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Energy Saving in a Copper Smelter by means of Model Predictive Control

Carlos Bordons¹, Manuel R. Arahal¹, Eduardo F. Camacho¹, and José M. Tejera²

¹ Departamento de Ingeniería de Sistemas y Automática. Universidad de Sevilla. Spain. 
{bordons, arahal, eduardo}@esi.us.es
² Atlantic Copper. Departamento de Servicios Generales, Electricidad e Instrumentación, Huelva, Spain. Jose-Maria-Tejera@fmi.com

Summary. This chapter presents an application of advanced control techniques on a copper smelter. The main objective of the control strategy is to keep the gas-circuit pressure at its desired value while achieving energy saving. Another objective of the control strategy is to reduce the risk of emissions. This chapter describes the design and implementation of the gas-circuit control.

The design phase includes an identification procedure. This is a multivariable process where a thorough analysis is needed for input-output matching. The identification phase included the determination of the best input-output pairing.

The control strategy has been devised taking into account not only system performance but also implementation issues. The designed controller runs on a distributed control system (DCS) using the available single-loop blocks and is able to perform a predictive control strategy with feedforward action using existing PID and lead-lag blocks.

3.1 Background

Advanced control techniques are normally used with two main objectives in mind: to reduce the manpower required to operate the system and to make it more efficient by allowing it to work closer to the optimal operating modes. Model predictive control (MPC) is one of the most popular advanced control techniques. MPC formulation integrates optimal control, stochastic control, control of processes with dead time, multivariable control and future references when available. Another advantage of MPC is that because of the finite control horizon used, constraints and, in general nonlinear processes that are frequently found in industry, can be handled [3]. In many cases advanced control techniques are applied on processes already controlled by existing supervisory control and data acquisition (SCADA) systems. In these cases, the new control techniques have to be implemented on existing equipment with small requirements in terms of quality of data required for model tuning, computation capabilities and plant operators retraining. Furthermore, in these cases, the success of the control technique is not measured by its dynamic response but by economic gains obtained from an increase of the production and/or quality and savings in the use of resources such as energy, raw material or manpower.
This chapter describes an application where the ideas described above are illustrated. The main goal was to design a control scheme for the gas circuit of a copper smelter having in mind all the limitations described above. The process requires to move high masses of gas pumped by compressors with high energy consumptions. At the same time, because of environmental reasons the operating pressure has to be kept below the ambient pressure.

The current status and future trends in the automation of mineral and metal processing is reviewed in [5]. A survey of issues related to copper pyrometallurgical practice is presented in [7] and some maintenance aspects in copper smelters are mainly considered in [9]. Although there are not many reports about automatic control in copper smelters, some improvements related to control of copper converters such as the diagnosis system are presented in [1]. The relevance in terms of benefits obtained from the use of predictive controllers are discussed in this chapter and can be compared with those of [10].

### 3.1.1 Plant Description

Atlantic Copper Smelter facilities in Huelva (Spain) include a Flash Furnace and four Pierce–Smith converters, two of them blowing simultaneously. The three currents of gases generated in these processes are mixed in the mixing chamber (MC) and sent to three acid plants operating in parallel. Figure 3.1 shows an overview of the plant, whose annual production is around three hundred thousand tons of copper.

*Fig. 3.1. General view of the copper smelter*