Cleaner Technology by Using Flowsheet-Simulation for Decision Support in Process Industries

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Production planning problems in the process industries have been subject to intense research in recent years. The approaches developed to tackle these problems are mainly based on MIP formulations or resource-constrained project scheduling. Many approaches were adapted from discrete parts manufacturing and have been enlarged to cope with the increased complexity and the characteristics of process industries. Though most sophisticated approaches proposed for the process industries so far allow solving even large-scale problems in batch or continuous production processes, technical particularities of unit operations are often over-simplified or even neglected. Unit operations are normally modelled with black-box models using linear input-output relations. However, the assumed linear dependencies do not necessarily describe the behaviour of the processes and the reactions between the chemical components appropriately.

In order to overcome the drawbacks of such simplified input-output models, approaches have to be used, which ensure a more realistic depiction of processes. Consequently, thermodynamics and cinetics with its strongly non-linear interrelations have to be respected. Since chemical processes bear several degrees of freedom, observations and measurement of all the relevant thermodynamic variables (e.g. pressure, temperature, density, volume, specific heat, compressibility) become costly or they are even not measurable for all places within a reactor. Instead, flowsheeting programs, which have proved to be an appropriate tool for process design, could be adjusted to the specific needs of production planning more easily. Flowsheeting systems are mathematical tools for the simulation of complex chemical plants. They can calculate not only loops, but also the non-linear equations of thermodynamics and cinetics. In the chemical industry and particularly the petro-chemical industry, the use of computerized flowsheet models in plant design and optimisation is already state of the art. However, the application of flowsheet-modeling in metallurgy is not too widely spread.

Therefore, in this paper a simulation approach based on flowsheeting process models is presented and validated for the metal industry. The proposed paper will highlight possibilities to use flowsheeting systems to support decisions on strategic, tactical and operative planning level tackling a variety of problems occurring in the metal industry.

Especially in iron and steel production, the peculiarities of process engineering require specific modelling. The iron and steel making industry which delivers large amounts of products for different sectors (automotive, construction, packaging) uses significant quantities of residues from its own processes (by-products like dust and sludges) and from other industrial fields (used products like scrap) as input materials. Therefore, recycling loops, like an internal recirculation of materials or the integration of (external) residues into the production processes have to be taken into account besides the mentioned characteristics of thermodynamics. For instance, the recycling of the materials containing the heavy metals lead and zinc can lead to a rising consumption of raw materials (e.g. coke) and energy, and to productivity losses due to the formation of scaffolds in the blast furnace. More zinc is being brought into steel works as the recycling of galvanized car bodies is continuously increasing. On the other hand, dusts and sludges rich in zinc and lead from the blast furnace (BF) and basic oxygen furnace (BOF) flue gas treatment may not be landfilled in future which means that measures have to be established to avoid, reduce or recycle these materials.

In the proposed paper, it will firstly be shown, how flowsheeting-simulation can support strategic investment decisions using the example of the iron and steel industry, where new installations and/or major changes in the material flow management in integrated plants will become necessary in the future. Due to the high technical and economic risks connected with such measures, there is an eagerly demand for a sound determination of the technical, ecological and economic impacts on the plant structure and its economics caused by certain decision alternatives in advance. Secondly, decision support on tactical planning level concerning the integration of new materials/products in exsiting production processes will be presented. Flowsheet-based process simulation will be used here as tool to investigate the possibilities for recycling spent alkaline manganese and zinc carbon batteries in existing metallurgical installations. Especially the changes in product quality, emission behaviour and in process economics will be focussed. Finally, the field of short-term production planning in the metal industry will be described. In an outlook, possibilities of a combination of flowsheeting simulation and short-term planning approaches will be sketched.