Control of Austenite Grain Size in Carburization of Steels

I. Introduction

It is known that grain growth of austenite in Al-killed steels is retarded below a critical temperature. However, an extensive grain growth proceeds above the critical temperature which is sometimes within the carburizing temperature.

To obtain a fine-grained carburizing structure without abnormal grain growth, the following three methods have been developed for fine and uniform dispersion of aluminium-nitride precipitates.

II. Prevention of Grain Growth

1. Micro-addition of Aluminium and Nitrogen

Prevention of grain growth requires a content of aluminium-nitride more than 200 ppm in steel after carburizing. Thus the nitrogen content should be more than 120 ppm and the acid-soluble aluminium more than 0.023 %. The high contents of nitrogen and acid-soluble aluminium are achieved with high cleanliness by RH process.

2. High Temperature Reheating for Rolling

Figure 1 illustrates the coarsening characteristics of steels. The area fraction of coarse grains is plotted against the temperature of carburizing for 4 h. By reheating at 1 200°C, coarse particles of aluminium-nitride are reduced less than 50 ppm by dissolution, resulting in a lower volume fraction of coarse aluminium-nitride particles in the rolled steels than that reheated at 1 000°C. On carburizing the volume fraction of fine and effective aluminium-nitride particles corresponds to the amount of aluminium-nitride brought into solution on reheating.

3. Pre-heat Treatment for Carburizing

As shown in Fig. 2, steels preheated at 650°C have fine aluminium-nitride precipitates after carburizing. Open circles represent the result of chemical analysis and solid circles the content of fine aluminium-nitride (below 0.1 µm). The amount of fine aluminium-nitride has a tendency similar to the critical grain coarsening temperature in the plot against the pre-heat temperature on Fig. 3. The effect of grain growth inhibition is shown to remain even after normalizing.

III. Conclusion

In order to prevent the grain growth in carburizing, the present three methods are applicable. Combination of these methods ensures a fine grain structure in the products.

Figure 4 shows the dependence of equivalent-strain on grain coarsening temperature; grain coarsening temperature decreases as equivalent-strain increases. Even in the case of cold works, pre-heat treatment is effective. The same effect can be achieved by controlling the heating pattern in carburizing.

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