Tempering characteristics of a Cu-Al-Ag alloy

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ALUMINIUM-BRONZES, particularly those containing 10% or more of aluminium, have a great potential as future engineering materials. Extensive research is being carried out at present for the development of aluminium-bronzes. Various steps for improving the mechanical properties of these alloys have been recently reviewed.[1] One possibility is to utilise the effect of ternary elements on mechanical properties and heat treatability of aluminium-bronzes.

In the present investigation, the tempering characteristics of a Cu-Al-Ag alloy have been studied at various tempering temperatures.

SYNOPSIS

Aluminium-bronzes, particularly those containing 10% or more of aluminium, are a very promising system of alloys as future engineering materials. Extensive research is being carried out at present for the development of aluminium-bronzes. Various steps for improving the mechanical properties of these alloys have been recently reviewed. One possibility is to utilise the effect of ternary elements on mechanical properties and heat treatability of aluminium-bronzes.

In the present investigation, tempering characteristics of a Cu-10·87% Al-0·25% Ag alloy have been studied at 380°C and 520°C. Tempering curve at 460°C shows a two-stage hardening while only single stage hardening is observed at 380°C and 520°C. The results have been discussed in terms of precipitation of the ∝ solid solution, formation of pearlite and of metastable phases.

Experimental procedure

The alloy was prepared in a coke-fired pit furnace from commercially pure materials and was hot-forged and then cold-rolled into bars of 1″ cross section. Homogenization was carried out at 900°C for nearly 40 hours. Chemical analysis revealed the composition of the alloy as follows :

Ag—0·25%
Al—10·87%
Cu—Rest

Specimens of ½″ thickness were cut off from the homogenized bars for hardness measurements.

The homogenized specimens were again heated and kept at 900°C for about 24 hours and were then water-quenched. Tempering of the quenched specimens was carried out at 380°C, 460°C and 520°C. Tempering was done in a salt bath using a mixture of 50% KNO_3 + 50% $NaNO_2$. After tempering up to various time intervals at the above temperatures, the specimens were again quenched and the Vickers hardness numbers were determined. The microstructures were studied in the usual manner.

Results

The results of the present investigation are summarised in Figs. 1 to 3. The tempering curve at 980°C (Fig. 1) shows that the hardness increases slowly in the initial stages followed by a rapid rise. Hardness peak is obtained after a time interval of 6×10^4 seconds and afterwards the hardness falls off. The initial portion of the tempering curve at 460°C (Fig. 2) is similar to that of the tempering curve at 380°C but a two-stage hardening is observed in this curve. The first hardness peak is obtained after a time interval of about 10^3 seconds and the second peak is obtained after 10^4 seconds. The tempering curve at 520°C (Fig. 3) shows a slow rise in hardness followed by a period in which the hardness increases rapidly. Again, the rate of increase of hardness becomes slow between the time intervals 10^2 and 10^3 seconds. Afterwards there is steep rise in hardness followed by a peak at about 9×10^3 seconds.

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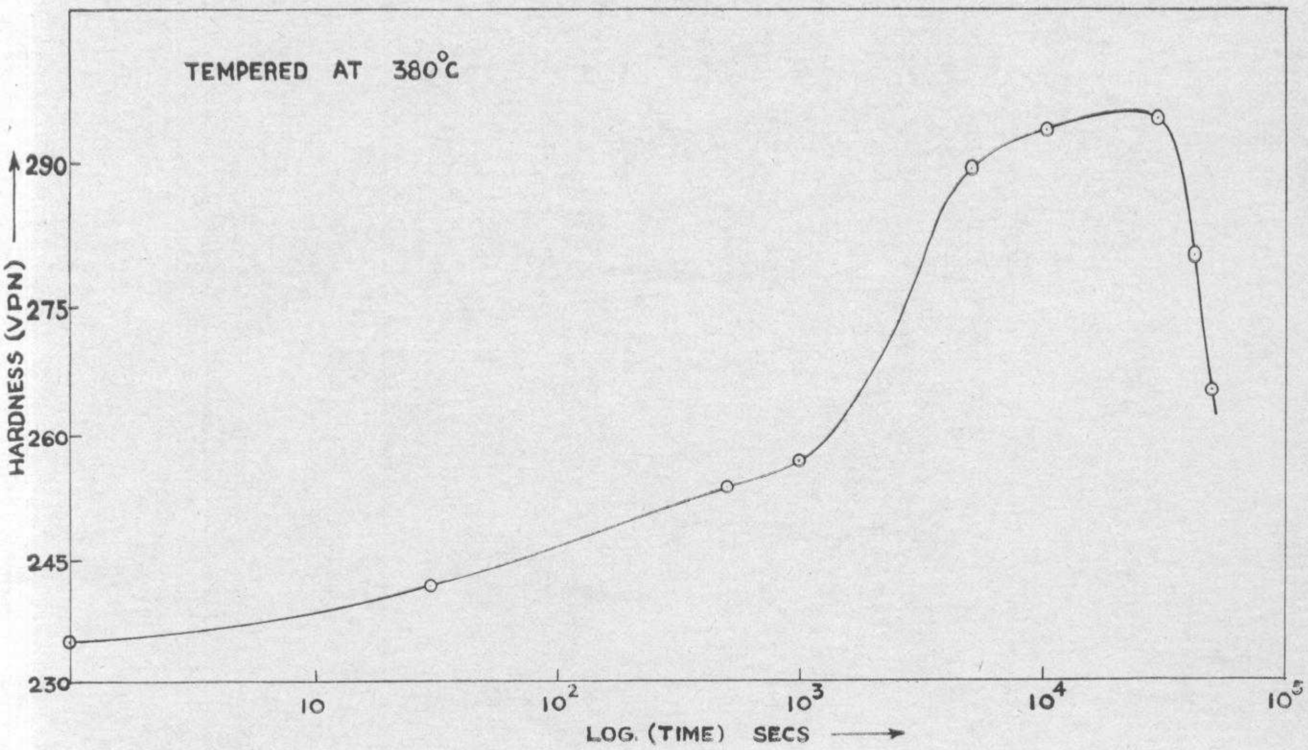
Discussion of results

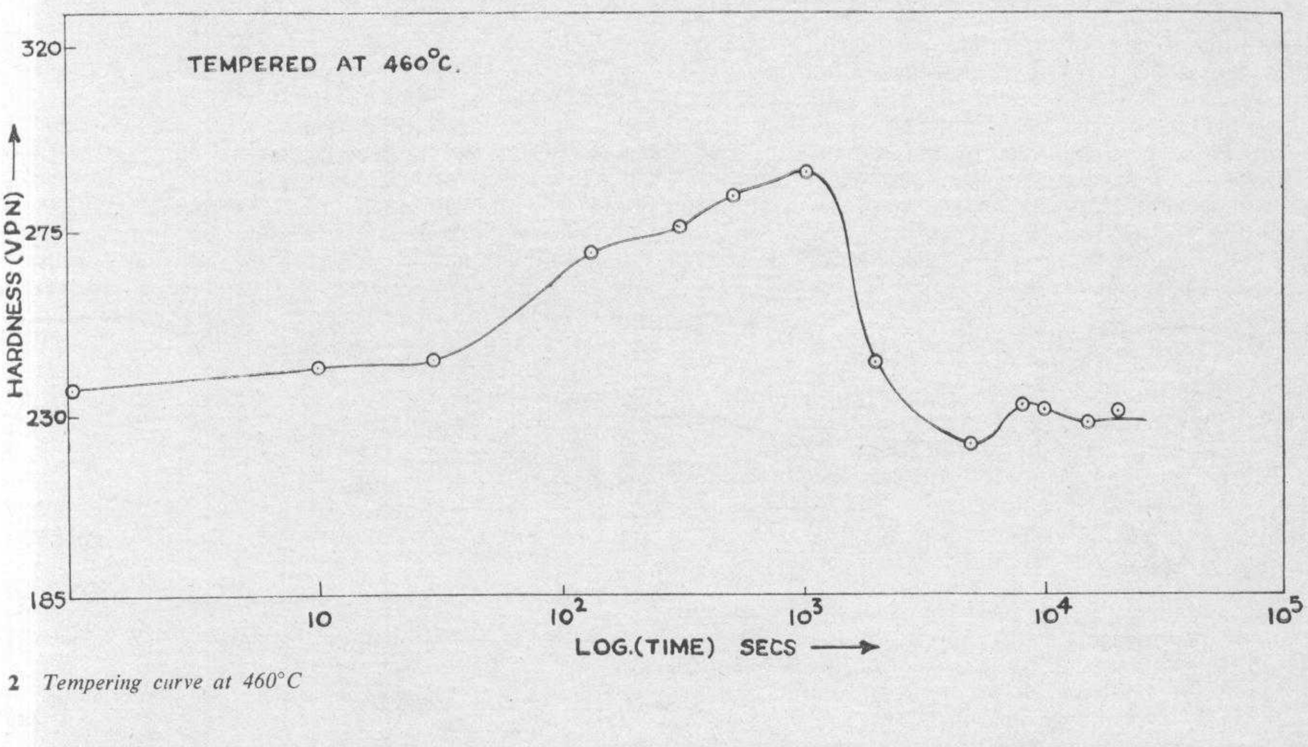
The structure obtained after quenching was martensite. The characteristics of tempering curves at 380°C, 460°C and 520°C may be interpreted as follows :

Tempering at 380°C

The slow and gradual increase in hardness in the initial stages is presumably due to the diffusion of aluminium from the β' martensite into the ∝ solid solution. ∝ solid solution formed in the initial stages will be in the

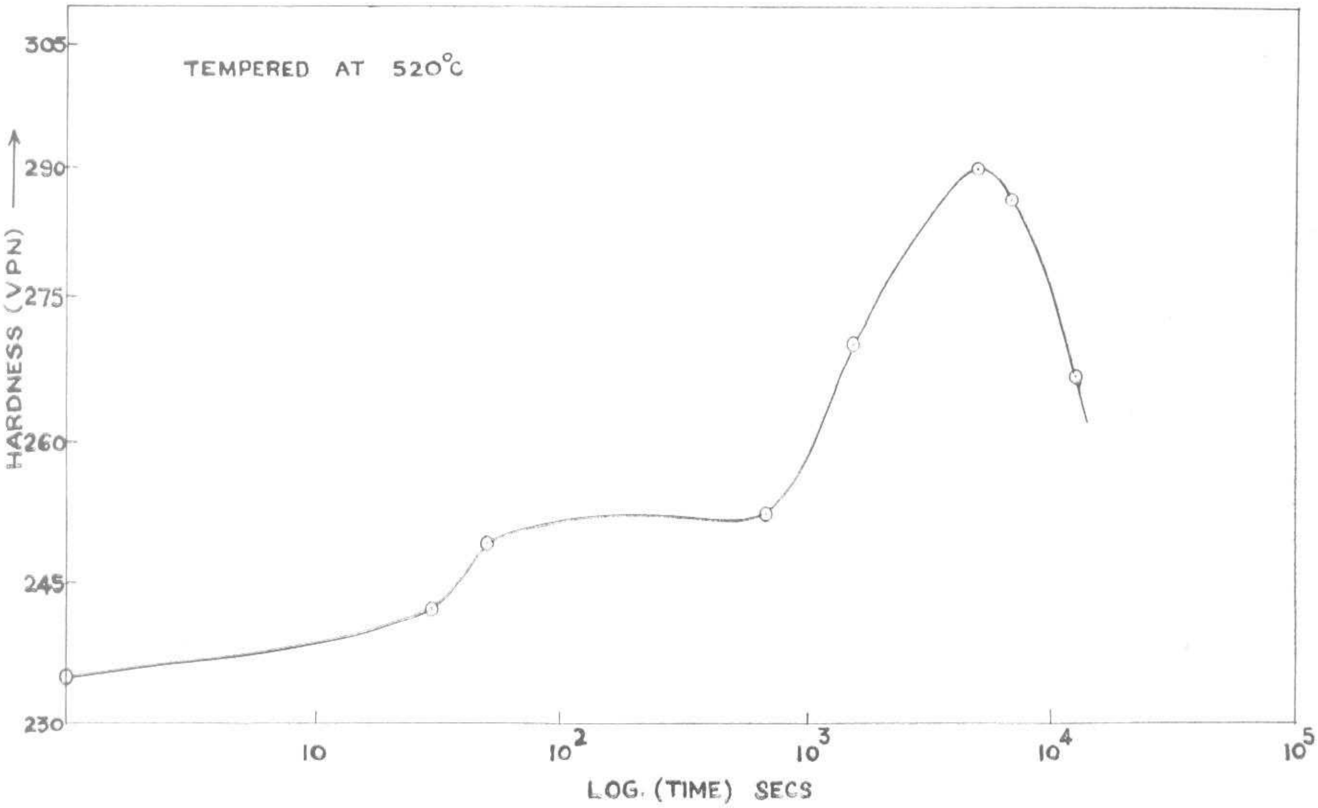


1 *Tempering curve at 380°C*



2 *Tempering curve at 460°C*

form of fine particles. With increasing time the particles of α will grow in size and hence the hardness is expected to start falling. A hardness peak should have been present at the about 3×10^4 seconds. But, no such peak occurred. This can be accounted for by the possible precipitation of pearlite, the effect of the presence of pearlite being to offset the effect of coarsening of the solid solution. The softening in



3 *Tempering curve at 520°C*

hardness due to the precipitation of pearlite. It may be that the rapid increase in hardness after the initial slow increase is also due to the fact that the softening caused by the coarsening of α is less than the increase in hardness due to the presence of pearlite. However, by further increasing the tempering time to 6×10^4 seconds, a peak in the hardness is noted. This is due to coarsening of pearlite. As soon as pearlite also begins to coarsen, the hardness starts falling off and hence a peak.

Tempering at 460°C

In this case also, the initial increase in hardness is due to the precipitation of α and the rapid rise is due to the precipitation of pearlite. The second peak obtained in this case may be due to the precipitation of some metastable phase.[4]

Tempering at 520°C

The peak obtained in this case is due to the precipitation of pearlite as in the above case. One peculiarity of this tempering curve is that hardness remains nearly constant between 50 seconds and about 1000 seconds. This is probably due to the fact that as soon as α starts coarsening, the precipitation of pearlite starts which stops the decrease in hardness values.

Conclusion

The eutectoid reaction in the Cu-Al system has not yet been commercially exploited. It is known that the martensite in this system has a low modulus of elasticity. Tempering of martensite results in an increase in hardness as shown in the above results. It may, therefore, be concluded that it should be possible, by a suitable combination of ternary alloying additions and tempering temperatures, to produce a structure in this system which will have a fairly high modulus of elasticity with the consequent satisfactory combination of tensile strength and ductility. The role of metastable phases appears to be very significant and needs further investigations.

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