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The Effect of Cold Forging on Carburizing Microstructure

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Abstract

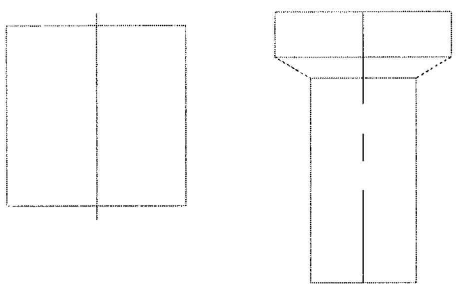
The aim of this paper is to illustrate which factors influence the martensite grain fineness made by subsequently surface carburizing of extruded component. The effects of surface decarburizing by annealing, residual stress, initial microstructure and crystal oriental made by forward extrusion were taken into account. The available evidence suggests that the residual stress inside crystal or the crystal orientation is the main factor that results coarse martensite while cold extruded component was treated by carburizing.

Keyword: cold extrusion, carburizing, coarse martensite, residual stress

1. Introduction

The advantages claimed for the cold forging of steel is much more popular in manufacturing industry. As it is widely used on the basis of economy of manufacture, some problems may appear. In this paper, investigations about the coarse martensite directly due to cold extrusion were carried out. Factors such as residual stress, initial grain size and surface decarburizing, were taken into account and discussed.

The component discussed in this paper is extruded and subsequently treated by carburizing hardening. The production process is shown below:



Cropping → Annealing → Surface treatment →Cold Extrusion-→Sub-critical Annealing →machining →Carburizing → Polish

Fig.1 Cold Extrusion

The coarse martensite was obtained form carburizing hardening of cold forgings as same time the microstructure obtained form hot forgings was acceptable. Although the problem can be solved by improving process of heat treatment, it is beyond the scope of this paper and is not essential for our purpose. We are interested in that which factor in cold forging effects on the microstructure of carburizing.

2. Investigation and discussion

2.1 Investigation

The material of specimen is 20Cr (Scr420 /AISI5120). The chemical composition is shown in Table 1.The microstructures of specimens in several stages are shown in Table 2.

Table 1: Chemical Composition (%)

C	Si	Mn	P	S	Cr	Ni	Cu
0.21	0.22	0.60	0.010	0.017	0.82	0.04	0.19

Table 2

No.	Specimen state	microstructure	grain size	grain grade
1	Annealing prior to extrusion	F+P	30μm	7
2	Extruded	F+P	25μm	7
3	No.2& sub-critical annealing	F+P	22μm	8
4	Hot forging	F+P	40 μ m	6

Specimen No.3 that is preparation prior to carburization shows ferrite--spheroidised pearlite structure and fine initial grain size. Thickness of decarburized layer is 0.3—0.5mm. The thickness of surface carburization is required to be 1.2—1.5mm and the treatment was carried out in pit furnace.

On the basis of foregoing descriptions, the different factors between cold forgings and hot forgings are residual stress, surface decarburizing, the crystal orientation and initial grain size.

The investigation was carried out to determine that which factor influence Ms grain size of component which was carburizing hardening. Various specimens were carburized together in same furnace and microstructures are shown in Table 3. There is little difference in Ms grain size.

The results obtained from the trail could not be used to explain the question. An expert in heat treatment suggested that the trail should be carried out with fine grain steel. Then solid carburizing at 930℃*7h shown the specimen is of coarse grain steel that grain size of ferrite obtained is 170μm.

Table 3 Carburizing trial with cold forgings

No.	State prior to carburizing	Ms grain size	grade
1	Sub-critical annealing at 580℃*4h	70-80μm	8
2	Peeled out 1mm on No.1	70-80μm	8
3	Normalizing at 860℃*4h	70-80μm	8
4	Peeled out 1mm on No.3	70-80μm	8

The specimens of fine grain steel 20Cr in seven different states were carefully prepared for next carburizing trail. The result is shown in Table 4 that the specimens of No.1,2,6,7 meet the requirement of surface hardening.

Table 4 Carburizing on fine grain steel

No.	State prior to carburizing	Ms grain size	grade
1	Hot rolled bar	20μm	5
2	Annealed	20μm	5
3	Extruded	80μm	8
4	Extruded and sub-critical annealing	80μm	8
5	No.4 and peeled	80μm	8
6	Extruded and normalizing at 860℃*4h	28μm	5.5
7	No.6 and peeled	28μm	5.5

2.2 Discussion

The residual stress distributions can be categorized to three kinds:

1st: residual stress between different deformed regions
2nd: residual stress between different crystals
3rd: residual stress in crystal

The 1st and 2nd residual stress can be relieved by heating the specimen to recrystal temperature below Ac1 that is states of No.4 and 5 specimens. The 3rd residual stress can only be relieved with phase transformation (states of N0.6 and 7). The higher energy level because of residual stress tends to coarse austenite grown.

The crystal orientation occurs that grains tend to have a same crystal direction along the axis during cold extrusion. It makes coarse grain size by heating steel at carburizing temperature 920℃. The structure of crystal orientation can be changed by normalizing that is the state of specimens No.6 and 7.

3. Conclusion

The investigations have not been success to determine the main factor that results coarse martensite while cold extruded component was treated by carburizing. But on the basis of carburizing trails of fine grain steel, some of conclusion could be obtained:

1. The coarse martensite is directly due to cold extrusion.
2. The surface decarburization does not effect on that.
3. The residual stress distribution in crystal or the crystal orientation is the main factor that results coarse martensite normalize
4. The fine martensite can be obtained by normalizing cold forgings of fine grain steel prior to carburizing hardening.