EXPERIMENTAL SIMULATION ON CONTROL ROLLING PROCESS OF 6201 ALUMINUM ALLOY[①]

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ABSTRACT Control rolling process of 6201 aluminum alloy was simulated on Gleeble-1500 . The deformed specimens under different processes were analyzed by the observation of optical microscopy and TEM , and the measurement of hardness . It was shown that solid solution and aging treatment can be effectively combined in one procedure by control rolling process , the deformation temperature is ranging from 540 ℃ to 200 ℃ . Precipitation of Mg_2Si is accelerated by the rising of the finishing temperature , the amount of precipitates increases with holding time after deformation . A more uniformly distributed and finer Mg_2Si particles can be observed on deformed specimens which have been subsequently held at 250 ~ 300 ℃ for 60 s .

Key words 6201 aluminum alloy control rolling process thermal simulation Mg_2Si precipitation

1 INTRODUCTION

6201 Aluminum alloy is used for overhead conductive wire , which can be fabricated by the following methods[1 - 4] . (1) Conventional process : involving CCR (continuous casting and rolling) , solution heat treatment and quenching , drying , drawing , aging respectively ; (2) Recent development : involving CCR and solution heat treatment , drawing , aging ; (3) Lamitref aluminum CHTA (continuously heat treatment alloy) : continuous casting and thermomechanical rolling , drawing . CHTA not only eliminates several procedures of heat treatment , thus leading to higher productivity and energy efficiency , but also ensures an optimal combination of mechanical and electrical properties . However , the key processing parameters of the CRP(control rolling process) are scarcely reported . Experimental simulation on control rolling of 6201 aluminum alloy is necessary to give a help for practical production of 6201 aluminum alloy overhead conductive wire .

2 EXPERIMENTAL PROCEDURE

2 .1 Chemical compositions of 6201 Al alloy

The materials were rapid cooling cast as 65 × 160 mm slab , alloyed with magnesium and master alloys of Al-Si and Al-Fe . The analyses of composition are given in the Table 1 .

Table 1 Main chemical compositions of specimens

Elements	Mass fraction/ %
Mg	0 .68
Si	0 .76
Fe	0 .27
Cu	0 .033
Al	Rem .

2 .2 Simulation of CRP

The CRP of 6201 aluminum alloy was simulated on Gleeble-1500 by simple high temperature compression tests according to the schedules shown in Table 2 . Specimens were heated to 540 ℃ in 180 s and held for 30 s before the deformation , after which , rapidly quenched with water sprays immediately to allow the observation and measurement of the deformed microstructures and properties . Machine-oil mingled with graphite powder was used as lubrication between the interface of the anvil and

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Table 2 Processing parameters of hot deformation simulation on Gleeble-1500

Pass Numbers	Temperature / ℃				Reduction / %	Strain rate / s^{-1}	Holding time / s
0	540	540	540	540			
1	520	520	520	520	37.4	0.70	180
2	480	480	480	480	32.4	0.76	5
3	420	420	420	420	32.4	0.79	2
4	360	360	360	380	32.0	0.82	2
5	300	300	320	350	29.4	0.79	2
6	250	260	280	330	27.1	0.92	2
7	220	240	260	310	17.1	0.90	2
8	200	220	250	300	13.8	0.93	10, 60

No. 1 —4 are the finishing temperature of 200, 220, 250, 300 ℃ respectively.

specimen.

2.3 Metallography examination and hardness measurement

The microstructures of the deformed specimens were observed with an NEOPHOT-21 optical microscopy and an H-800 TEM respectively, the HB hardness was measured by using a 62.5 kg load in HW187.5.

3 RESULTS AND DISCUSSION

3.1 Development of microstructures and changes of hardness during CRP

In Fig.1 it is shown the development of microstructures of deformed specimens under No. 4 process. It is clear that grains are ragged and elongated with the increasing strain and the original interdendric structure was replaced by flow lines and a little metastable phase after the first pass deformation followed by 180 s duration at 520 ℃, indicating that solid solution is induced and accelerated simultaneously by the high temperature and strain, and that the time for solid solution during the deformation is much less than the traditional treatment without deformation (usually about an hour[5]). TEM (see Fig.2) shows that a large amount of dislocation is anchored by the second phase particles giving obstacle to the slipping and climbing of dislocation as well as the occurrence of recrystallization during and after the deformation. This provides motivation and preferential neucleation site to benefit the stablized precipitation of the second phase

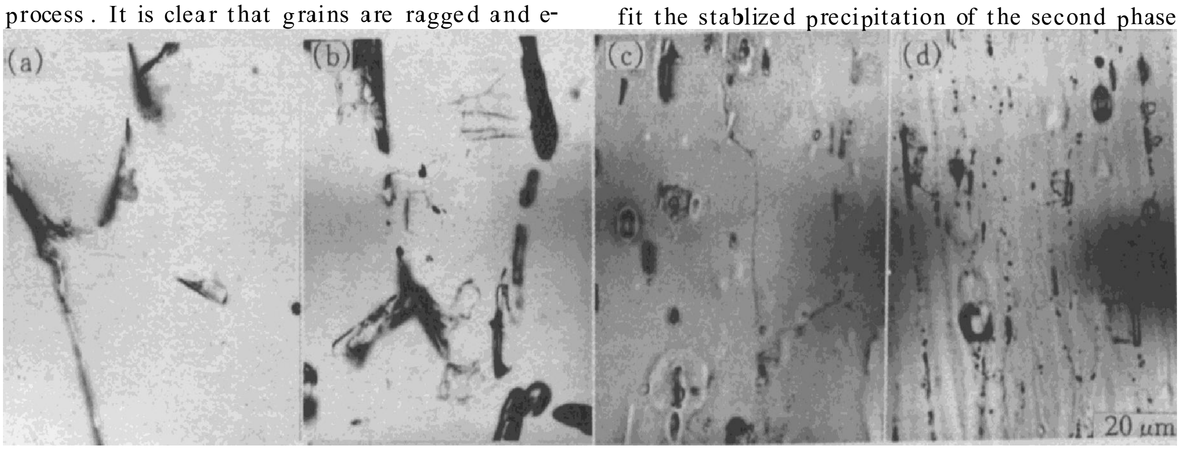

Fig.1 Optical microstructures of deformed specimens under No.4
(a) —1^{st} pass; (b) —4^{th} pass; (c) —6^{th} pass; (d) —8^{th} pass

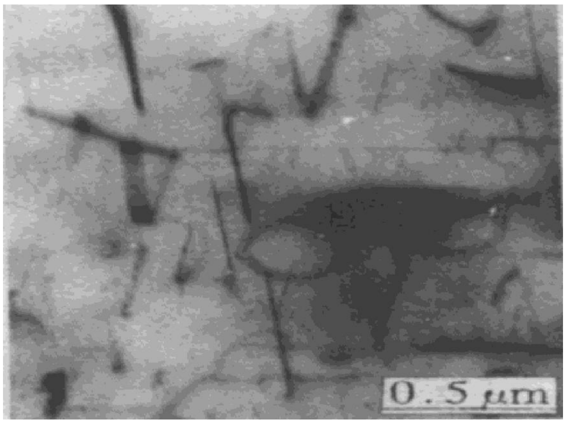

Fig.2 Pinning of dislocation by particles

particles[6-8]. The hardness changes of deformed specimens are shown in Fig.3. It is found that the hardness increases directly before the 6th pass followed by a slight drop, due to the decreasing temperature and the increasing strain resulting in the substructure strengthening during the deformation process, and the slight drop is possible because of dissolution of supersaturated solute[3,8,9,10].

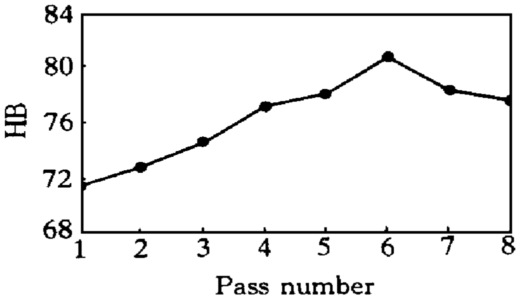

Fig.3 Hardness changes of deformed specimens under No.4

3.2 Development of microstructures and changes of hardness under different processes

Fig.4 to Fig.6 show the microstructures of the deformed specimens. The amount of the second phase precipitation increases and the speed accelerates with the rising of the finishing temperature. More complete precipitation was observed with the longer holding time after the deformation. The prevailing needle-shaped metastable phase is observed under the finishing temperature of 200 ℃, while the fine and stable particles are diffused from local grain boundary to the inner of the grain at an enhanced tempera-

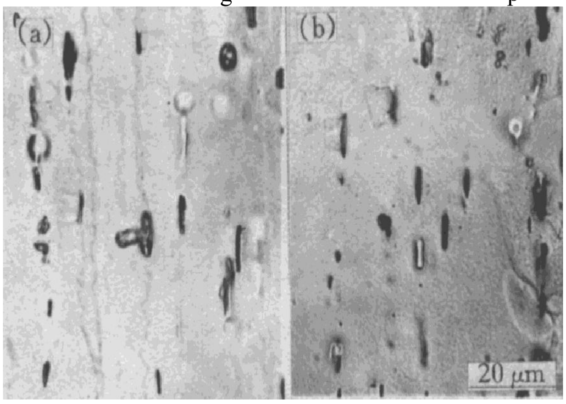

Fig.4 Optical microstructures of deformed specimens under No.1

(a) —holding for 10 s; (b) —holding for 60 s

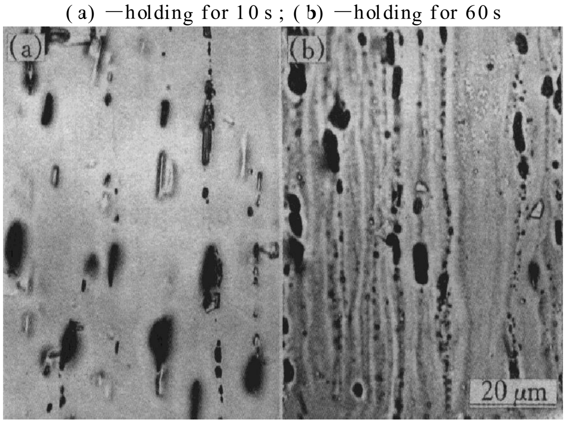

Fig.5 Optical microstructures of deformed specimens under No.3

(a) —holding for 10 s; (b) —holding for 60 s

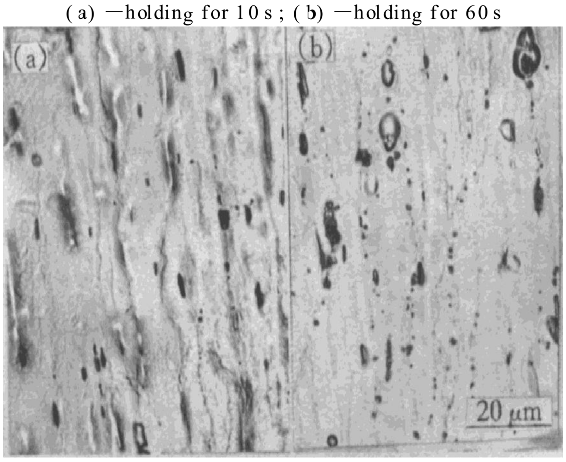

Fig.6 Optical microstructures of deformed specimens under No.4

(a) —holding for 10 s; (b) —holding for 60 s ture of 300 ℃.

TEM of the deformed specimens holding for 60 s under No.4 is given in Fig.7. The selected-area diffraction pattern proves the precipitation particles are Mg_2Si, which are uniformly distributed within the grains.

In addition, the hardness changes of deformed specimens under different processes are given in Fig.8. The hardness decreases with the increasing of finishing deformation temperature

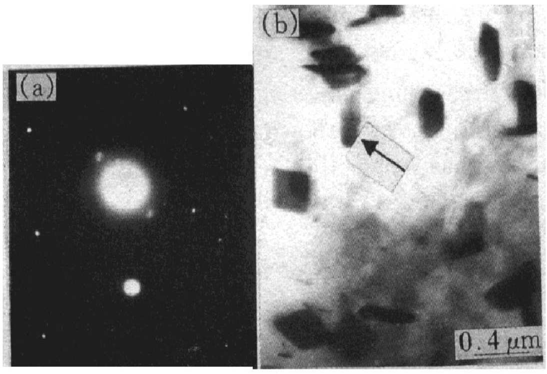

Fig.7 TEM of deformed specimen holding for 60 s under No.4

(a) —diffraction pattern pointed by the arrow;
(b) —TEM

and increases slightly with the holding time, but the increasing extent is less at higher finishing temperature.

As is shown above, CRP can be applied to practical production of 6201 aluminum alloy conductive wire by the effective combination of solid solution and aging treatment in a pass schedule.

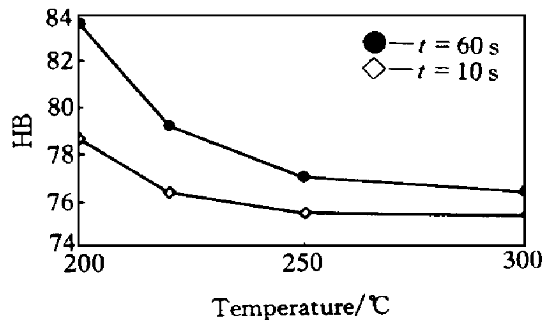

Fig.8 Hardness changes of the finally deformed specimens under different processes

4 CONCLUSIONS

(1) Solid solution and aging treatment can be effectively combined in one processing by control rolling process, the deformation temperature is ranging from 540 ℃ to 200 ℃.

(2) Precipitation of Mg_2Si is accelerated and stablized with the rising of the finishing temperature.

(3) The amount of precipitates increases with the holding time after deformation. A more uniformly distributed and finer Mg_2Si particles can be observed on deformed specimens which have been subsequently held at 250 ~ 300 ℃ for 60 s.

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