Department of Mechanical Engineering

Development of Innovative Manufacturing Technology for steel materials to reduce CO_2

Kohichi ISOBE
Professor, Dr. Eng., Honorary professor (NIT , Akita College)
Email : isobe-k@gifu-nct.ac.jp

Research Fields Mechanical engineering, Material science

Keywords Reverse transformation , Insert casting, Macro segregation

Research Outline

Development of Steel Toughening Technology by Advanced Utilization and Optimization of Reverse Transformation Processing

For drastic reduction of CO_2 emissions during steel manufacturing, it is important that continuous casting and blooming integrated process, need to improve hot charge rolling (HCR) ratio and promote scrap reuse. In that case, mixing of tramp elements such as Cu and N content increasing and microalloying such as Nb for improving the performance of steel materials reduce the hot workability of steel materials . As a countermeasure, this study proposes the application of reverse transformation treatment and its optimization, which realizes toughness of steel materials by miniaturizing the γ grain structure on the surface layer of steel materials. To achieve this, it is necessary to elucidate the cooling method and cooling conditions for refining the surface layer γ grains without thermal distortion of blooms and quenching cracks by using the metallo-thermo-mechanics analysis , that is coupling analysis of thermal elasto-plastic analysis, heat transfer analysis and transformation behavior analysis(Fig.1). It has been elucidated the effects of various cooling methods (immersion cooling, mist cooling, spray cooling) and cooling water temperature on the required cooling time, thermal distortion , and stress generation behavior, and their mechanisms. Furthermore, by combining materials engineering methods, CCT diagrams up to the coarse γ grain size equivalent to bloom's are estimated, and the effect of the γ grain size is being investigated.

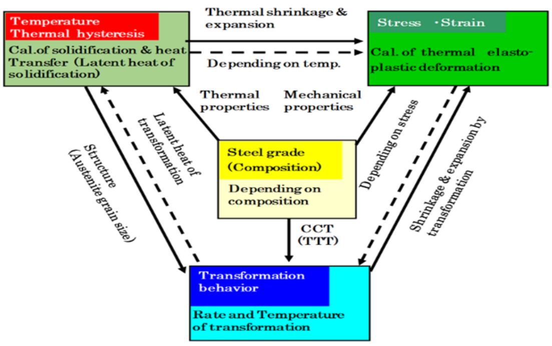

Fig.1 Schematic view of the model of metallo-thermo-mechanics

Development Technology for Prevention of Macro-segregation in Casting of Steel Ingot by Insert Casting in Vacuum Atmosphere

In order to drastically reduce CO_2 emissions during power generation, along with the development of various advanced power generation processes, improvement of thermal efficiency by the capacity increasing of power generation unit and increasing steam and gas temperature and steam and gas pressure in power generation turbines, is pursued. As the size of steel ingots for manufacturing large parts increases and the usage environment becomes harsher, the generation of macro-segregation is promoted, and the permissible segregation level is becoming stricter. A drastic improvement in macro-segregation is eagerly desired. Until now, a versatile and effective macro-segregation countermeasure for the casting has not been developed.

For the purpose of developing countermeasures in the casting of large steel ingots, the insert casting in vacuum atmosphere, in which a core material with the same composition as the base steel is placed at the center of the steel ingot, has been proposed and investigated. The effectiveness of the proposed insert casting as a macro-segregation countermeasure was verified in laboratory experiments. In addition, it has been clarified that good bonding between the core material and the base material can be realized even under conditions where bonding by normal insert casting in air atmosphere is difficult. The mechanism of suppresses the macro-segregation and the reasons and conditions for good bonding in this insert casting are clarified.

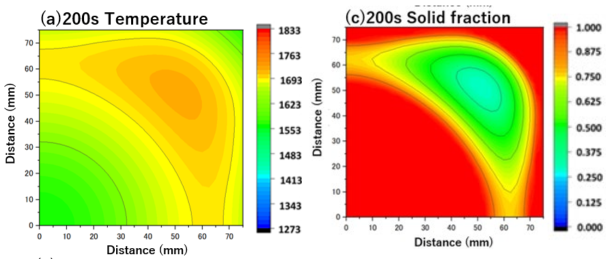

Fig.2 Calculated distribution of temperature and solid fraction on 1/4 cross section of ingot at 200 s from teeming. (Insert casting,S50C, 150mmsquare Ingot,60Φ)