INSTITUTO DE PESQUISAS TECNOLÓGICAS

COMUNICAÇÃO TÉCNICA

Nº 179290

Effects of heat treatment temperature 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. 14 slides.

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

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September 3, 2024

Introduction

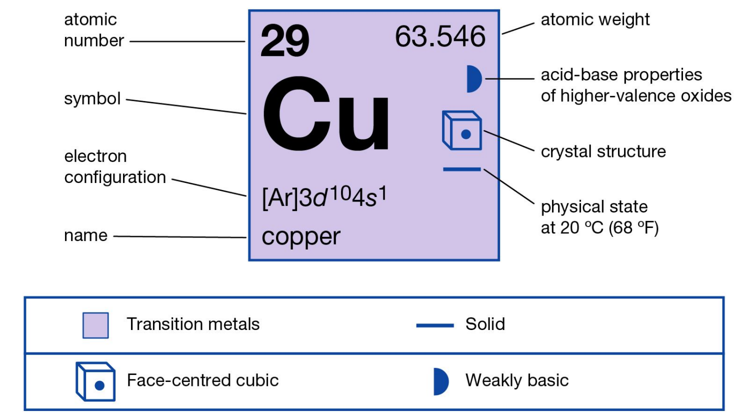
What is Brass and why is it used?

- ✓ Copper alloy with addition of Zinc (Zn)
- ✓ Excellent combination of physical and mechanical properties
  - ✓ high corrosion resistance
  - ✓ high thermal and electrical conductivity,
  - ✓ good formability, and machinability

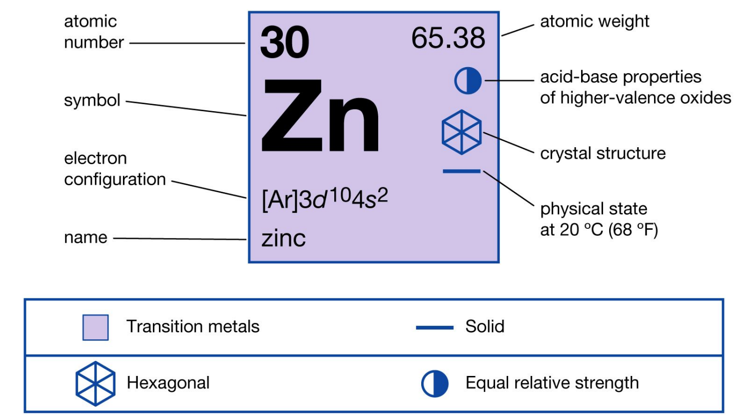
Main commercial alloys

- ✓ α brass alloys
- ✓ Dual phase brass alloys ($\alpha + \beta$ brasses)
- ✓ β brass alloys

Copper



Zinc



Introduction

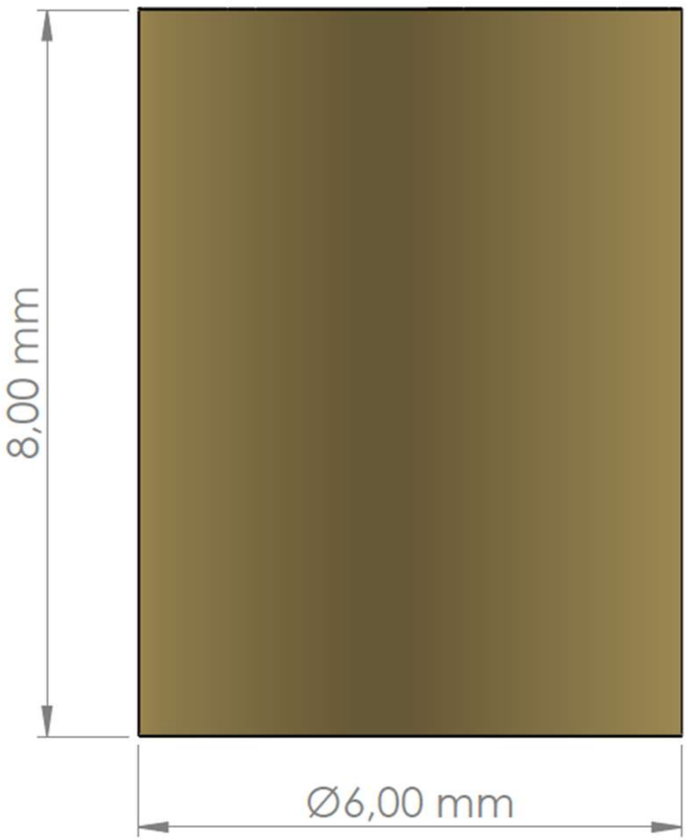
Dual phase brass alloys

- ✓ 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
- ✓ 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
- ✓ Temperatures → 250 °C to 850 °C / 1h
  - ✓ 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

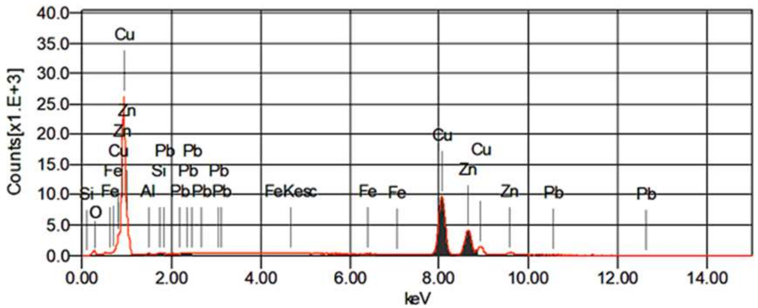
Results and Discussion
Characterization of brass as received

3 microconstituents

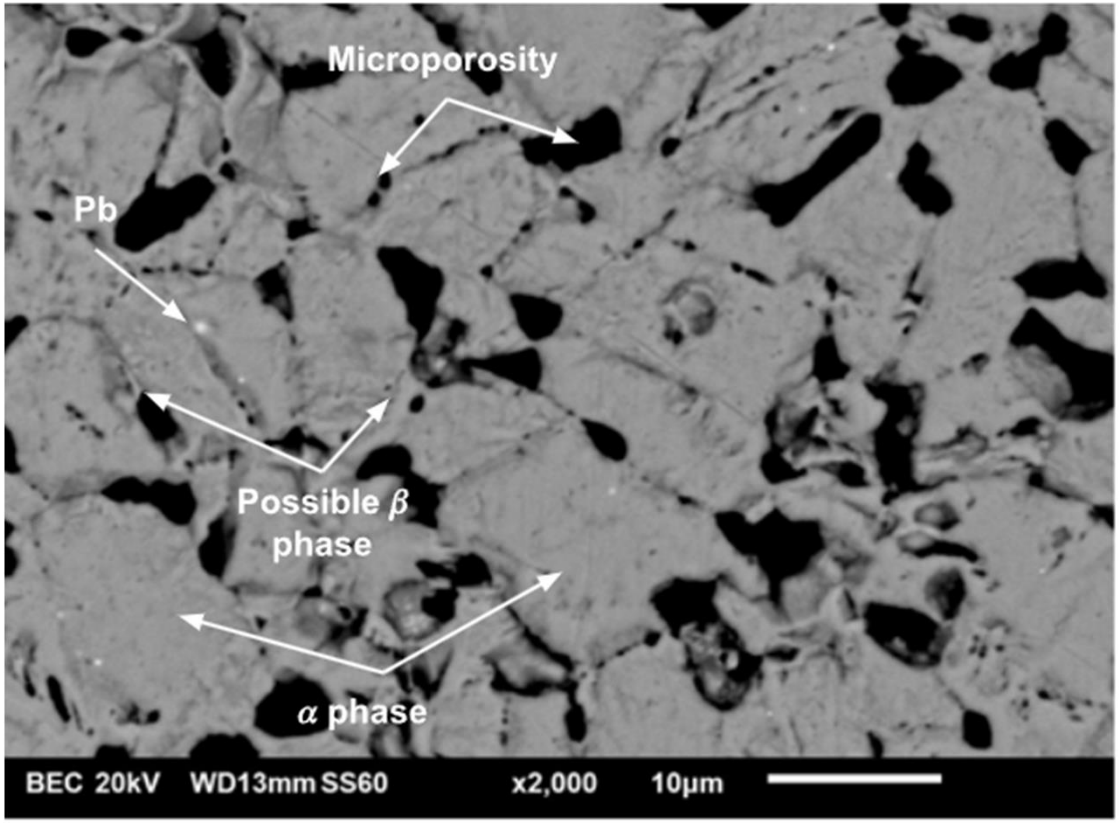
- ✓ White dots → lead (Pb) particles
- ✓ Light gray phase → α phase
- ✓ Darker gray phase → β phase

Average grain size → (9.6 ± 0.6) μm

Black regions → microporosity



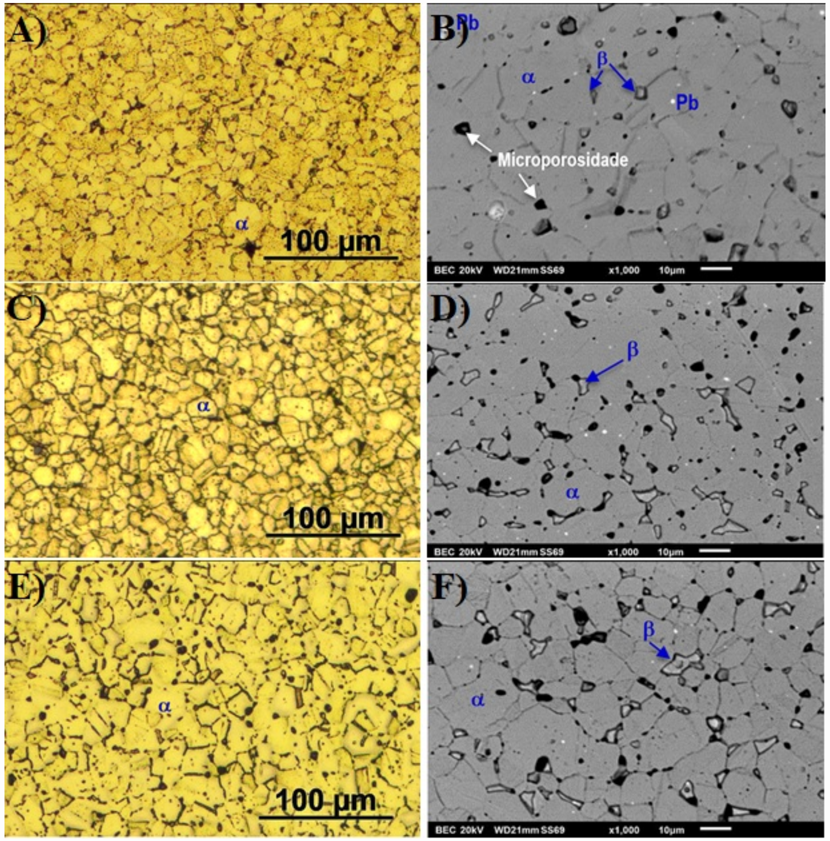
EDS Spectrum from a Microporosity in the Microstructure of Brass C36000 as received



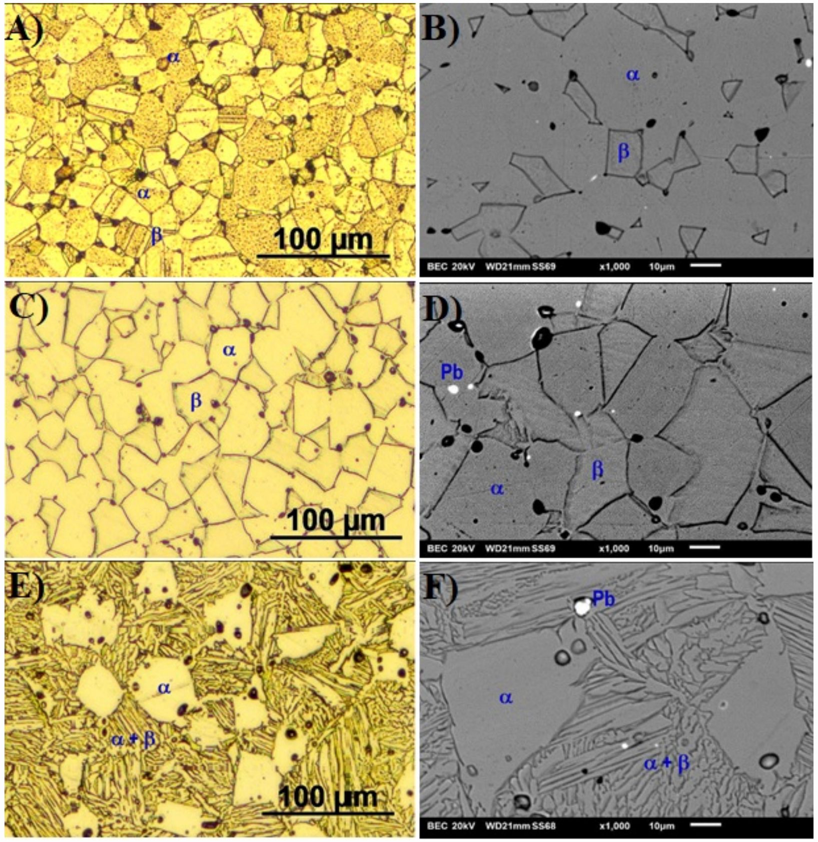
SEM image (backscattered electron mode) of C3600 Brass as received

Results and Discussion

Microstructural Characterization



Micrographs of C36000 Brass after annealing at temperaturas A) 250 °C-1h (OM), B) 250 °C-1h (SEM), C) 400 °C-1h (OM), D) 400 °C-1h (SEM), D) 550 °C-1h (OM) and E) 550 °C-1h (SEM)

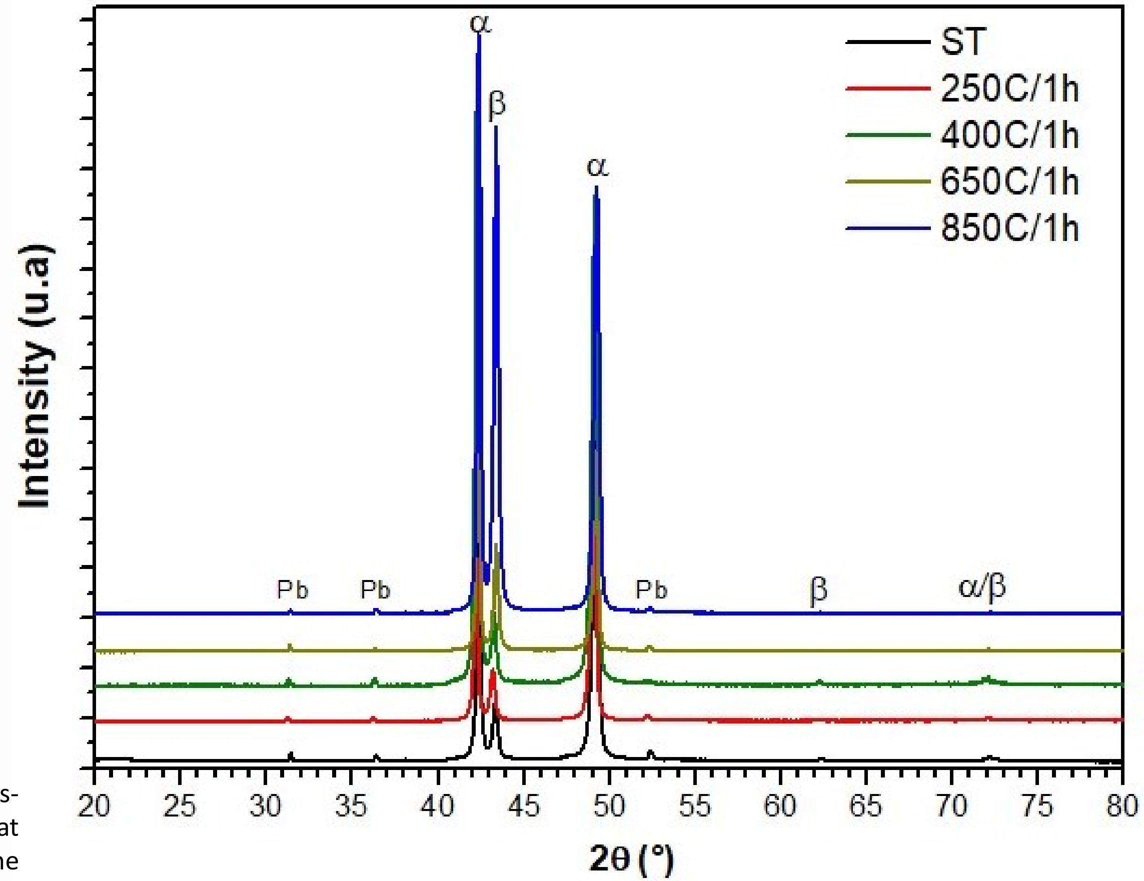


Micrographs of C36000 Brass after annealing at temperatures A) 650 °C/1h (OM), B) 650 °C/1h (SEM), C) 750 °C/1h (OM), D) 750 °C/1h (SEM), E) 850 °C/1h (OM) and F) 850 °C/1h (SEM)

Results and Discussion
Microstructural Characterization

<u>Phases identified with XRD:</u>

- ✓ α phase
- ✓ β phase
- ✓ Pb peaks



X-ray diffraction (XRD) patterns of the as-received sample and samples annealed at 250, 400, 550, 650, 750, and 850°C from the sample extruded at 790°C – C36000 Brass.

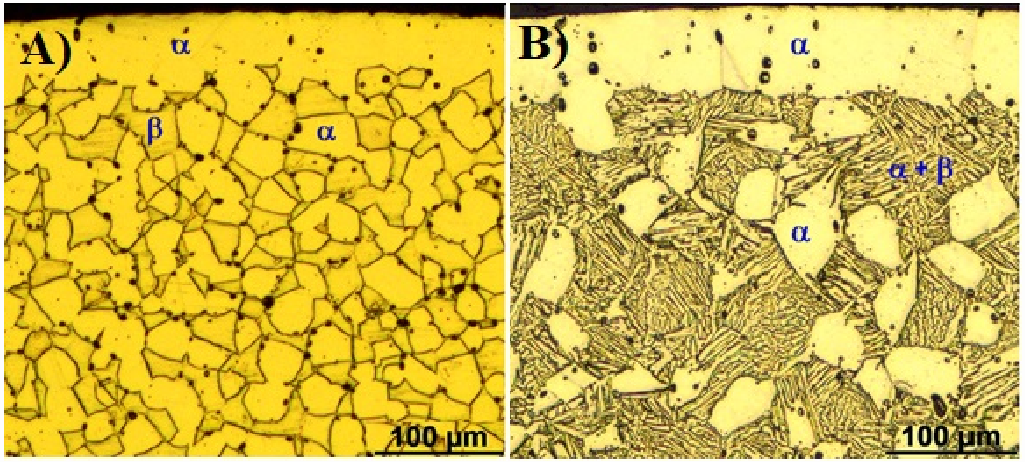
Results and Discussion
Microstructural Characterization

Stable grain size up to approximately 400 °C

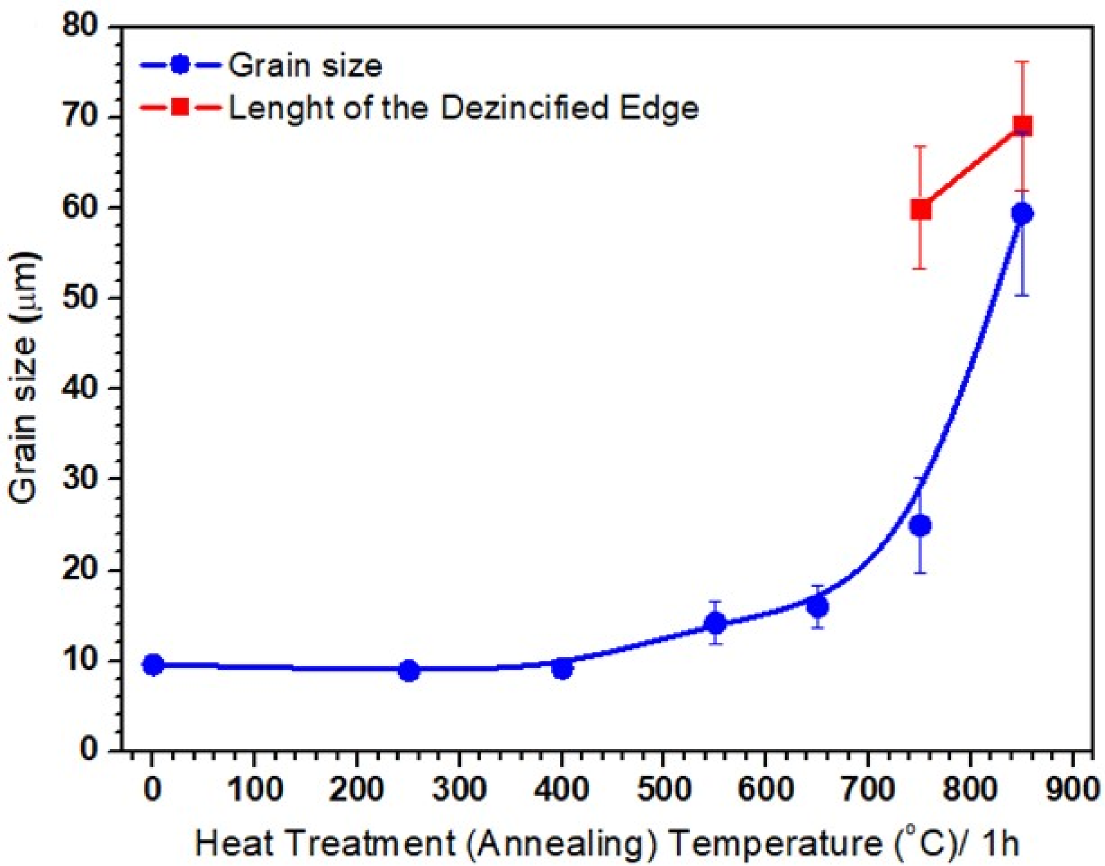
- ✓ ~ 10 µm

Treatments above 400 °C

- ✓ Exponential growth → ~ 59 µm at 850 °C/1h
- ✓ Behavior consistent with the literature



Optical micrographs of the edge region of samples treated at A) 750°C and B) 850°C for one hour.



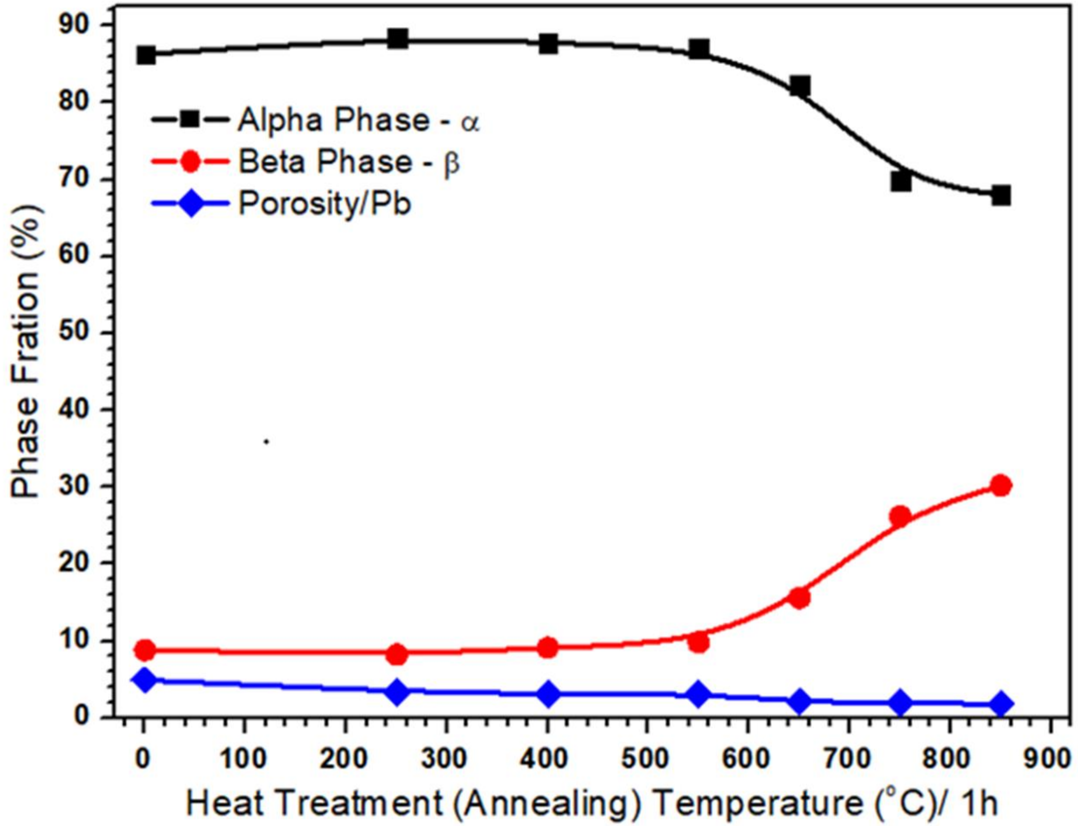
Grain size and length of the Dezincified Edge of samples annealed at temperatures of 250, 400, 550, 750, and 850°C for one hour.

Results and Discussion

Microstructural Characterization

<u>**Phase fraction**</u>

- ✓ Decrease of α phase
- ✓ β phase fraction → Similar behavior as grain size evolution
  - ✓ Stable up to 400 °C
  - ✓ Significant increase at temperatures above
  - ✓ 850 °C/1h → ~ 30%



Volume fraction of phases α, β, and microporosity of samples annealed at temperatures of 250, 400, 550, 750, and 850°C for one hour.

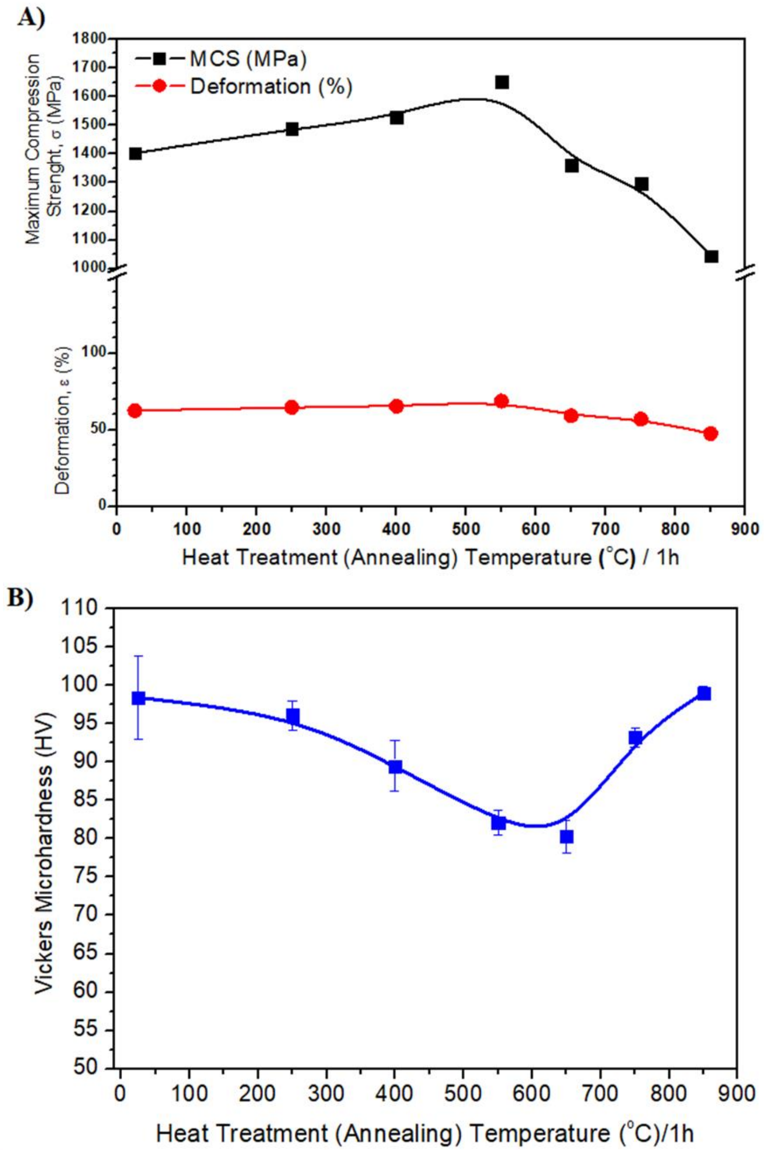
Results and Discussion
Mechanical Characterization

Maximum Compressions Strenght

- ✓ Increase in mechanical resistance (MCS) with increasing annealing temperature up to 550°C

Temperatures above 550°C

- ✓ Decrease in MCS and deformation
    - ✓ Significant increase in the fraction of β phase and grain size
- ✓ Increase in hardness
    - ✓ Significant increase in the fraction of β phase



a) Maximum compressive strength and strain as a function of annealing temperature, and b) Vickers microhardness as a function of annealing temperature, at 250, 400, 550, 650, 750, and 850°C for 1h.

Conclusion

After evaluating the results, it can be concluded that:

- ✓ Specimens did not show significant grain size changes when annealing treatment was performed between 250°C and 400°C, indicating that under these conditions, the grain size remains practically stable.
- ✓ Annealing temperatures above 400°C result in exponential grain growth, as well an exponential growth in the β-phase fraction.
- ✓ Regarding dezincification, for the one-hour heat treatment time, it can be concluded that it only becomes a concern at temperatures above 750°C, since only the specimens treated at 750°C and 850°C exhibit dezincification characteristics.
- ✓ From a mechanical properties standpoint, there was increase in the mechanical strength with increasing temperature up to 550°C. However, there was a decrease in mechanical strength and an increase in hardness at temperatures above 550°C due to the increase in volume fraction and grain size of the β-phase, which is harder and less ductile than the α-phase. Further studies are needed to better understand the observed behaviors.

Thank you

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