# 論文の内容の要旨

## 論文題目　　Dissolution Mechanism of Steelmaking Slag into Seawater

## (海水中への製鋼スラグの溶解機構)


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In Japan, steelmaking slag is mainly used as road base course material, aggregate for asphalt concrete, and fertilizer *etc*. However, still about 0.8 % of converter slag and 8.8 % of electric furnace slag are landfilled without any utilization. As containing various oxides such as FeO, CaO, $SiO_2$, $P_2O_5$ *etc.*, steelmaking slag is believed to be able to supply nutrient elements for restoring the disappeared seaweed beds along the coast caused by ISOYAKE. In the present research, the dissolution behaviours and mechanisms of elements from steelmaking slag, steelmaking slag with gluconic acid addition, steelmaking slags-dredged soil mixture were comprehensively investigated. In addition, the prospect of utilization of steelmaking slag in the coast was also evaluated.

In chapter 1, the present situation of steel production and recycling of steelmaking slag and the situation of sea desertification are described. Research progress about utilization of steelmaking slag in the coast and the academic research progress on the dissolution of steelmaking slag are introduced.

In chapter 2, the calculation for solubility diagrams of Ca and Mg, Si, Al, P and Fe and potential-pH diagram for iron-water system are illustrated.

In chapter 3, the dissolution of elements from synthesized slags into seawater with changing the amount, $CaO/SiO_2$ ratio and particle size of slag are investigated by the shaking experiments. The $CaO/SiO_2$ ratio of slag as the primary factor greatly affects the dissolution behaviours of elements. At the same time, amount and particle size of slag also affects the dissolution behaviours of elements. Larger amount and smaller particle size of slag have a larger concentration of Ca and smaller concentrations of Si and P. Solubility diagrams reasonably elucidate the different dissolution mechanisms of Si and P from the two different slags. Solubility diagram together with potential - pH diagram of Fe shows the existing species of iron ions in the shaking solution and the dissolution behaviour of iron ions.

In chapter 4, the influence of gluconic acid on the dissolution of elements from steelmaking slags into seawater is investigated with the concentration of gluconic acid changing from 0 to 0.4 g/L. Gluconic acid enhances the dissolutions of Ca, Fe, Si and P greatly, but the enhancement mechanisms are different. The complexes between Ca, Fe and gluconate ion are formed and the hydrates of Si and P are increased when gluconic acid is added.

In chapter 5, the dissolution behaviours and mechanisms of elements from steelmaking slags-dredged soil mixture are studied. The three primary parameters are the ratio of steelmaking slag and dredged soil, the $CaO/SiO_2$ ratio of slag and the content of FeO in slag. In the case of the different ratio of steelmaking slag and dredged soil, the dissolutions of Ca, Si, P and Fe are enhanced by the addition of the dredged soil and also increased with decreasing the slag/soil ratio. At the same time, a buffering action on pH is provided by the dredged soil. The maximum dissolution of Fe during shaking is attributed to the photo-reduction reaction of ferric-organic acid complexes. In the case of the different $CaO/SiO_2$ ratio of slag, the dissolutions of Ca and Al increase with increasing the $CaO/SiO_2$ ratio of slag as well as the addition of dredged soil. The enhancement effect of dredged soil on the dissolution of Si is attributed to the formation of silica hydrate. The concentration of soluble Fe is extremely low whether with adding dredged soil or not. The dissolution of Ca increases with decreasing the FeO content in slag. The influence of FeO content on the dissolution of Al, Si, P and Fe is not clear.

In chapter 6, the prospect of utilization of steelmaking slag-dredged soil mixture in coastal environment is discussed. Comparing the difference between laboratory and field experiments, the practical condition seems to be a much more beneficial for the dissolution of nutrient elements especially iron from steelmaking slag into seawater. Furthermore, the purification effect of steelmaking slag on coastal sediment is also considered. Steelmaking slag can effectively immobilize phosphorous and sulfur to inhibit the eutrophication and oxygen deficiency of coastal environment. Moreover, the dissolution of harmful substances from steelmaking slag is not detected or under the environmental qualities standards. Based on the above comprehensive evaluation, the utilization of steelmaking slag-dredged soil mixture in the coastal environment seems to have possibility for recovering the marine ecosystem.

In brief, the present research clarified the dissolution behaviours and mechanisms of elements from steelmaking slags-dredged soil mixture in detail, providing a reliable fundamental information and reference for utilizing the steelmaking slag in the coast.