MECHANICAL AND STRUCTURAL PROPERTIES OF SOME ALUMINIUM BINARY ALLOYS

THESIS

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NOTE

Beside the work conducted in this thesis the candidate had studied advanced M.Sc. courses in Physics during one year.

1- Theoretical solid state physics.

2- X-ray and Metal physics.

3- Electronic measurements.

4- Numerical analysis and computer programes.

5- Statistical analysis.

6- Electrodynamic and quantum mechanics.

He had passed on examination in these courses.

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ABSTRACT

The formation and dissolution of G.P. zones in based aluminium silver alloys containing 2 wt. % Ag and 5 wt. % Ag were studied by tracing the changes in hardness and creep behaviour after isochronal and isothermal ageing in temperature range 140-250°C.

The effect of isochronal aging of quenched Al-2 wt % Ag and Al-5 wt % Ag on the steady creep was determined in the temperature range (120 - 350°C), with measuring the steady strain rate ($\dot{\epsilon}_{st}$) for a period of 2 min. at a temperature series, 20°C apart. Two and three successive steady strain rate stages were found in the disintegration of quenched (supersaturated) samples depending upon the ageing temperature. The first stage involves the formation and subsequent dissolution of G.P. zones. The second stage involves the formation and subsequent dissolution of metastable γ'-phase. The third stage involves growing of stable γ-phase. The G.P. zones formation dependence of transient creep in both alloys was studied on wire samples which had been given different heat treatments in the G.P. zones. The time-temperature dependence of transient creep strain ϵ_{tr} was described by

$$\epsilon_{tr} = \beta t_{tr}^{n} \qquad (1)$$

where (β) is the transient creep parameter, (t_{tr}) is the transient creep time and n is the creep time exponent.

The pronounced decrease in the transient creep parameter (β) from 6.5×10^{-2} to 0.5×10^{-2} $(mm^{-1})^{n}$ was attributed to the formation of G.P. zones. The increase in the time exponent (n) from 0.05 to 0.6 could be due to the coarsening and increased interparticle spacing of G.P. zones.

The analysis of the isothermal hardness results showed that Vickers hardness peaks taking place at ageing time 45 min. were associated with the coalescence of G.P. zones; confirmed by a drop in V.H.N. peak.

The analysis of the isothermal creep results showed that the steady strain rate peaks taking place at ageing temperature 230 ± 2°C were associated with the maximum partial dissolution of G.P. zones.

Optical, electron metallographic examinations and X-ray analysis, after isochronal ageing from 120-140°C and isothermal ageing at 140°C revealed growth of spherical G.P. zones and corroborated by a remarkable drop in the grain size, in the integral X-ray intensities and broad lines of matrices.

CHAPTER I

INTRODUCTION

1.1.1 Precipitation Hardening in Metals and Alloys:

The necessary condition for precipitation from solid solution is merely the existence of a sloping solvus line (1).

There is no doubt that virtually any metal can be made to precipitation harden by the addition of a properly chosen alloying element.

The entire process of producing a precipitation - hardened alloy may be divided into three parts :

(1) Choice of the composition (2),
(2) Solution heat-treating, and
(3) Precipitation heat-treating, see Fig. (1).

In some cases the precipitation may occur in a reasonable time at room-temperature, and the alloy is then said to be naturally aging.

Usually it is necessary to age the alloy artificially by holding it in a temperature (3). The exact temperature used for the precipitation heat treatment is determined by two factors :-

(1) The time for appreciable reaction, and
(2) The property of principal interest.

Precipitation at a relatively

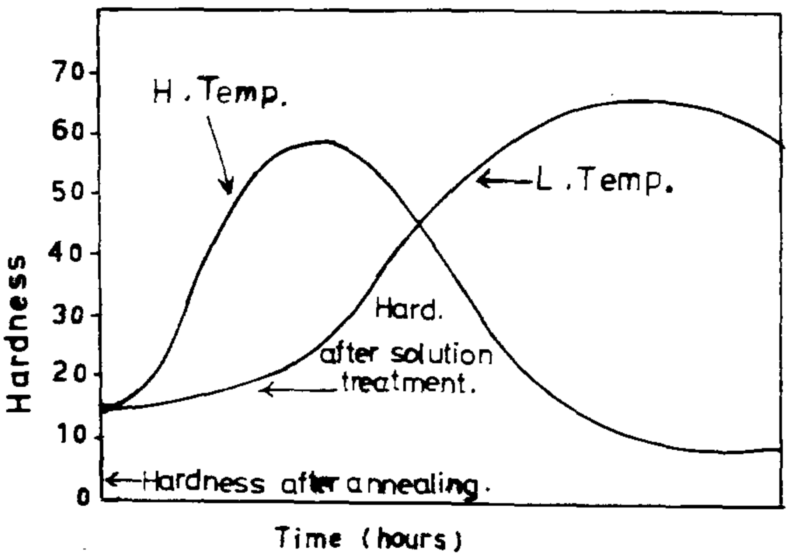

Fig. (1). The course of hardening during precipitation heat treatment at two different temperatures.

The time factor must be of reasonable length for industrial heat treatment,[4] (The higher the temperature, the shorter the time). In regard to the second factor it should be understood that different properties change at different rates during precipitation. For example, the strength properties tend to reach higher maximum values at lower precipitation temperatures. See Fig. (2).

Properties such as hardness attains a maximum value during precipitation at a given temperature and then gradually decreases as a result of overaging[5,6] . See Fig. (1).

Precipitation hardening is the most important method of strengthening nonferrous metals by solid - state reaction.[7]

It is especially useful for aluminium, the principal metal of this class, and both cast and wrought aluminium alloys are precipitation hardened[8].

1-1-2 Precipitation Reactions :

The processes of nucleation and subsequent growth have been especially thoroughly studied for precipitat-

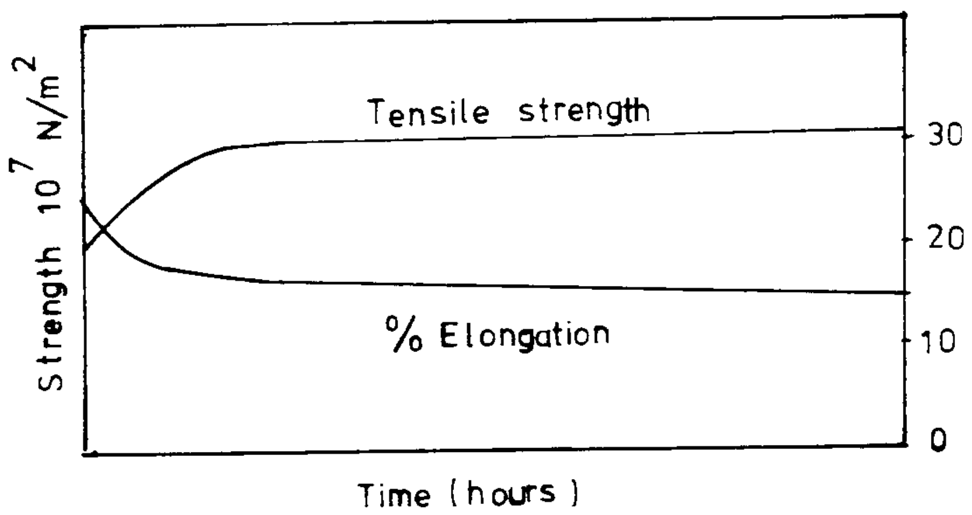

Fig. (2). Property changes during the precipitation heat treatment of aluminium alloy (Al-5.6 % Zn - 2.5 % Mg - 1.6 % Cu) sheet at 120°C.

ion reactions. The first step in producing a precipitation reaction is solution heat treatment(9).

In addition to putting the silver atoms in the $\propto$-phase of Al-Ag alloy, this treatment produces a high fraction of vacancies.

During rapid cooling from high to room-temperature, virtually all these vacancies may come out of solution by one of various processes(10). The process of most interest is the formation of tiny clusters of vacancies, for example, four vacancies in the configuration of spherical.

The number of these vacancy clusters is so enormous that their mean spacing (λ) is only some tens Angstroms . If each sphere serves as the nucleus of a G.P. zones(11), see Fig. (3), a time of about several minutes and houres is required to complete this stage of precipitation.(12,13)

During the initial distribution of G.P. zones, if the temperature is increased so as to be somewhat above the G.P. solvu , the G.P. zones gradually disappear, where a phenomenon known as reversion. This behaviour demonstrate that G.P. zones are an equilibrium phase(14).