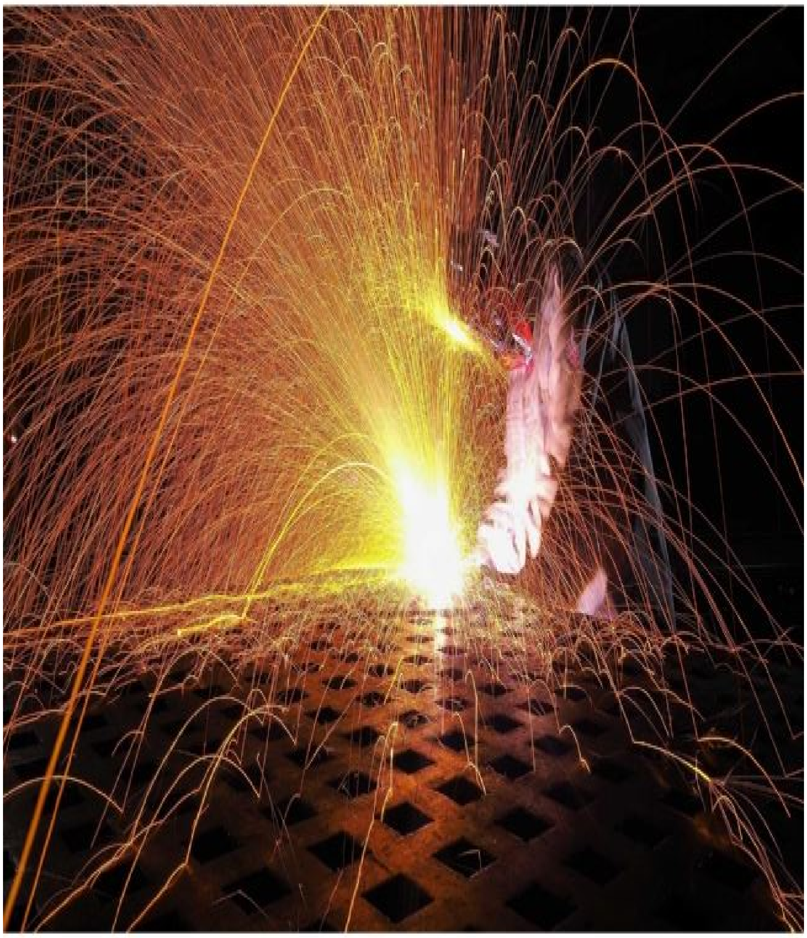
Automation， control and modeling of basic oxygen steelmaking



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In basic oxygen steelmaking， the basic oxygen furnace or converter produces liquid steel by reducing the carbon content of the hot metal produced in the blast furnace from about 4.5% to 0.03% to 1.0%. The converter blows large amounts of pure oxygen into the hot metal and refines it into steel in a short period of time. Currently， the basic oxygen steelmaking process uses combined blowing (top blowing and bottom blowing). The bottom blowing is done with inert gas. In the refining process， various materials are used in the converter.

Besides hot metal and scrap iron as main raw materials， other materials used in the basic oxygen steelmaking process are calcined lime， calcined dolomite or calcined magnesite for proper slag formation and different coolants in the process (e.g. ore， sponge iron， etc.). The operation of the converter requires a high gas temperature and generates a lot of dust.

The purpose of the basic oxygen steelmaking process is to refine the liquid metal (molten scrap + hot metal) and to adjust the composition and temperature of the molten steel. To achieve this， the steelmaking process uses automation and control systems， usually consisting of a basic automation system and a process control system.

The engineering facilities for basic oxygen steelmaking are actually the design and assembly of various subsystems. The main equipment for basic oxygen steelmaking is a refractory-lined converter (basic oxygen furnace)， in which the steelmaking process takes place. In addition to the converter vessel， the steelmaking process has several subsystems， including (i) converter vessel tilt drive， (ii) oxygen lance system， (iii) inert gas bottom stirring system， (iv) top gas (converter gas) cooling， cleaning， analysis and recovery system， (v) sub lance measurement system， (vi) anti-slip system， and (vii) material handling system. (viii) scrap charging system， (ix) solder and coolant charging system， (x) ferroalloy charging system， (xi) horizontal temperature measurement and sampling system， (xii) automatic steel discharge system， (xiii) slag blocking system， (xiv) secondary dust removal system， (xv) interlock and alarm system， and (xvi) human-machine interface system.

In addition to these subsystems， the oxygen steelmaking will operate in an integrated manner with the upstream and downstream processes. In addition， the steelmaking process will be connected to external systems such as (i) the steel melting plant laboratory， which includes optical emission spectrometers and X-ray fluorescence spectrometers and other analytical equipment， and (ii) the supervisory control and data acquisition (SCADA) system.

Basic oxygen steelmaking is a complex physicochemical process with a large number of influencing factors. There are two methods used to control the blowing gas in the converter. The first method uses indirect measurements of the waste gas， while the second method uses direct measurements of the subgun. In the second method， the temperature of the steel (in degrees Celsius) is measured directly during the blowing process at the same time. This method can also be used for various purposes， such as water bath leveling， slag leveling， measuring oxygen concentration and slag sampling.

In the basic oxygen steelmaking process， the classical process models are still valid and require the operator to know as much as possible about the inputs， process parameters and outputs， which he needs to have free access to in order to make the necessary adjustments to the process to produce medium to large products. In order to achieve this goal， various control and estimation techniques need to be used that function in an organized manner in order to provide the required information for the operator's actions.

Subsystems appropriate to this engineering level are (i) hot metal mass measurement， (ii) hot metal analysis， (iii) inert gas bottom stirring， (iv) oxygen supply， (v) charge temperature and analysis， (vi) melt and coolant charging systems， (vii) ferroalloy charging systems， (viii) process control computers， and (ix) management computers. Measurements required during the steelmaking process are (i) temperature measurements， (ii) melt pool carbon content， (iii) melt pool depth， and (iv) complete chemical analysis. This is usually achieved by stopping the process， tilting the converter， and taking manual temperature and samples.

Process control is an important part of the basic oxygen steelmaking operation， as the heat production time is affected by it. There are several steelmaking process control strategies available， and steel mills use strategies based on their facilities and needs. Process control models can be broadly classified into two categories， i.e. (i) static， and (ii) dynamic.