An Investigation on the Aging of the Aluminium Alloy by Measuring the Damping Capacity (3ed Report)

On the Aging of Al-Cu Alloy

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Synopsis

In the previous report, it was found by measuring the damping capacity, the specific volume, the lattice consant in X−ray analysis and others on the aging of 17S that the internal structure treaded very complicated change and gradually was near a stable state. The authors found in the experiment of aging of 2S, which was simple in chemical composition compared with 17S, that 2S showed a change similar to the aging and was an unstable state especially in early stage by the same experiment in spite of the 2S was apt to be looked upon as non-aging metal in the past.

Now, we search the aging of Al−3.116% Cu alloy in the early stages by the same experimental method in order to find the influence of the added component on the aging, because this material was studied enough on the internal change in the aging by Mr. Hardy and others in the past and it is convenient to discuss the result for the above reason. And we pursue the aging by measuring the damping capacity in torsional oscillation to this time, but, in this paper, the damping capacity in cantilever type transverse oscillation of the plate specimens are measured and the results are compared with the ones by the former method in order to find whether these unstable changes are depend upon the measuring method and to confirm the reliability of the analysis by measuring the damping capacity.

1. Changes in early stage on the aging

As previously reported, it was found out by measuring damping capacity, specific volume, lattice constant in X−ray analysis, etc. On the aging of 17S[1] that the internal structure shows very complicated change in early stage and gradually becames stable. It was known through the experiment on the aging of 2S[2], which was simple in chemical composition compared with 17S, that 2S also shows a change in internal structure similar to that by the aging and there was an unstable state especially in early stage through this had been looked to be a non-aging metal.

This time, the aging of Al−3% Cu alloy in the early stages was studied through the same experimental method in order to find out the influence of the added component on the aging. This material was used, because it had been studied many times on its internal change in aging by Mr. Hardy[3] and others. Up to this time, the aging has been studied by measuring the damping capacity in torsional oscillation, but, in this experiment, the damping capacity in cantilever type transverse oscillation of the plate specimen was measured and the results were compared with ones by the former method. This was for finding out whether or not these unstable changes depend upon the measuring method and for confirming the reliability of the analysis method of measuring the damping capacity.

2. Specimen

Used specimen is Al—Cu alloy as shown in Table 1.

Table 1 Chemical compositions of specimen

Fe	Si	Cu	Al
0.075%	0.047%	3.116%	bal.

3. Damping capacity in torsional oscillation

After the slub (about $30\times100\times200$ mm³) was hot rolled up to 20 mm and was cold rolled to about 16 mm, the specimen for torsional oscillation test was finished as shown Fig. 1.

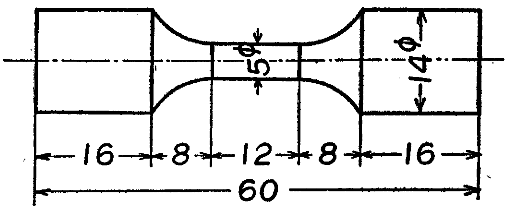


Fig. 1 Specimen for torsional oscillation test

After having been kept in 500°C for 30 minutes, the specimens in Fig. 1 were quenched in the eater of 20°C recieved the aging at room temperature for 96 hours, and were set in the torsional oscillating apparatus[1),2)]. The relation between the torsional angle $\pm\theta$ and the logarithmic decrement λ of the specimen in the torsional oscillation is as shown in Fig. 2 and its oscillating characteristics is like as one of 17S and 2S which was reported previously. That is, there is a range in which λ is not so changeable in oscillation without regard to the increasing of $\pm\theta$ between the range of the elastic oscillation in which λ increases with $\pm\theta$ and the range of the plastic oscillation in which λ increases largely with $\pm\theta$, and this range is in so-called "the quasi-elastfc" range and, if the comparison of the damping capacity is tested in this range, the influence of error by the fluctuation amplitude is small.

After being kept in 500°C for 30 minutes, the specimens are quenched in the water of 20°C and recieve the tempered aging for a long time in the prescribed temperature (seven grades of 20, 80, 120, 150, 180, 200 and 220°C tempering), and then, they are set in the apparatus after prescribed period of the aging, the damping capacity λ in $\theta=\pm20°$ is measured. The results are shown in Fig. 3.

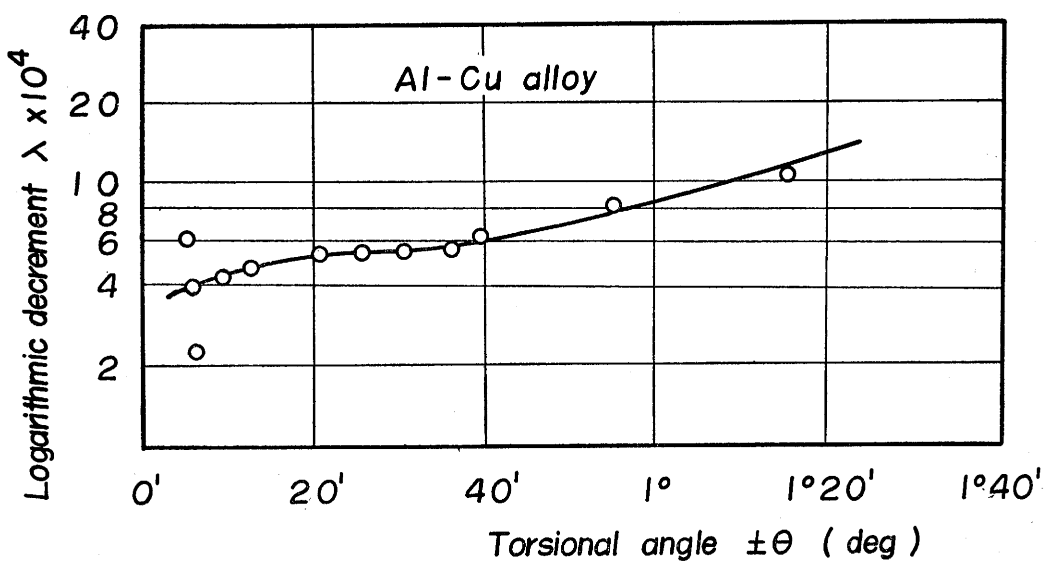


Fig. 2 Relation between torsional angle $\pm\theta$ and logarithmic decrement λ.

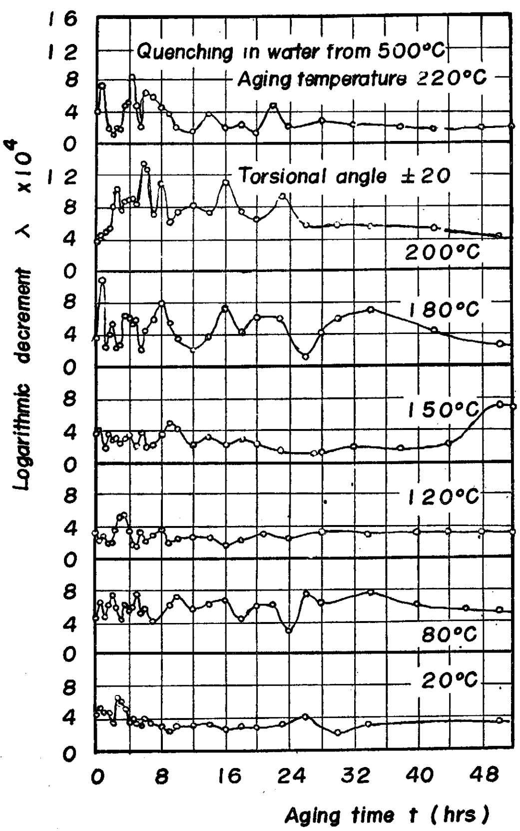


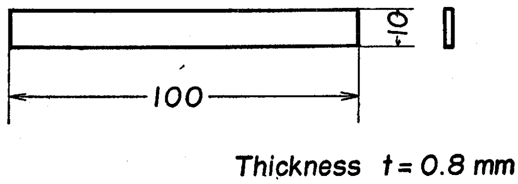
Fig. 3 Changes of logarithmic decrement λ

The changes of λ are very unstable and have several peaks values in λ in early stages of aging in the respective temperature, and the changes are like in the case of 2S and are more larger than the case of 17S. The changes of λ fluctuate largely in the aging of 150~200°C, and it is found that the internal changes are complex in this temperature, and considering that the change of λ-curve in 500°C aging is in time corresponded to the precipitation of the transitional phase which was searched by Hardy[3] and that the change of λ-curve is became fluctuateless at the time of which the precipitation of the transitional phase in 200°C stabilizes electron-microscopically, it seems that there are some grounds for the change of λ.

4. Damping capacity in transversal oscillation

As the torsional oscillation has been used in the pursue of the aging by measuring the damping capacity, the transverse oscillation is experimented for the purpose of examining the difference of oscillating method. That is, the distinguished fluctuation of λ in early stages of aging which was observed in Fig. 3 is peculiar to the used torsional oscillation.

2S slub were hot rolled to 10 mm and then were cold rolled to 1 mm. The finished specimen in Fig. 4 is set in the cantilever type transverse



Fjg. 4 Specimen for transverse oscillation test

oscillating apparatus[6] in same heat treatment as above mentioned experiment and the logarithmic decrement λ_c in the transverse oscillation is measured for finding out whether or not these unstable changes depend upon the measuring method when the type of oscillation is altered. This method was used in measuring of the aging of Al−Cu alloy by Prof. Y. Kitani[7].

After being kept in 500°C for 30 minutes and aging in room temperature for 96 hours, the specimen is measured the changes of the damping capacity λ_c according to the rising of the amplitude A on the oscillo-paper which was set on the rotating drum in cylindrical lens camera parted 1.7 m from the wall. The results are shown in Fig. 5 and it is found that the characterestics of the damping capacity is like the one in the torsional oscillation as shown in Fig. 3. There is a quasi-elastic range in which the oscillation has nearly constant λ, the damped oscillation with in the quasi-elastic limit has no connection with the amplitude A so this oscillation is in applicablecompared with the quasi-elastic oscillation in the case of measurement by exchanging many specimen as like in the case of the torsional oscillation. For example, the changes of the damping capacity λ_c with the elaspe of the aging time t in isothermal aging for same specimen with above mentioned heat treatment in the

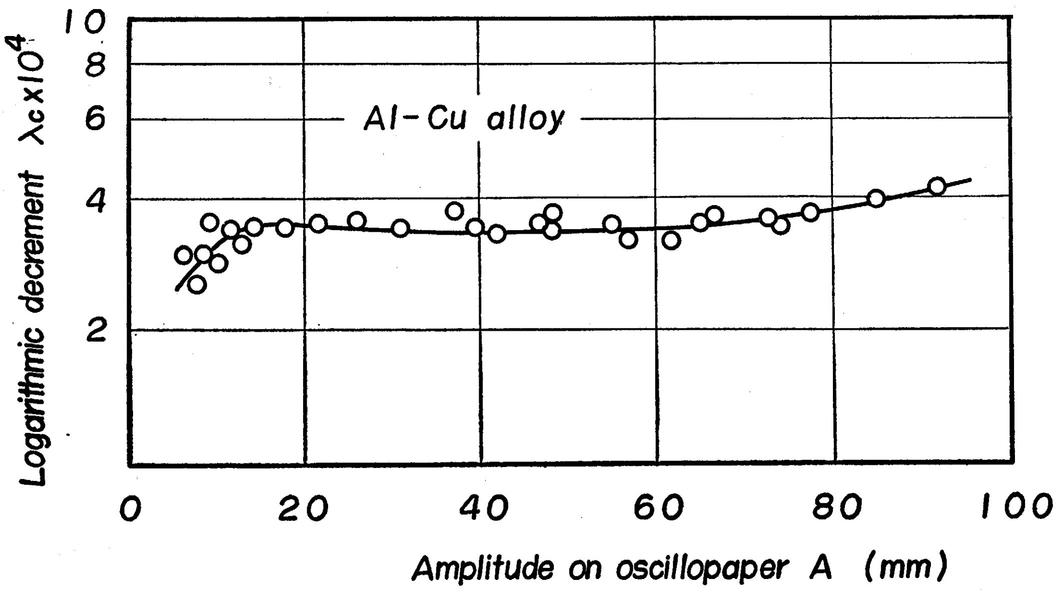


Fig. 5 Relation between amplitude on oscillopaper and damping capacity λ_c in transverse oscillation

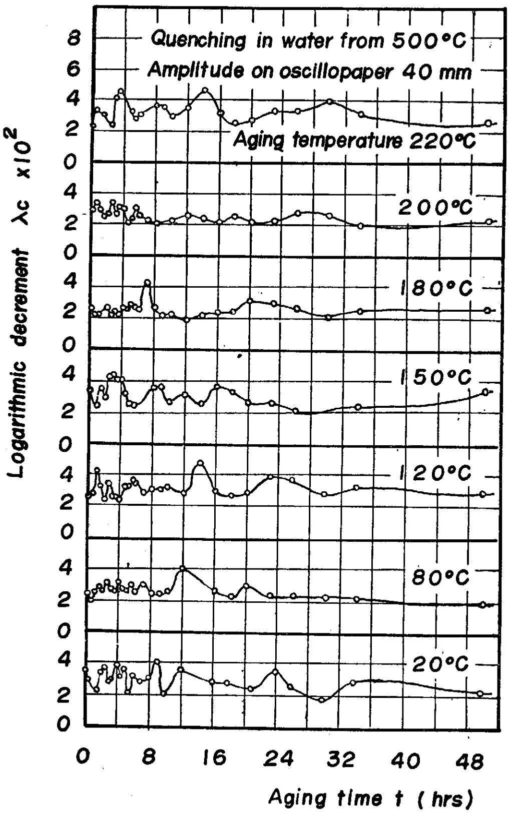


Fig. 6 Changes of logarithmic decrement λ_c in transverse oscillation.

torsional oscillation is shown in Fig. 6 and it seems that there are some differences in the degree of fluctuation but same tendency with Fig. 4 is shown, and that the fluctuation is not particular phenomenon in the oscillating method or the measuring apparatus.

From this, the dampfng capacity measurment is sencible and it is said that the measurment has reliability comparatively for the material analysis.

5. Knoop hardness

The cylindrical specimen of 15 mm$\phi\times$12 mm having been heat treated as like above. The changes of the Knoop hardness H_k with aging time t are obtained as shown in Fig. 7. (Measurments are done in two times on two specimens respectively, that is, the values in four times are shown in the figure.)

There are some dispersions in each case, but, from the other properties, that is, the changes of damping capacity, the changes of specific volume and others, there seems the fluctuation beyond the dispersion of the measured value, especially, in early stages of the aging and it is found that the hardness reaches at saturated values after treating these fluctuation.

As the previously reported[8] on the aging of 17S, considering that Hv-curve is affected in measuring of the diagonal length by the influence

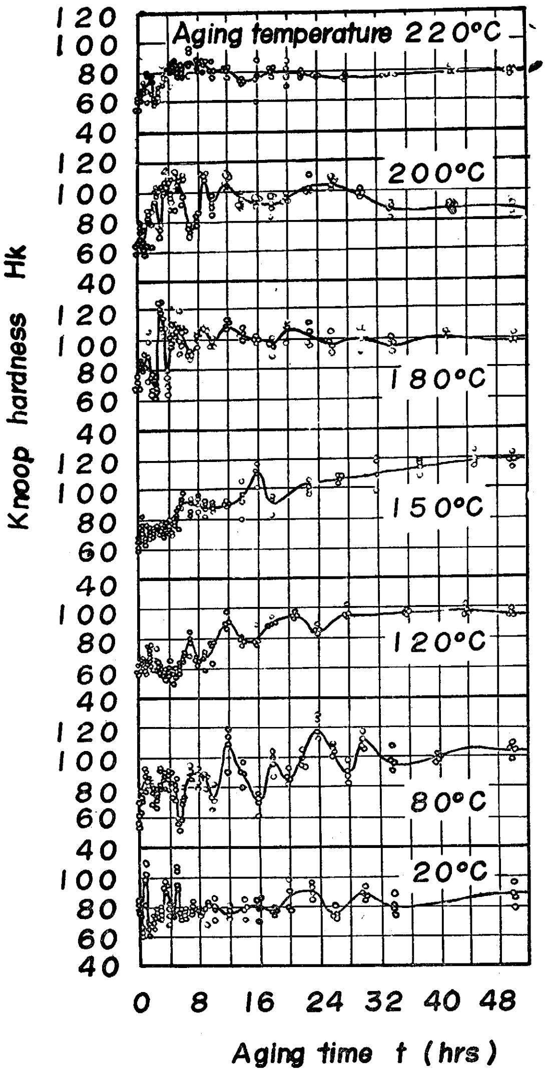


Fig. 7 Changes of Knoop hardness H_k.

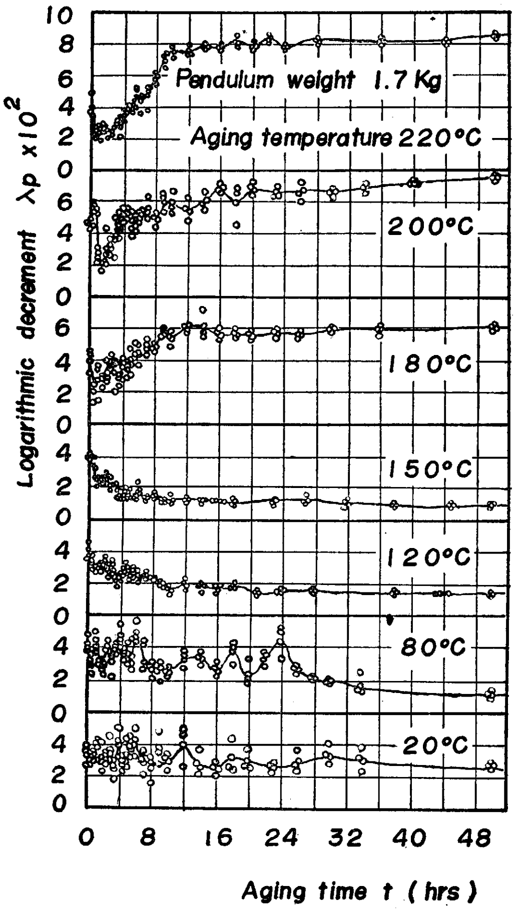


Fig. 8 Changes of logarithmic decrement λ_p

of the piling-up but the H_k-curve is measured by the major diagonal length of which is expected the influence of the piling-up and that the piling-up is changeable in aging[8], it is natural that this change of Knoop hardness H_k is differ slightly from the previous results of which the change of Vickers hardness H_v of this alloy had been measured by Hardy[3] and others.

6. Decrement of Harbert pendulum

The experiments are pursued on the cylindrical specimen of 15 mm$\phi \times$12 mm heat treated as like above (two pieces specimen) by means of the Harbert pendulum as same method in previous report.

The changes of tne logarithmic decrement λ_p are obtained as shown in Fig. 8. In early stages of aging in 20~80°C, the changes show a great dispersion comparatively, but, with the rising of the temperature, the dispertion tends to be small on the whole, the chane is in lever relation with the H_k-curve in Fig. 7 as like in the case of 17 S[1], and the fluctuation of λ_p is large in time up to the saturating value and there are many peaked values within the range of λ_p large fluctuated, so it can say that the properties shown in the decrement of Harbert pendulum present the internal change of materials.

7. Specific volume

After being heat treated as like above on the

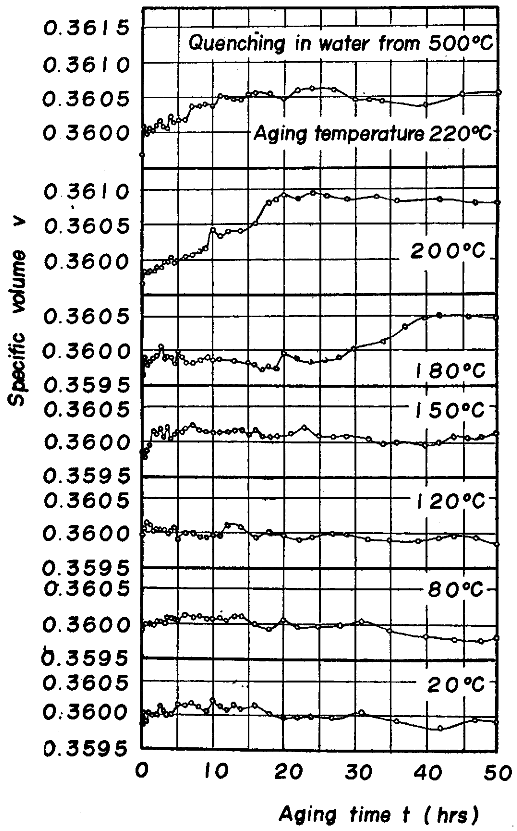


Fig. 9 Changes of specific volume V.

square pillar spccimen of $10\times10\times20$ mm^3, the relation between the aging time t and the specific volume v is obtained as shown in Fig. 9.

Considering that the specific volume increases rapidly correspond to the time of which the hardness increases rapidly, it seems that there are some grounds to rely upon the nature of the v-changes.

8. Summary

In short, the results of the analysis by the damping capacity show that there are very unstable stages in structure up to the precipitation of the meta-stable intermediate phase in early stages of the aging on the Al−3% Cu alloy and there are no influence for the Cu-adding, and that the characteristics of changes of the damping capacity in torsional oscillation are same one in transverse oscillation. The results are support by the change of hardness, the chauge of the decrement of the Harbert pendulum and the specific volume analysis, but it must be discussed whesher these phenomena are pecular to the precipitation type super-saturated solid solution, to the poly crystal metal or the material being stressed by heat treatmeut.

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