Chapter 1
Introduction

1.1 Background

For last half a century past, materials of hot work rolls in the steel industry changed from low-alloyed chilled white iron through adamite or hyper-eutectoid Ni-Cr steel and Ni-hard cast iron to high chromium cast iron. The high chromium cast iron, which was developed in the nineteen-seventies, is even now used not only for hot working mill rolls but also for pulverizing mill rolls in the mining and cement industries because of its high wear and heat resistance. According to the demands in upgrading the productivity and the quality of products, the roll materials are being compelled to shift to a new type of material with much more performance. The multi-alloyed white cast iron or multi-component white cast iron is a new type of alloy which contains plural kinds of strong carbide forming elements such as chromium (Cr), vanadium (V), molybdenum (Mo), tungsten (W) and resultantly, plural kinds of their special carbides with high hardness and strong matrix with secondarily precipitated carbides. This iron was developed around 15 years ago in Japan and has been tried to apply to the work roll of hot finishing stands for the past 10 years. Nowadays, a large portion of the work rolls in hot rolling mills is replaced from high chromium and Ni-hard white cast iron rolls. It is worthy of note that the trial rolls were served recently to the mineral pulverizing mill rolls. The new rolls made of multi-alloyed white cast iron have been showing high quality and long service life in the hot rolling. There is the research to compare the wear resistance of three kinds of hot work rolls, Ni-hard cast iron, high chromium cast iron and multi-alloyed white cast iron[1)]. The results show obviously that

multi-alloyed white cast iron has highest wear resistance than Ni-hard cast iron and high chromium cast iron, and it is convinced that newly developed multi-alloyed white cast iron will find much wider applications in the field of abrasion wear resistant materials.

Multi-alloyed white cast iron rolls have been mostly used in Japan because a new roll making process called CPC process that is particularly suitable to make a roll containing many kinds of carbide forming elements was originally developed in Japan[2]. In several countries, however, the introduction of multi-alloyed rolls which were made using a centrifugal casting process (CF) is gradually increasing because of the good reputation of CPC rolls. Especially, in Nippon Steel Corporation, the service life of rolls could be extended 3 to 5 times more than that of the conventional rolls made by Ni-hard and high chromium white cast iron.

When such a high performance multi-alloyed white cast iron roll is considered, it is a mutter of course that roll makers as well as rolling mill shops expect to apply the multi-alloyed white cast iron for the material of work rolls of cold rolling mill that should have different characteristics from the hot work rolls.

Recalling the main properties which the cold work roll should have, the following characteristics are listed.

(1) high hardness more than 800 HV for good wear resistance.

(2) maintenance of reasonable degree of surface roughness to protect the slipping between roll and sheet.

(3) minute and homogeneous microstructure for strength and toughness.

In case of multi-alloyed white cast iron roll, 15 to 25 volume percent of eutectic carbide such as MC, M_2C and M_7C_3 exist in the matrix[3], and they are sometimes large massed or segregated. If this multi-alloyed white cast iron is made to apply for the cold work roll directly, the printing may take place on the rolled sheet. To prevent the sheet from printing,

therefore, new alloy design must be considered to reduce the amount and the size of carbides and to uniform their distribution.

To satisfy the characteristics of cold work roll mentioned previously, heat treatment of the roll is very important even if the multi-component white cast iron with expected microstructure is obtained due to the success of alloy designing. The heat treatment of the cast iron can control the matrix structure and will improve the mechanical properties. The fundamental and systematic researches on heat treatment behavior of multi-alloyed white cast iron can be found in several papers. With respect to the multi-component white cast iron for the cold work roll, however, neither alloy designing nor heat treatment has not been reported at all. From the viewpoints mentioned above, the research on the heat treatment behavior of cast irons designed by focusing on the materials for cold work roll has been proposed in this thesis.

1.2 Objective of Research

Study on heat treatment behavior of multi-component white cast irons to develop the new type rolls for cold working mill.

1.3 Scopes of Research

(1) To clarify the heat treatment behavior of multi-component white cast irons of which alloying elements are varied in the interesting range.
(2) To measure the hardness of cast irons and volume fraction of retained austenite in order to compare them with heat treatment condition.
(3) To measure the alloy concentration of various phases precipitated in the cast irons.

(4) To investigate the change in microstructure of heat-treated specimens by means of optical microscope and scanning electron microscope (SEM) to confirm the experimental results.

1.4 Advantages of Research

(1) To obtain the data concerning the most important heat treatment behavior of multi-component white cast irons which contain the wide range chemical composition and to be able to evaluate the properties from the viewpoints of application for cold work roll.
(2) To be able to use the obtained data as the reference for the researches such as wear, strengthened toughness tests in order to find the suitable heat treatment condition to endow the expecting properties of cold work roll.
(3) On the basis of these data, the practical heat treatment process of multi-component white cast irons will be examined in the conventional roll scale, and therefore, the development of these cast irons for practical rolls will advance more and more.