# STUDY OF SOME ELECTRICAL AND MECHANICAL PROPERTIES OF SOME ALLOYS

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الله

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« صدق الله العظيم »

بسم الله الرحمن الرحيم

Study of Some Electrical and Mechanical
Properties of Some Alloys.

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ARABIC SUMMARY

## ABSTRACT

The present work is an attempt to add some experimental informations by studying the aging characteristics in cold-worked Al-1 wt %-Mn 0.28 Wt% Fe alloy and the mechanical properties through measurements of resistivity, TEM and internal friction $Q^{-1}$.

The material used in this work was prepared by melting Aluminium containing Iron and Manganese of purity 99.99% in air. Then the alloy homogenized for 4 days at 620°C, furnace cooled and swaged by cold drawing to wires of 0.35 mm diameter or rolled into sheets of 0.2 mm thickness for TEM. The tested specimens were heated at 620°C for 4 hrs then quenched rapidly in water to maintain it in a metastable state, as supersaturated solid solution. This treatment borught the specimens always to an identical initial state.

Resistivity measurements were obtained by using a microvoltmeter of high sensitivity of $10^{-7}$ volt. Room temperature changes in resistivity were traced for quenched samples given heat pulses up to 3 hrs at temperatures 400 , 450 , 500 and 550°C. The results suggested the presence of three stages whose nature was identified by resistivity measurements. (This part of work has been

accepted for pablication in "J. of Physics D: Applied Physics 19 (1987).

Within the temperature range of each stage, isothermal aging was carried out for quenched specimens and the relative percent change in resistivity ($\frac{\Delta \rho}{\rho_o}$) was plotted against time t from which the energy activating the vacancy migration in stage I was obtained and was found to be 0.5eV The energy activating the precipitation process in stage III was obtained and was found to be 0.50 eV.

The effect of deformation was studied by cold working the specimens immediately after quenching to degrees of torsional deformation ($\frac{N}{N_f}$) equal 35%, 55% and 75%, where N represents any number of turns twist before fracture and $N_f$ is the number of turns twist required for fracture, and for tensional deformation ($\frac{\Delta \ell}{\Delta \ell_f}$) 25%, 50% and 75%, where $\Delta \ell$ represents any elongation before fracture and $\Delta \ell_f$ is the elongation corresponding to the fracture for resistivity measurements.

Isothermal aging at the same previously mentioned aging temperatures 400 , 450 , 500 and 550$^{o}$C was carried out and the energy activating the vacancy migration in stage I was calculated as well as for the activation energy for precipitate formation in stage III. The results showed a decrease in the activation energy by increasing the degree of both types of deformation. This was explained on the basis of dislocation theory. Cold working increased the stored energy produced as a result of the internal strains and so the energy activating the migration process and precipitate formation will be decreased.

The energy stored in the lattice by tensional deformation was found to be higher than that stored by torsional deformation as indecated through the higher rate of decrease of the activation energy in case of tensional deformation. Hence the vacancy migration and precipitation processes was found to be enhanced by both types of deformation. A flat needle-like precipitates of $Al_6Mn$ were observed by TEM examination after prolonged aging.

The present work was also concerned with the study of the recovery of internal friction $Q^{-1}$ under the effect of excitation, cold-working and aging temperatures using the torsion pendulum technique. The degrees of cold-working by torsional deformation applied in $Q^{-1}$ measurements were calculated by the same method that applied in resistivity measurements $(\frac{N}{N_f})$ and equal 2 %, 5% and 10 %.

The analysis of the results was carried out by applying the Avrami-type relation $Q_t^{-1} = Q_o^{-1} \exp(-Kt^n)$.

where n represents the power of the time dependence and K is the decay rate. The results showed that each curve can be devided into three stages.

(1) The rapid stage for which n takes value larger than 0.7.

(2) $t^n$ stage for which n varies between 0.4 and 0.6.

(3) Slow saturation stage, $n < 0.3$.

The first two stages were only considered in the present work.

The decay rate K was found to be affected by the mode of excitation, degree of cold-work and aging temperature in the two stages.

The decrease of $Q^{-1}$ with time after straining has been explained as due to one or both of the following two effects:-

(i) Pinning of dislocations (by Mn and Fe atoms), impeeding their motion and cause the decrease of $Q^{-1}$.

(ii) Rearrangement of dislocation networks.

It has been found that the contineous excitation CE enhances the decay rate under the same working temperature. This has been attributed to the fact that contineous excitation (CE) acclerate the rearrangement of dislocations in the form of networks due to the additional elastic strain energy accompanying the CE. This was shown as a decrease in the activation energy for di-vacancy migration obtained in case of CE compared with that obtained in case of restrictively excited (RE) specimens.

The decay rate K was found to be considerably increased by increasing the degree of cold-work. This was attributed to fact that higher degrees of deformation gives more substaintial strain energy to the lattice and the probability of formation of networks will be higher due to the large number of dislocations introduced by higher degrees of cold-work. This was noticed through the decrease of the activation energy for di-vacancy migration by increasing the degree of deformation.

The decay rate K was found to be decreased by increasing aging temperature, this was explained as due to the effect of aging on the concentration of impurities which act as pinners for dislocations. At higher aging temperature concentration of Mn atoms is expected to be decreased, i.e., the concentration of pinners is decreased and consequently the decay rate K will be decreased. Hence higher aging temperature cleared the matrix from the internal strains and this means that the external energy needed for activating the di-vacancy migration is increased. This was shown as an increase in the activation energy by increasing aging temperature.

# CHAPTER I

# INTRODUCTION