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Research on Aluminum Brass Alloy Hot Compressive Deformation Characteristics

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Abstract: HAL60-1-1 aluminum brass alloy hot compression characteristics have been investigated for its microstructure examination in Gleeble-1500 thermal simulation experiments in strain rate of 0.01-10S-1, deformation temperature of 650-800°C, Analyzed the rheological stress, the flow stress is reduced with deformation temperature increased and increased with the increase in strain rate. When alloy processing temperature at 750°C and the deformation rate in 0.1 S^{-1}, the primary alpha phase has equiaxial shape and uniform composition, the alloy dynamic recovery is flat and the deformation has lowest reinforcement.

Key words: Aluminum brass alloy, isothermal deformation, hot compressive, microstructure

INTRODUCTION

HAL60-1-1 aluminium brass belong to multiple brass, in order to improve the corrosion resistance, mechanical property and machinability, adding a small amount of tin and lead, manganese and iron, nickel in binary brass. HAL60-1-1 belong to Cu-Al-Fe department copper alloys, adding a small amount of aluminium alloy in surface can formation a strong oxidation film, increase corrosion resistance for gases, solution, especially high-speed water, improve the strength and hardness of the alloy.

The high-strength wearable brass research and development is a new field of material industry developed for the requirements of users (Li and Luo, 2008; Liu, 2010). At present, the project produced by cutting process, the production efficiency is low, the low material utilization ratio, the high cost, casting internal organizational segregation of such parts, defects cause osteoporosis in low into rate. How to increase casting aluminum brass plastic, favors the plastic forming and improving the strength and wear resistance is our urgent need to resolve the problem.

EXPERIMENTAL METHODS

Experiment within the scope for setting a series of different thermal deformation simulation experiments of parameters. The experimental is processed by Gleeble-1500 thermal simulation experiment machine, it can automatic acquisition data.

The main parameters of deformation conditions:

- Deformation temperature: 650, 700, 750, 800°C
- Strain rate: 0.01, 0.1, 1.0, 10 S^{-1}
- Deformation degree: 80%

EXPERIMENTAL RESULTS AND ANALYSIS

Influence on the performance of different temperature: From Fig. 1, we can see, true stress rising trend is bigger with the rising of true strain, it shows the alloy under different conditions would not have dynamic recrystallization. With the deformation temperature increased, the strain rate curve becomes quite flat, processing harden to the increase of flow stress basically offset by dynamic recrystallization (Ma, 2001).

Different deformation rate on the alloy performance influence: The impact of deformation rate on the material deformation strengthen is bigger, the size of the strain strengthening index n, which is a very significant performance indicators for the ability of strengthening or the ability of further plastic deformation resistance. Index n can indicated by the slope of line, if the slope more bigger, the deformation strengthen is stronger, deformation strengthen is highest under the strain rate of 10 sec^{-1}. The lowest deformation strengthen is under 0.01/sec^{-1}. So, choose the strain rate on 0.01 sec^{-1}.

From Fig. 2, we can see, in hot compress, the overall flow stress change the rules: In the same deformation temperature, the strain is lesser for different strain rate, the

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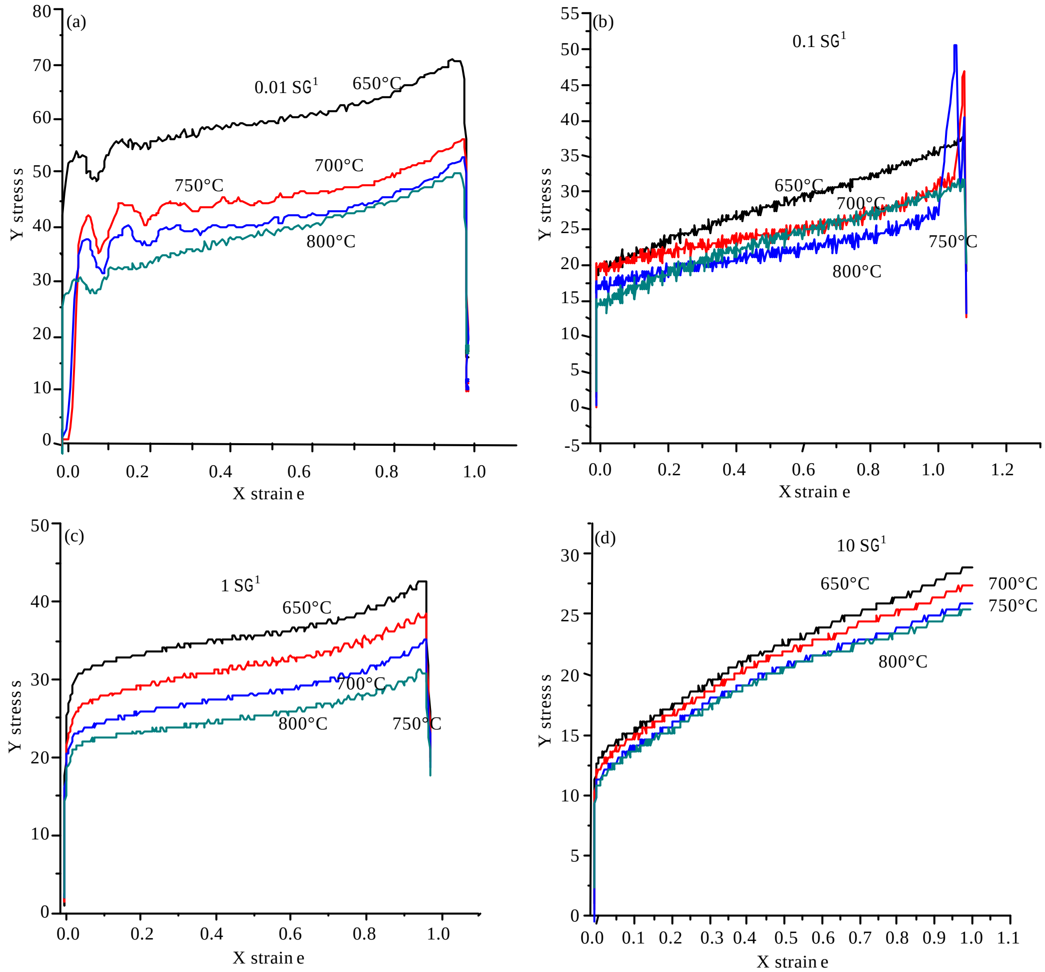

Fig. 1(a-d): Stress-strain curve on different temperature condition, (a) 0.01 S^{-1}, (b) 0.1 S^{-1}, (c) 1 S^{-1} and (d) 10 S^{-1}

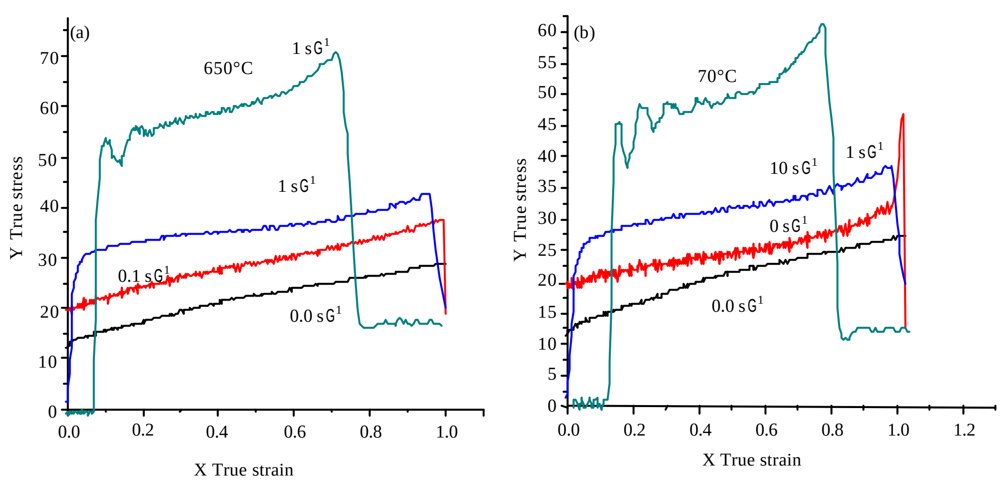

Fig. 2: Continue

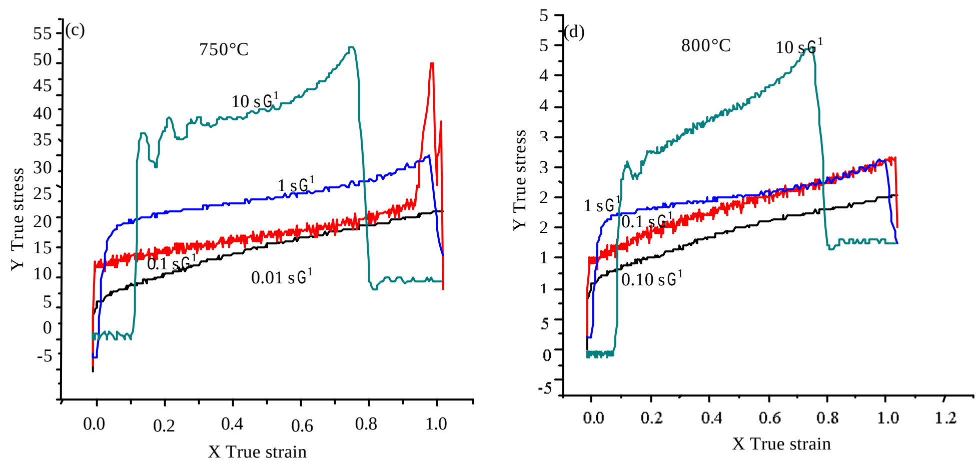

Fig. 2(a-d): Real stress-strain curve under the different strain rate, (a) 650°C, (b) 700°C, (c) 750°C and (d) 800°C

flow stress increased almost a like linear relationship with the strain increased. The work hardening is very severe. When strain to 1%, the curve appears inflection point, the flow stress slow increased with the increased of the strain. Then the material started to dynamic softening, namely, the dynamic recovery or recrystallization. When the strain reached to 7%, the flow stress keep stable and has nothing to do with the strain, the material hardening and softening reached balance. In addition, with the deformation temperature unchanged, steady-state flow stress increased with the increase of strain rate (Lancaster, 1990; Yuan and Chen, 2009).

HOT COMPRESS MICROSTRUCTURE ANALYSIS

Microstructure in thermal simulation configuration influence on the microstructure of deformation temperature: The strain temperature which is the basic parameters to decide the microstructure and properties has significant influence on the microstructure. From Fig. 3 we can see, the microstructure morphologies were alike after the deformation, with the temperature increasing, the alpha phase in the organization happened alpha-beta phase shift, it make the content of primary alpha phase decreased. But because of higher deformation temperature provides more energy, it strengthen the alpha phase's interfacial diffusion ability and it have a chance to annex the near smaller alpha grain, so the number of alpha phase grain decreased, but alpha grain size is in a little change. Look from whole, with the deformation temperature increased, the content of primary alpha phase is gradually reduced, the size of alpha grain in small changes at first and then decreased. In (alpha+beta) two-phase area deformation, the heating temperature before the deformation will directly influence the content of alpha phase organization after deformation. The deformation temperature more below the alpha+beta transition temperature, the more primary alpha proportion will greater. Figure 3b shows the microstructure under 750°C, the extrusion temperature is above the (alpha+beta) -beta transition temperature, just after the end of the extrusion, the beta phase exhalation from alpha phase. The white alpha phase squeezed distributed in black beta phase substrates, black granules is Fe phase.

Influence on the microstructure of deformation rate: The strain rate take a little influence on the content of alpha phase in the microstructure, As shown in Fig. 3, it have certain effect to the microstructure of the morphology of primary alpha phase. The initial alpha grain is equiaxed crystal under the deformation speed of 0.1 S^{-1}. The grain is evener because it happened fully dynamic recrystallization in the deformation condition. So if the deformation in the speed of 1 S^{-1}, the initial alpha phase will not thinning. if strain rate is low and have better control of deformation process, it can be refined the grains of alpha phase. Deformation rate have certain influence to organizations, too fast or too slow are bad. If deformation rate is too large, on the one hand, the large deformation resistance increases, it will increase energy consumption; On the other hand, deformation process produces a large number of deformation heat, it can make the deformation of the actual temperature inside thing beyond the applicable temperature, it makes the microstructure deteriorated.

If deformation rate is lesser, softening mechanism is given priority to dynamic recovery during the

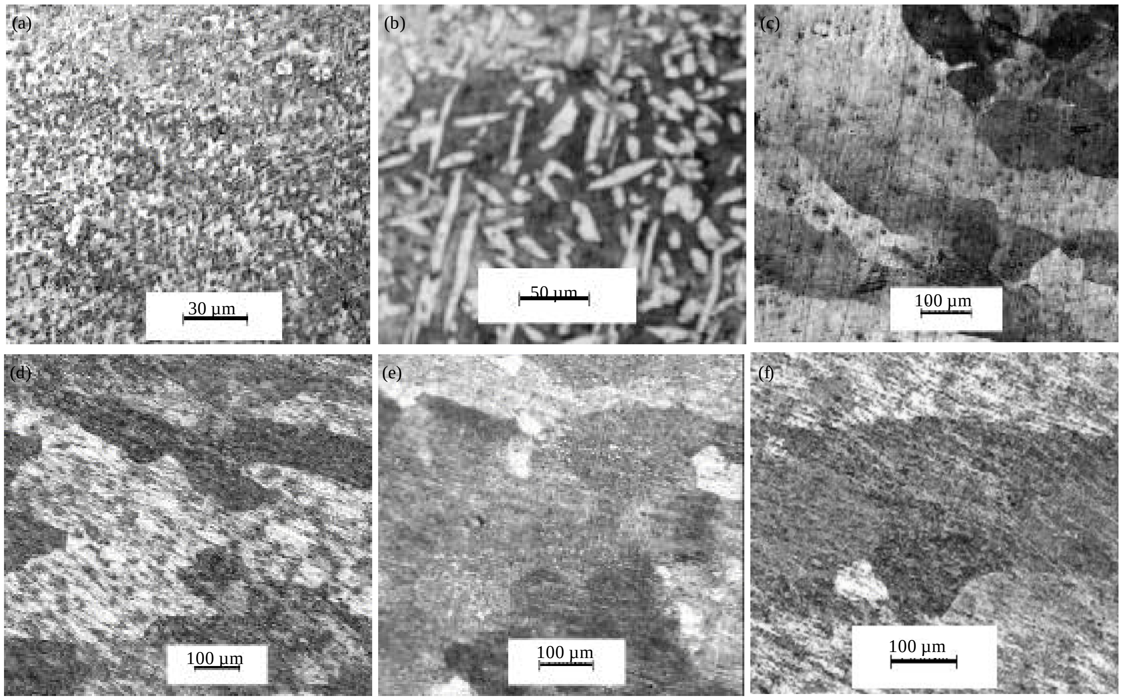

Fig. 3(a-f): Different temperature and different strain rate of metallographic organization

deformation. The dynamic recrystallization wil not completely, it can make the deformation of internal microstructure of workpiece appeared to have a clear direction. If it appears this kind of circumstance, the deformation degree should be properly increased in order to broken the long strips organizations.

CONCLUSION

During HAL60-1-1 brass alloy aluminum thermal deformation, rheology stress curve is nearly steady-state rheological phenomenon. The flow stress reduced with the deformation temperature is rising and the flow stress increased with the increase of strain rate. The influence of temperature on the rheological stress is more significant than the influence of strain rate to the flow stress.

Only in 700-800°C, the strain rate curve becomes quite flat, it is explained by the alloy happened dynamic recrystallization, processing harden to the increase of flow stress basically offset by dynamic recrystallization function. When other conditions remain unchanged, the more prone to dynamic recovery and dynamic recrystallization if the deformation temperature is higher or deformation rate is more lower.

The deformation resistance would increased if the strain rate is too big, deformation process produces a large number of deformation heat, it can make the deformation of the actual temperature inside thing beyond the applicable temperature, it makes the microstructure deteriorated. If deformation rate is lesser, softening mechanism is given priority to dynamic recovery during the deformation. The dynamic recrystallization will not completely, it can make the deformation of internal microstructure of workpiece appeared to have a clear direction.

The alloy processing temperature should choose on 750°C and deformation rate should chosen in 0.1 S^{-1}. In the deformation condition above, the primary alpha phases have equiaxial shape and uniform composition. The alloy dynamic recovery is flat and the deformation has lowest reinforces.

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