Effect of Stress Relief Annealing and Homogenizing Annealing on the Microstructure and Mechanical Properties of Cast Brass.

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ABSTRACT

The effects of stress relief annealing and homogenizing annealing on the microstructure and mechanical properties of cast brass were studied. The test samples were heated to 200°C, 230°C, and 260°C for stress relief annealing. Other sets of samples were heated to 650°C, 680 °C, 700°c, 750 °C, and 800°C, respectively, for homogenizing annealing. Each test sample was held at the test temperature for one hour and furnace cooled to room temperature.

The microstructural changes during stress relief annealing and homogenizing annealing were studied. Mechanical properties such as tensile strength, hardness, yield strength, and impact strength were also studied. It was observed that stress relief annealing has little or no effect on the microstructure and mechanical properties of each cast brass while homogenizing annealing increases the impact strength but reduces the tensile strength, yield strength, and hardness as a result of elimination of the brittle phase, or intercrystalline segregation, present in the cast brass.

(Keywords: cast bras, stress relief annealing, homogenizing annealing, microstructure, mechanical properties)

INTRODUCTION

Cast brass has poor mechanical properties due to the presence of residual stress and the presence of concentration differences in the material as a a result of non-equilibrium solidification known as coring (Higgin, 1983).

According to Rajan et al. (1988), stress relief annealing carried out on the as cast brass will relieve internal stresses generated during solidification of the casting while homogenizing annealing will eliminate micro-segregation caused by non-equilibrium solidification and different composition.

This research project seeks to investigate the response of cast brass to both stress relief annealing and homogenizing annealing.

MATERIALS AND METHODS

The material made use of for this research is a cast brass with the chemical composition shown in Table I. The brass was cast to specification using a crucible furnace fired with oil. The final analysis of the melt was taken to ascertain the actual chemical composition. The samples were then machined to specification for tensile test, impact test, and hardness test.

Sets of nine samples were subjected to both stress relief annealing and homogenizing annealing while a set of samples were left as control samples.

All the test samples were subjected to tensile test, impact test, hardness test, and microstructural examination.

RESULTS AND DISCUSSIONS

Variation of the mechanical properties with annealing temperatures are shown in Figures 1-4 while the photomicrographs at the annealing temperatures are shown in Figures 5-13.

Figure 1 shows that tensile strength of the annealed sample decreases as annealing temperature increases. It is noticed that there is no remarkable decrease in the values for the sample which were stress relieved at $230^{o}C$ and $260^{o}C$ while there is a remarkable decrease in the values of samples that were homogenized ($650^{o}C$-$800^{o}C$). This was because the brittle phase present in the structure of cast brass could not be dissolved by stress relief annealing but were dissolved into the phase during homogenizing annealing (Rajah et al., 1988).

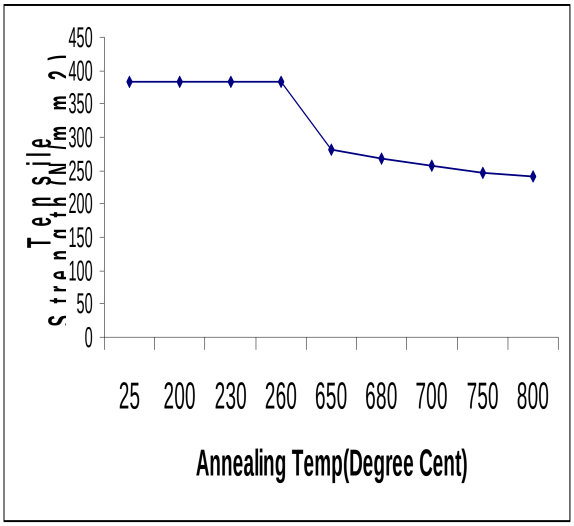

Figure 1: Variation of Tensile Strength with Annealing Temperature.

Figure 2 shows that hardness value follows the same trend as tensile strength. This is attributed to the fact that homogenizing annealing has softened the metal by the dissolution of the hard phase present in the structure. it is also observed that stress relief annealing has little or no effect on hardness value.

Figure 3 shows that impact strength values increase as annealing temperature increases. It is noticed that the increment is not pronounced during stress relief annealing but there is a mark increase in the impact strength for the homogenized samples. According to Raghram, 1989, dendritic intracrystalline segregation (which increases the susceptibility of metal to brittle failure) present in the cast brass could not be removed by stress relief annealing but were eliminated by homogenizing annealing.

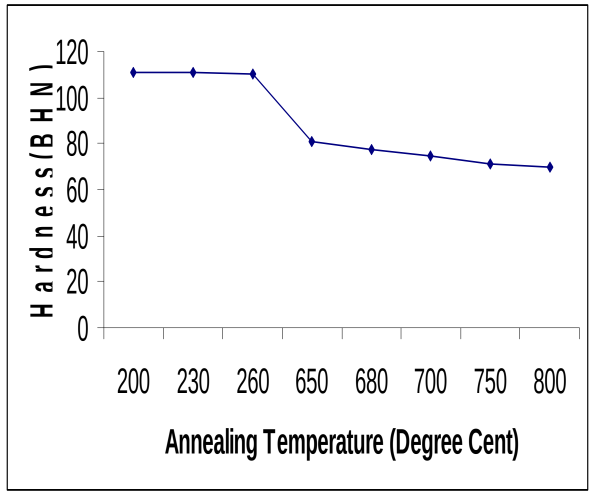

Figure 2: Variation of Hardness with Annealing Temperature.

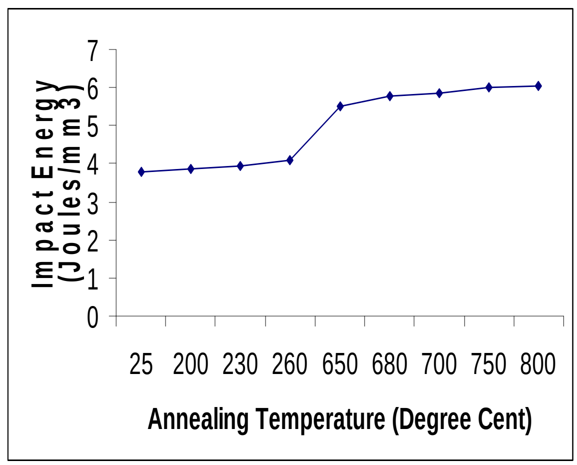

Figure 3: Variation of Impact Energy with Annealing Temperature.

Dendritic segregation reduces ductility and toughness of cast brass. Impact tests are almost direct measurements of ductility. Hence, from this result, it can be said that homogenizing annealing promotes ductility more than stress relief annealing.

Figure 4 shows that the trends of yield stress with annealing temperature. It is observed from the graph that the yield stress decreases as annealing temperature increases. The reason for this is that layer of atoms tend to move when annealed. They were loose from the neighboring bonds holding back slip. Therefore, when free, the dislocation could move at a lower stress which was related to the lower yield point as annealing temperature increases.

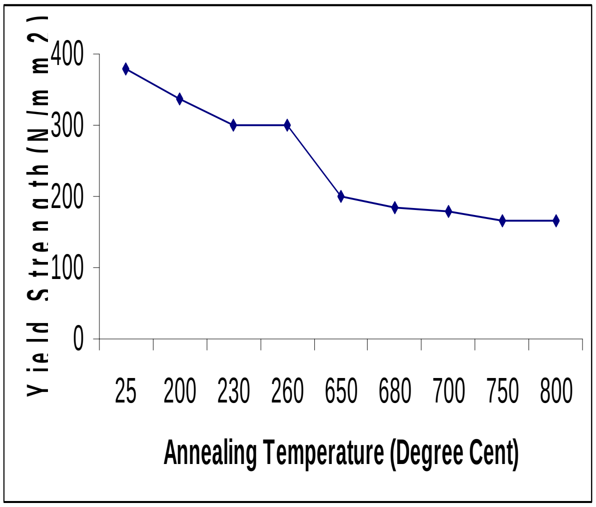

Figure 4: Variation of Yield Strength with Annealing Temperature.

Figures 5-13 show the microstructure of the test samples. Figure 5 shows the as cast sample. This type of brass shows single phase alloy known as alpha brass. in addition to intracrystalline segregation present in the as cast structure, voids which are black colors are also present in the structure. Voids are formed as a result of impurities, sand inclusion and trapped gases.

Figure 6 shows the structures as stress relieved at 200^{0}C. It shows that there is no structural change noticed though some changes must have taken place in the energy level.

Figures 7 and 8 show the dendritic structure of the cast brass after it was stress relieved at 230^{o}C and 260^{o}C, respectively. The voids (inclusions) are also seen in the structures. This is because, according to Rajah et al. (1989), stress relief annealing is unable to eliminate the inclusions.

Figures 9, 10, 11, 12, and 13, which are samples homogenized, show gradual reduction in the degree of dendritic structure as homogenizing temperature increases. It is observed that the brittle phase is more pronounced in Figure 9 and 10 than in Figures 11, 12, and 13. This is due to the fact that diffusion is fast and completed at elevated temperature (Donal and Wilber, 1987)

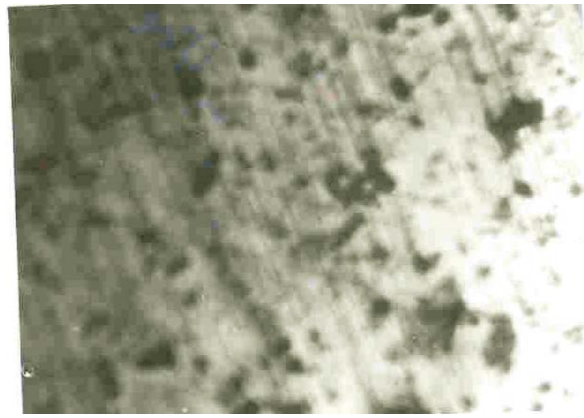

Figure 5: As Cast (Not Heat-Treated) Etched in Acidified Iron (111) Chloride. (X100).

Figure 6: Stress Relieved @2000C (1hr) Etched in Acidified Iron(111) Chloride. (X100).

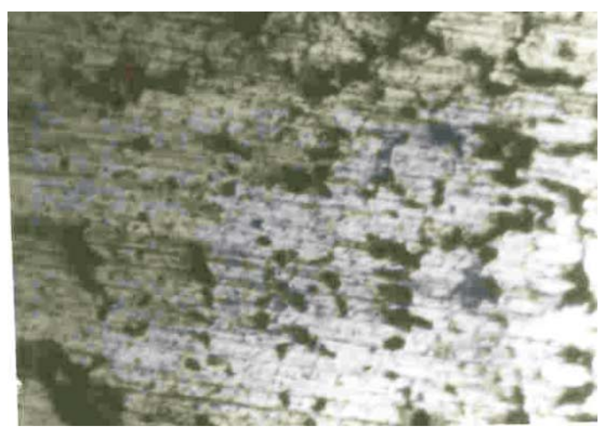

Figure 7: Stress Relieved @2300C (1hr), Etched in Acidified Iron (111) Chloride (X100).

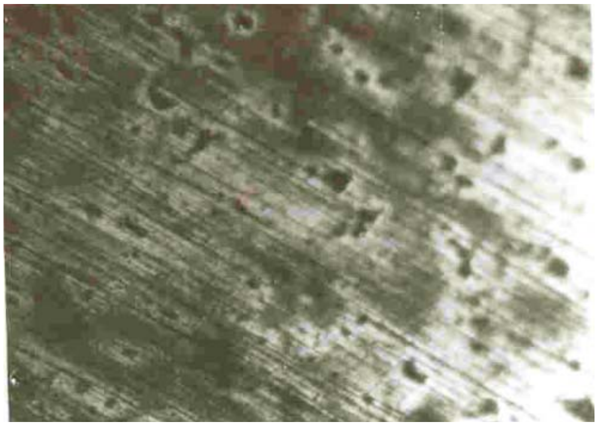

Figure 8: Stress Relieved @2600C (1hr) Etched in Acidified Iron(111) Chloride. (X100).

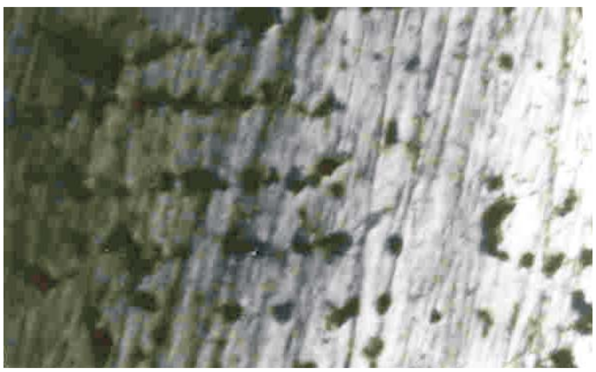

Figure 9: Homogenized @6500c (1hr) Etched in Acidified Iron(111) Chloride. (X100).

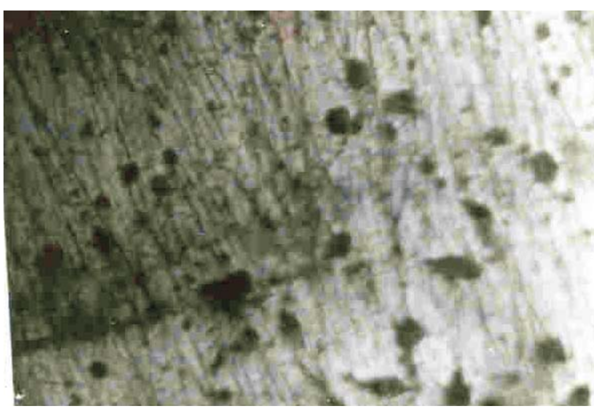

Figure 10: Homogenized @6800C Etched in Acidified Iron(111) Chloride. (X100).

Figures 9, 10, and 11 show that they were partially homogenized because traces of coring are noticed in them while structure in Figures 12 and 13 were fully homogenized because only boundaries and porosity are left in the structure, but no traces of dendrite.

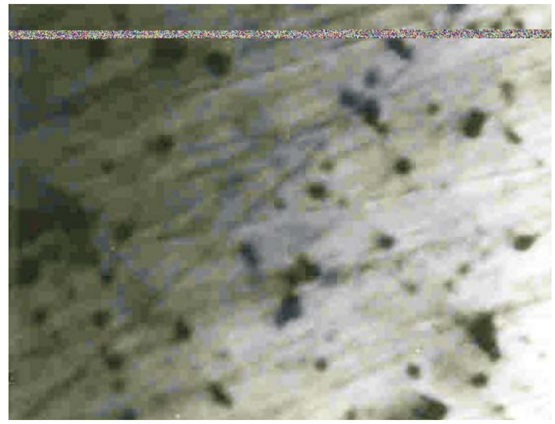

Figure 11: Homogenized @7000C (1hr) Etched in Acidified Iron(111) Chloride. (X100).

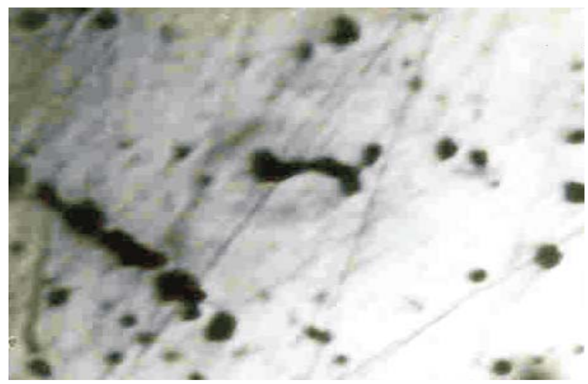

Figure 12: Homogenized @ 7500C Etched in Acidified Iron(111) Chloride. (X100).

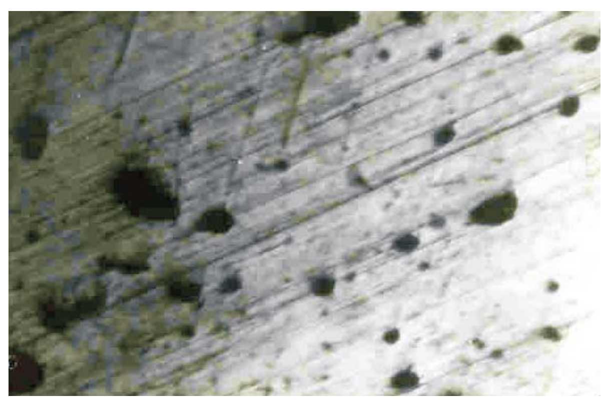

Figure 13: Homogenized @8000 (1hr) Etched in Acidified Iron(111) Chloride. (X100).

It clearly shows that homogenizing annealing can not completely eliminate voids but the number of voids can be reduced.

According to Nivikov (1978), during homogenizing annealing, the quantity of point defects was reduced and the dislocations were redistributed but no new subgrain boundaries were formed. Surplus vacancies and interstitial atoms were absorbed by the dislocation when the latter redistributed on heating. Besides, the vacancies migrated to the grain boundaries thereby reducing the vacancy concentration.

CONCLUSION

The cast brass has a high degree of coring as a result of non-equilibrium solidification during casting and that this coring can be eliminated by homogenizing annealing and not by stress relief annealing. It can also be concluded that the impact energy and ductility of the cast brass increase as the homogenizing temperature increases and that the hardness, yield strength and tensile strength decrease with an increase in the homogenizing temperature.

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