Corrosion of monolithic refractory castables for steel production at high temperatures

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For the working lining of steel ladles following variations are applied:
1. Monolithic lining with alumina rich castables,
2. Brick lining in the liquid steel zone and in the slag zone,
3. Zoned lining, a combination, with monolithic refractory materials in the liquid steel zone and MgO-C bricks in the slag zone.

To insure adequate thermodynamic stability (Richardson-Ellingham Diagram) the monolithic refractory castables have to be manufactured with either Al_2O_3 or MgO. This inhibits the release of oxygen from the refractory material into the liquid steel. Currently alumina rich castables are applied but MgO materials are being developed. Spinel Al_2O_3*MgO has better corrosion resistance than Al_2O_3. Therefore spinel forming or spinel containing castables are predominately used.

The low porosity and small pore size are advantageous for good corrosion resistance. Castables with a low cement content [ULCC: Ultra Low Cement Castables] or cement free castables [NCC: No Cement Castables], which are spinel forming or spinel containing, are applied. The low cement content results in a low water content in the castable material leading to low porosity.

Castables can be produced with respect to the application and grain structure, which are either:

* Thixotropic: with mandrel, distribution via vibration,
* Self-flowing: with mandrel, distribution via gravitation,
* or Shot-creting: without mandrel, distribution via spraying.

An exceptionally favorable solution is the Endless Lining System (see figure) through which only the worn layer of the working lining is relined. The new material and the old material of the working layer sinter after curing together and create a new stable working layer.

Advantages of the monolithic manufacturing are:

* Reduced refractory material,
* Reduction of disposal costs, especially by application of Endless Lining System
* Reduction in the personnel costs, i.e., lower man-hours.

The application of monolithic castables is problematic because they are not sintered when first in contact with steel in production facilities (transfer and teeming ladles, blast furnace runners). Instead they have to be slowly cured and dried and then heated to ca. 1000°C. In particular the spinel forming starts at this temperature range. This means that the material gets the important high temperature properties during the initial application.

The production of high alloyed steels or steels with high cleanness need higher demands to the refractory material as compared to production of mass steels. This is due to the higher

production temperatures, longer treating times and more aggressive slags. For these applications further research concerning the corrosion resistance of monolithic castables is required.
Due to this, several methods for the determination of the corrosion resistance properties are tested. The goal is to develop a methodology allowing the testing of a large number samples in a short period of time. Results of such a test allow a preselection of suitable materials for installation in steel ladles.

For the investigations, a static crucible test method is applied. As corrosion media several synthetic slags and slag samples from steel mills are used. Samples with steel are also tested. The main parameters of the experimentation are temperature and holding duration at maximal temperature.

After the tests the crucibles are cut in the middle (in half) with a stone saw. The profiles are then judged after following criteria:

* Infiltration,
* Cracking and deformation,
* Corrosion,
* and the Remaining slag.

After the development and testing of the analysis possibilities several tests of spinel forming castables have been conducted. A special refractory material has been developed and successfully tested under real conditions. Some results of corrosion tests are presented.

Scheme of the Endless Lining System (ELS)