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The Study on the Mechanical Properties with Various Control Cooling Conditions for Ball Joint Socket

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Abstract

In this study, to show well favorable characteristics of warm forged material, we compared and analyzed microstructure and mechanical properties of general hot-forged material which finished heat treatment with warm-forged material which was produced by control cooling condition. Along with this, we suggested better direction of control cooling condition to be able to remove heat treatment process while satisfying mechanical properties.

Key words : Hot forging, Warm forging, Ball joint socket, Control cooling

1. Introduction

As industrial technology grows fast with development of auto industry, forging and machining technique is reaching it's highest level. Recently with auto makers focusing on light weight of product, automobile component suppliers are also making intensive study for light mass design, mass production and diminution of manufacturing process.

In steering part ball joint socket which is subject of this study is assembled to ball stud which is connected to control arm, and does very important function in suspension and steering.

Prototype ball joint socket has very complicated 3D shape and is made by hot forging. The forging yield of hot forging is 60~80%, that shows large quantity of material is wasted away. In addition, hot forging product have to assure large amount of machining allowance which lead to long time machining process and material loss. To get rid of this problem of hot forging we developed and applied in mass production warm forging which makes it possible to achieve over 90% of forging yield and take minimum time in machining.

2. Experimental procedures

Mechanical properties of S45C which is used for ball joint socket can be changed to our need, Appling different heat treatment condition. Especially heat treatment has an effect not only on mechanical properties of forged material but also on productivity in production line, making it very important the development of efficient heat treatment process. So we performed test targeting on development of heat treatment process of hot forged material to acquire good mechanical properties and productivity.

2.1 Experimental conditions

We made specimens of hot and warm forging for experiment. First to make test piece of hot forging, we forged materials that was heated up to 1200℃ used hot forging press. Second, to make test piece of warm forging, we preheated materials up to 200℃ and coated graphite lubricant and then heated materials again up to 850℃(a temperature of warm forging) used by high frequency radio heating system. By 1600Ton warm forging press, we made test piece of warm forging. The following is a summary about heat treatment conditions of test piece hot and warm forged.

Table 1 Summary of cooling conditions

① Air-cooling	Natural cooling in ambient air after hot forging.
② Air-cooling	Natural cooling in ambient air after warm forging.
③ Air-spray / A.C. (10℃, 90sec)	Air-spray cooling for 90sec through by using an industrial air conditioner after warm forging.
④ Air-spray / A.C. (10℃, 120sec)	Air-spray cooling for 120sec through by using an industrial air conditioner after warm forging.
⑤ Air-cooling	Natural cooling in air after hot forging and then quenching-tempering.
⑥ Air-cooling	Natural cooling in air after warm forging and then quenching-tempering.

2.2 Experimental method

To analysis mechanical properties of hot and warm forged specimens according to heat treatment conditions, we studied microstructures of each test pieces used electron microscope and did hardness test, tensile test and impact test.

3. Results and discussion

3.1 Microstructure

Fig. 1 (a) shows the microphotographs of hot forged part after quenching-tempering. The structure of tempered martensite seems not to have been completely recovered yet, because some grain boundaries exit clearly. On the other hand, the microstructures of warm forged part shows the fine ferrite-pearlite structures, as shown in Fig.1 (b), (c), and (d). The grain size of cooled part after warm forging is smaller than that of hot forged part. Specially, the cooling may be necessary for the control for inside of part.

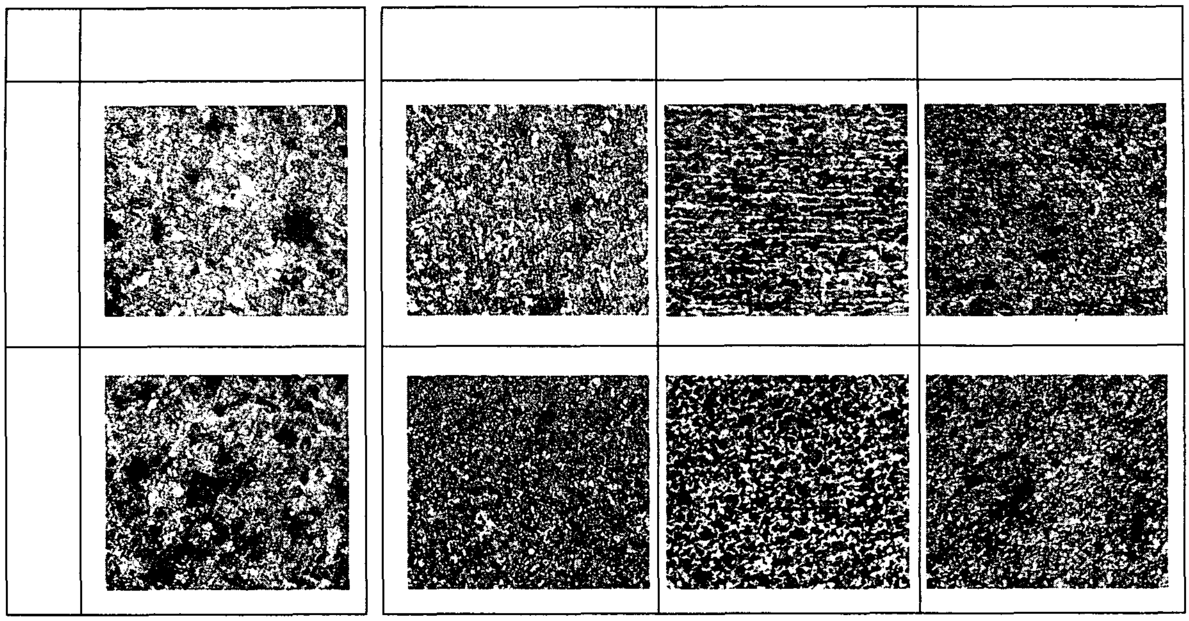

Fig. 1 microstructures of AISI1045 according to the forging temperature and heat-treatment

3.2 Hardness

Table 2 Hardness at different heat treatment conditions

Heat treatment condition	Hardness (HRB)
Natural cooling in air after warm forging	88.8
Natural cooling in air after hot forging and then quenching and tempering	96.0
Natural cooling in air after warm forging and then quenching and tempering	97.4
Air-spray cooling for 90sec through by using an industrial air conditioner after warm forging.	89.0
Air-spray cooling for 120sec through by using an industrial air conditioner after warm forging	89.9

3.3 Mechanical properties

Fig. 2 shows test results about (a)Elongation, (b)Yield Strength, (c)Tensile Strength, (d)Impact energy of each hot and warm forged specimens according to heat treatment and cooling condition. In elongation, warm forged specimens by control cooling marked 21% which is superior to others. And in yield strength, warm forged specimens which had finished Q/T marked 550MPa, that shows better strength of warm forged specimens than hot forged that. And as for tensile strength and impact energy, warm forged specimens which had finished Q/T was also found to have better characteristics than hot forged that. In this study we could find the fact that mechanical properties of warm forged material can be improved by merely control cooling to warm forged material without applying Q/T.

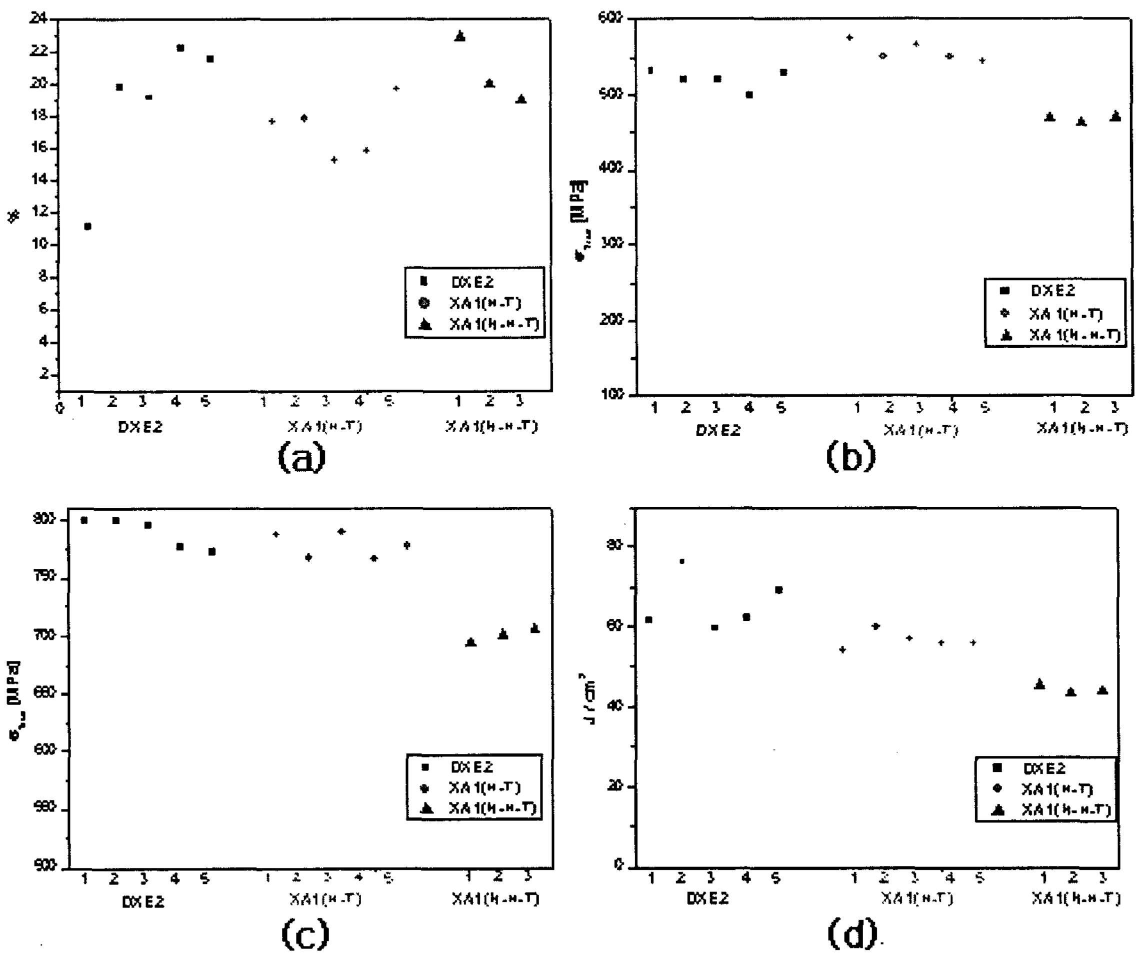

Fig. 2 (a) Elongation(%), (b) Yield Strength(Mpa), (c) Tensile Strength(Mpa), (d)Impact Energy(Mpa)

4. Conclusions

In this study, we compared and analyzed microstructure and mechanical properties of general hot-forged material which finished heat treatment with warm-forged material which acquired by control cooling conditions. The results are as follows,

(1) Micro structure of warm forged socket is finer than hot forged socket.

(2) According as cooling rate is fast, we can find that microstructure of forged socket is finer and mechanical properties are also excellent.

(3) As warm forged socket is quenched and tempered, comprehensive quality is better than an usual quenched and tempered hot forged socket.

(4) As a result of performance test of controlled cooling socket after warm forging, forged socket is suitable to be used for ball joint socket.

(5) When control cooling process without heat treatment process can be applied to warm forged socket, we will reduce the cost of heat treatment.

As a result of above statement, warm forging is also suitable to be used for products manufacturing through same Q/T process with hot forging.

Therefore we can reach a conclusion that if we find an optimizing condition of control cooling through research and development, we can not only improve mechanical property of products but also remove heat treatment process. Finally it could improve productivity

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