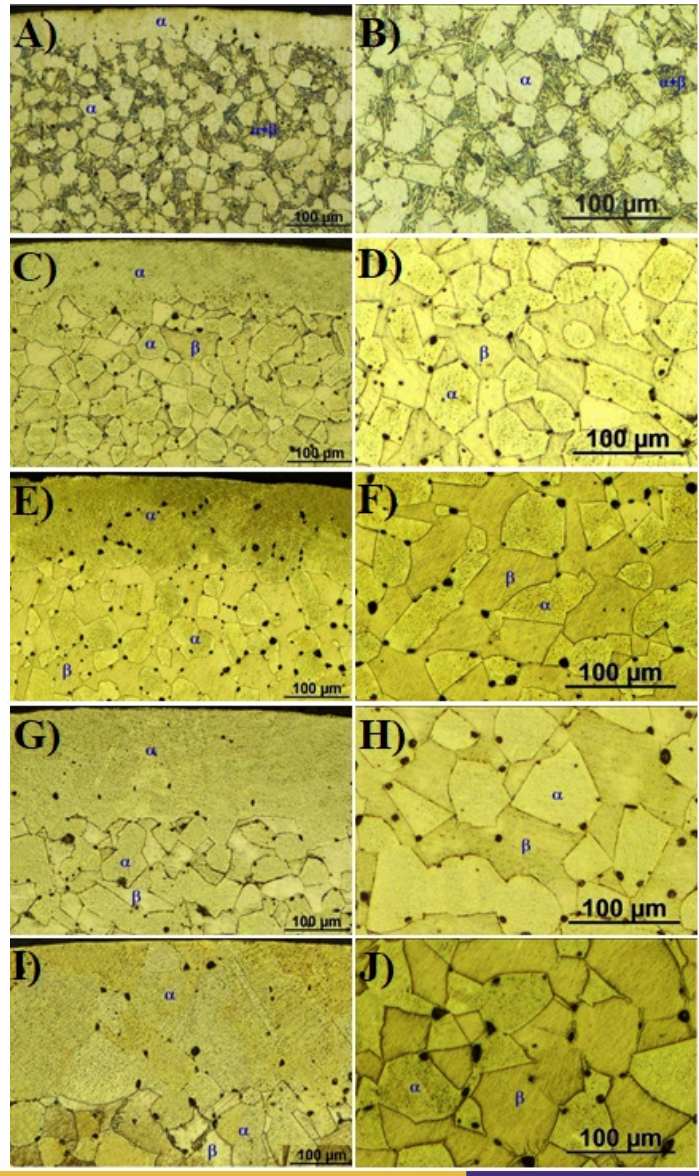
Results and Discussion
Microstructural Characterization

Similar characteristics observed with SEM

- ✓ Biphasic microstructure:
  - ✓ $\alpha + \beta$
- ✓ Microporosity

Edge region

- ✓ Increased annealing time → increased edge size

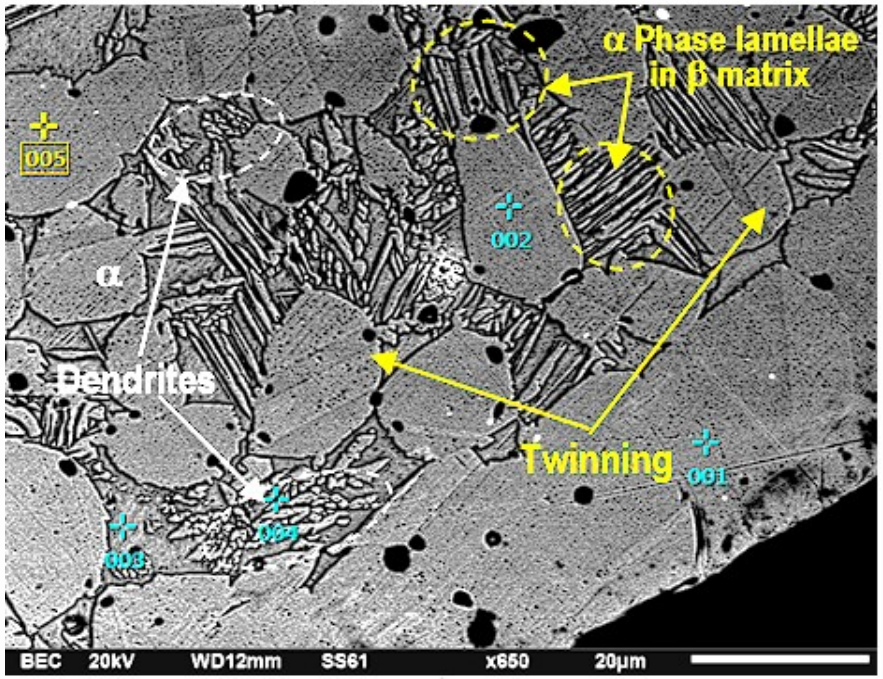


Optical micrographs of C36000 brass after heat treatment at 790°C for A) 30 min - Edge region, B) 30 min - Center Region, C) 90 min - Edge region, D) 90 min - Center Region, E) 150 min - Edge region, F) 150 min - Center Region, G) 270 min - Edge region, H) 270 min - Center Region, I) 480 min - Edge region and J) 480 min - Center Region

Results and Discussion
Microstructural Characterization

Dezincification

- ✓ Detected by SEM-EDS analysis)
  - ✓ Point 001
- ✓ Loss of Zn present in the alloys
  - ✓ Zinc-poor phase
- ✓ Processes favoured by the presence of the β/β' phase and by the increase in grain size



Analysed point	% wt / EDS-SEM				Phase
	Cu	Zn	Pb	Sn/Fe/Al	
+001	67,2	31,8			α
+002	65,6	34,5			α
+003	60,3	39,5		0,2	β
+004	62,3	37,5		0,2	β
+005	65,7	34,3			α

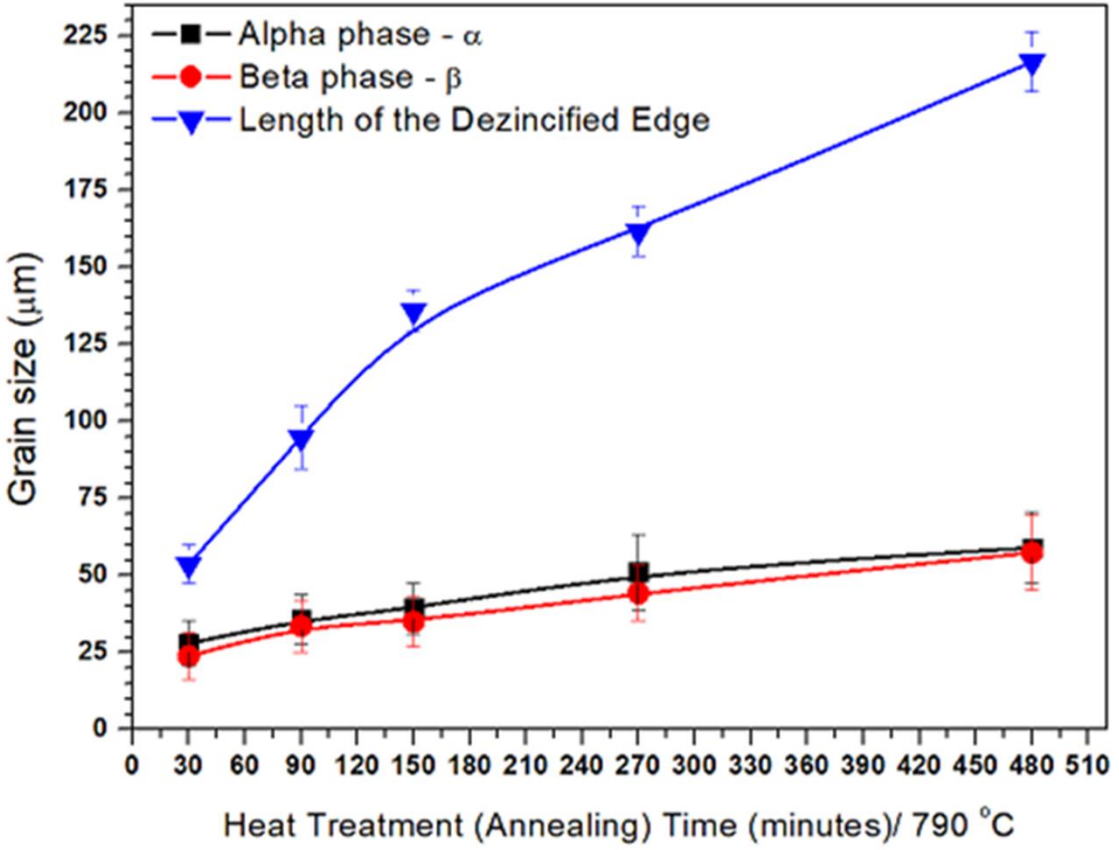
SEM (backscattered electron mode) images of C36000 brass specimen annealed for 30 minutes (Edge region)

Results and Discussion

Microstructural Characterization

Increase in annealing time

- ✓ Increase in the length of dezincified edge
- ✓ Increase in grain size
  - ✓ ~ 9,6 µm (as-received) → 59 µm (480 min at 790 °C)



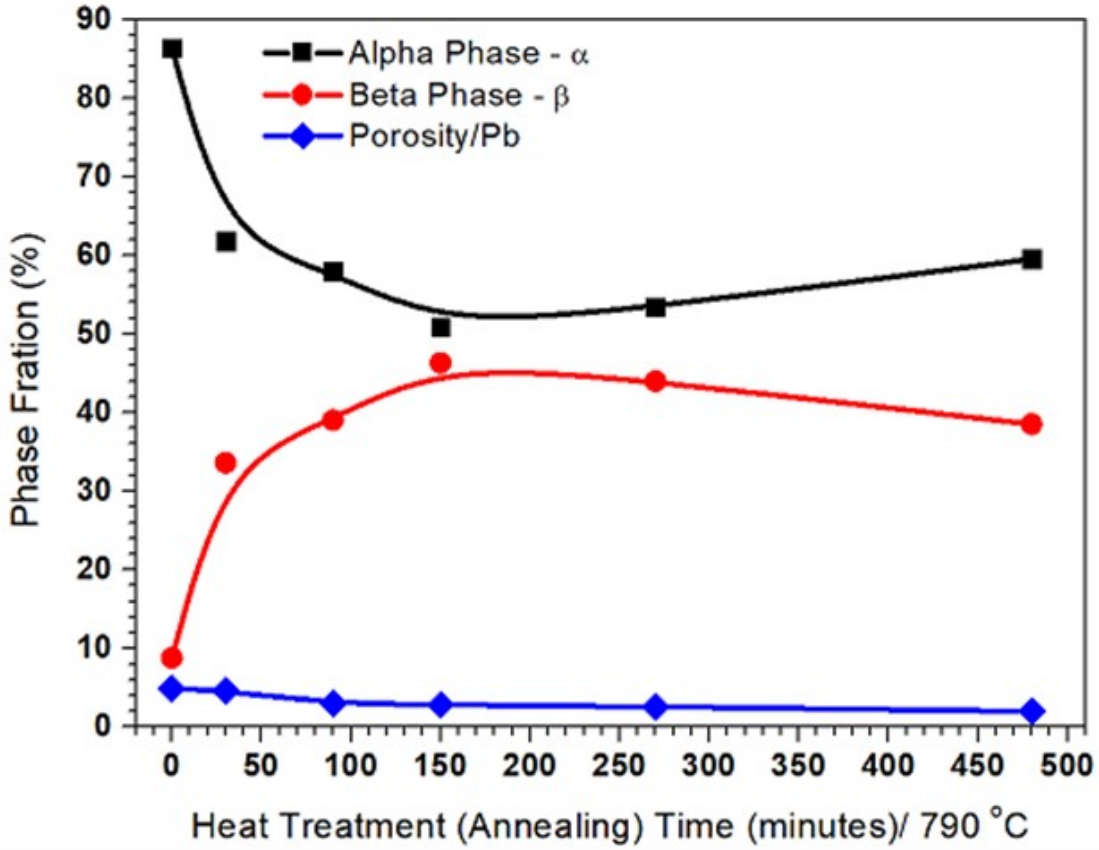
Grain size and length of the Dezincified Edge of specimens annealed for 30, 90, 150, 270, and 480 minutes at the temperature of 790°C, and the specimen in the as-received condition

Results and Discussion

Microstructural Characterization

Phase fraction

- ✓ As-received condition: ~ 8,6% of β phase
- ✓ For annealing times up to 150 min
  - ✓ Rapid increase in β phase (Maximum fraction: ~ 48%)
  - ✓ Reduction in α phase
- ✓ Times exceeding 150 min → stabilization of phase fractions



Volume fraction of phases α, β, and microporosity of specimens annealed for 30, 90, 150, 270, and 480 minutes at the temperature of 790°C, and the specimen in the as-received condition

Results and Discussion
Mechanical Characterization

High compressive strain

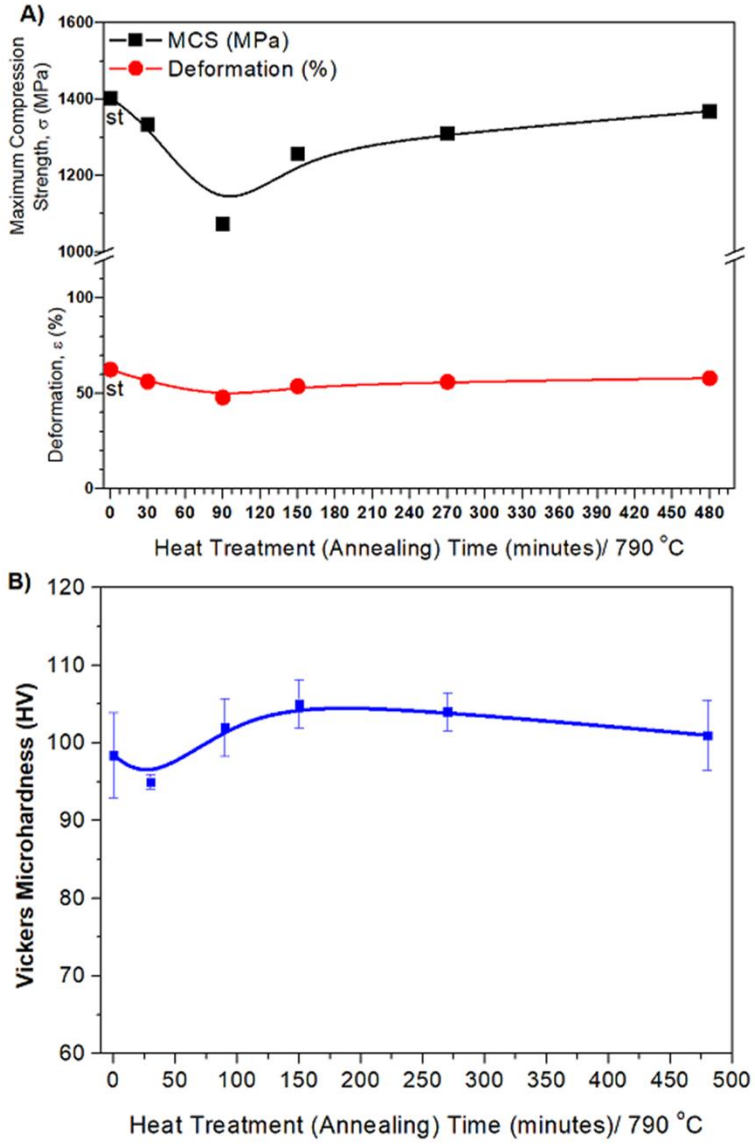
- ✓ Between 50% and 60% (regardless of annealing time)

Annealing times up to 90 min

- ✓ Decrease in mechanical resistance (MCS) and hardness
  - ✓ Stress relief + grain growth

Annealing times above 90 min

- ✓ Increase in MCS
- ✓ Decrease in hardness (times above 270 min/790°C)



a) Maximum compressive strength and strain as a function of annealing temperature, and b) Vickers microhardness as a function of annealing time at 790 °C for 30, 90, 150, 270, and 480 minutes

Conclusion

After evaluating the results, it can be concluded that:

- ✓ All specimens, regardless of heat treatment time, exhibited a biphasic microstructure composed of α phase and β phase, as observed through various microstructural characterizations.
- ✓ An increase in grain size and edge length with increasing heat treatment time was noted, indicating dezincification (loss of zinc in certain regions) and the formation of a coarse layer on the outer edge of the samples richer in copper and poorer in zinc (α phase).
- ✓ Specimens subjected to 30 and 90 minutes of treatment showed a reduction in mechanical strength, suggesting stress relief during this period.
- ✓ Longer treatment times at 790°C resulted in the maximum fraction of the β phase, leading to a slight increase in mechanical strength. The slight decrease in hardness can be associated with the increase in grain size. Further studies are needed to better understand the observed trend of increased mechanical strength and decreased hardness.

Thank you

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