Chapter 6
Conclusions

Multi-component white cast irons containing strong carbide forming elements such as Cr, Mo and V and with chemical composition of Fe-5%Cr-5%Mo-1~3%V-0.5~1.5%C, where the special carbides of MC and M_2C types coexist, are designed aiming at the materials for cold work roll because of good reputation of multi-component white cast iron rolls developed for hot working mill. The cast iron specimens were hardened and tempered after annealing, and the effects of heat treatment condition and chemical composition on the hardness and the volume fraction of retained austenite are clarified.

The conclusions obtained are as follows :

In as-hardened state

(1) In the case of 1273 K austenitization, the hardness of 0.5% and 1.0%C cast irons decreases and that of 1.5%C cast iron settles down to approximately a constant value, as V content increases.

(2) In the case of 1373 K austenitization, the hardness of 0.5%C cast iron decreases and that of 1.0%C cast iron shows nearly a same value and it rises conversely in 1.5%C cast iron, as V content increases.

(3) Volume fraction of retained austenite ($V\gamma$) decreases regardless of C content and austenitizing temperature, as V content increases and at the same V content, the higher the C content and austenitizing temperature, the more $V\gamma$ increases.

In tempered state

(1) Curve of tempered hardness in each specimen shows the secondary hardening at certain range of tempering temperature due to both the precipitation of hard special carbides from martensite during tempering and the martensite transformation of destabilized austenite during cooling after tempering, and the maximum tempered hardness (H_{Tmax}) is obtained from the curve of each specimen.

(2) Micro-hardness or the hardness of the tempered matrix shows very similar behavior to the macro-hardness in every specimen.

(3) Hardness of tempered specimen varies depending on chemical composition, the more the C content and the lower the V content at the same C level, the higher the hardness.

(4) Maximum value of H_{Tmax} is obtained when the specimen contains around 30% $V\gamma$ in as-hardened state regardless of austenitizing temperature.

(5) The wide range of $V\gamma$ like 10% ~ 50% is permitted in as-hardened state to fulfill the required hardness for the cold work roll if the same tempering condition as this experiment is used.

(6) The highest value of H_{Tmax} is obtained when the C_{bal} is 0.48% in 1273 K and 0.16% in 1373 K austenitizing.

(7) The H_{Tmax} values of specimens hardened from 1373 K are higher than those hardened from 1273 K when C_{bal} of specimen is less than about 0.3%, and they are reversed after C_{bal} gets over it.

(8) Tempering temperature to obtain the H_{Tmax} (T_{HTmax}) is higher in 1373 K austenitizing than that in 1273 K austenitizing, and T_{HTmax} are almost same in 0.5%C and 1.0%C cast irons, but they decrease in 1.5%C cast iron, when V content increases.

(9) In other words, T_{HTmax} can be related to the C_{bal} and they are

constant until the critical values of C_{bal}, 0.13% in cast irons hardened from 1273 K and –0.10% in cast irons hardened from 1373 K. After the C_{bal} increases over each critical value, the T_{HTmax} rises in proportion to the increase of C_{bal}.

(10) The tempering temperature at which the $V\gamma$ is reduced less than 2% can be expressed by the following equations as a function of C_{bal},

At 1273 K austenitizing,

$$T_{2\%\gamma}\ (K) = 776 + 121 \times \%C_{bal}$$

At 1373 K austenitizing,

$$T_{2\%\gamma}\ (K) = 822 + 198 \times \%C_{bal}$$

(11) From SEM observation of matrix structure at high magnifications, it is found that secondarily precipitated carbides in the specimens which show the maximum tempered hardness are most in the amount and finest in size.