M2A
MATERIALS AND MANUFACTURING ACADEMY

Case Studies

# Basic Oxygen Furnace (BOF) Tuyères and Surrounding Refractories Development

Refractory materials are high temperature resistant ceramics used for lining metallurgical vessels. In a steel plant, refractories enable containment of liquid metal products, ensuring availability of furnaces for production and safe conduct of metallurgical operations.

Tuyères are stirring elements used for bath agitation in Basic Oxygen Steelmaking, increasing efficiency of the process by improved mass transfer between gas and steel, and steel and slag.

This results in homogenous temperature and chemistry, higher yield and better phosphorus partition. The only drawback of the technology is, however, localised wear of refractories surrounding the element.

**Researcher Szymon Kubal investigates.**

In the course of my study I have investigated thermo-mechanical behaviour of refractory materials exposed to two-dimensional thermal gradient, and interactions between gas and liquid steel in the vicinity of the injection point, both **in-situ** and on laboratory scale.

Combined results of literature search and **post mortem** analysis of tuyères led to a new BOF stirring element design based on optimised material selection and gas channel geometry. These changes will enable consistent delivery of mixing energy to the system and extend refractory lining service life, improving overall vessel availability.

Swansea University
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# The Challenges

The biggest challenge of the project was lack of expertise in the field of refractories in Wales.

The distance between Swansea University and my Academic Supervisor Prof. Bill Lee from Imperial College of London as well as Tata Steel Centre of Expertise Refractories in IJmuiden was especially disturbing at the beginning of the research work.

**Another challenge was related to finding a partner for the project among refractory materials manufacturers, as development of the new BOF stirring element requires investment into production technology and testing equipment.**

**Joint efforts of Magnesita Brazil and Tata Steel CoE Refractories enabled production of a prototype for laboratory and full-scale trials.**

# The Patent

Development of a new design of BOF stirring element resulted in a patent application submitted by Department of Research and Innovation of Swansea University. The document is currently being reviewed by both partners – Tata Steel and Swansea University – with a focus on expanding its geographical coverage and potential commercialisation.

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# The Prototype

Work on the prototype required substantial spend from all partners. Swansea University invested £10,000 in a device enabling precise measurement of wear of converter tuyères. Tata Steel in Port Talbot covered installation of the wear tracking instrument as well as financed construction of a water tank designed for physical modelling of BOF stirring elements, totalling £30,000. Magnesita Refractarios spent additional €20,000 on moulds for an isostatic press used for production of prototypes for full-scale trials.

# The Impact

Potential financial implications of the development need to be considered at two different levels – operational (steelmaking process) and commercial. Anticipated performance of the stirring element should bring to Port Talbot savings in aluminium consumption and refractories spend totalling £4,000,000 per annum.

**Consequently, during the first three years from launching, the new product should reach 10% of the market of a total value estimated at £9,750,000 per year.**

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