Granulation Plant Modeling and Design Using SysCAD

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With the uptick in the phosphate fertilizer market, Hatch has seen an increased demand and urgency from clients to expedite engineering design, construction, and startup of ammonium phosphate granulation plants. Clients are eager to leverage Hatch's extensive phosphate experience and robust engineering capabilities to optimize engineering schedules and get new fertilizer production online as quickly as possible, while maintaining safety and quality.

Hatch has developed and verified with operational data an ammonium phosphate granulation plant process model in SysCAD using their industry experience and plant operating knowledge to better serve client projects within the phosphate industry. By utilizing Hatch's granulation plant process simulator, we can enhance the analysis of process flowsheets, incorporate improved process designs, and ultimately drive expedient and well-informed engineering decisions.

Designing ammonium phosphate fertilizer granulation plants is a tedious and time intensive process. For years, specifying unit operations and process equipment was done on a per unit basis, making it very challenging to produce comprehensive plant-wide closed material and energy balances. Granulation plants are highly interconnected; even a small modification in one area of the plant can have a significant impact on overall plant operability and the plant water balance.

With the advancement of computer technology, the efforts required to complete constituent-based plant-wide material and energy balances have evolved and became more efficient with tools such as Microsoft Excel. Over the years, Excel models have been enhanced to incorporate improvements aimed at streamlining design activities outside of the software itself. With that said, significant challenges exist while using Excel to wholly model a processing plant even when including exhaustive lookup tables and speciated data.

Spreadsheets are generally built from the ground up with no thermodynamic, physical, or chemical data to rely on and have no simple means for error checking. On top of this, Excel modeling for material and energy balances tend to be a cumbersome and a slow task. Circular references tend to be a common point of error as well as program crashes, which limit accuracy and efficiency. Excel balances also need to be rebuilt and customized for each plant design. It is impossible to build a comprehensive balance that can be interchanged with countless plant configurations.

To create a reliable process model for an ammonium phosphate granulation plant, a detailed understanding of the process chemistry is required, including, but not limited to behavior of ammonium phosphate compounds at varying concentrations and temperatures. This knowledge must be coupled with robust industry knowledge of the interactions between each unit operation and the materials feeding into and out of the system.

Hatch phosphate engineers have been able to leverage their industry experience and design prowess, and couple this with a powerful software package to create a process simulator capable of producing a numerically rigorous mass and energy balance for an ammonium phosphate granulation plant. This tool is capable of being modified to countless variations of product specifications, production rates, and flowsheet configurations. The power of building this tool within modeling software allows for seamless integration of powerful convergence algorithms, control loops, background physio-chemical equilibrium,

aqueous thermodynamics and extensive databases containing critical information on the physical properties of the process components.

Although there are tried-and-true process technologies within the phosphate industry, many of these technologies matured before steady-state simulation was practical. The presented work constitutes an effort to increase rigor in process technology evaluation and improve the efficiency to produce a reliable output of an ammonium phosphate fertilizer granulation plant using SysCAD. The model generated by Hatch phosphate engineers is not limited in its ability to model different grades or production rates of fertilizers, nor is it limited in its ability to generate a reliable output based on a particular flowsheet selection, titration methodology, or equipment layout.

Hatch has worked diligently over the last two years developing the granulation plant simulation model and improving the predictability and accuracy of the tool. The granulation model has been built using industry standard design criteria for unit operations and refined through a validation process that involved calibration to actual plant operating data.

Generally, industry technology providers can produce heat and material balances quickly, but these models are often unique to a particular licensed plant design. This limitation can serve as a challenge as countless different configurations of ammonium phosphate granulation plants exist, and plant modifications are continually made by producers to maximize throughput, improve environmental compliance, and maximize plant efficiency, making each operating plant unique and different. This is particularly true when evaluating scrubbing circuits, heat recovery systems, and titration methodologies.

The benefits of using the SysCAD software for plant simulation have been well documented across various industries. In the case of modeling an ammonium phosphate granulation plant, one of the key benefits includes the software's capability to integrate with third-party thermodynamic equilibrium and property calculations. The success/accuracy of a plant simulation model starts with a strong fundamental understanding of the process chemistry taking place within the plant being simulated. SysCAD's integration with high-fidelity thermophysical software enables prediction and understanding of solution chemistry and physical equilibrium. In ammonium phosphate fertilizer plants, solution chemistry predictions enable more complex simulation of unit operations such as reactors, evaporators, and scrubbers. In the past, this has been an area that heat and material balances built in Microsoft Excel and other similar platforms have fallen short.

Hatch's SysCAD model is malleable and can be tailored to any plant design or flowsheet. Building the simulation model in the SysCAD software allowed Hatch engineers to incorporate maximum flexibility into the tool to accommodate unique client demands. For example, many clients operate their granulation plant with only a pipe reactor and do not use a preneutralizer. The SysCAD software allows for Hatch engineers to easily modify the plant balance by simply turning unit operations on/off as required. Some clients use sulfuric acid and/or filler for grade control, these input streams can be easily toggled to simulate plant operation and support balance convergence.

Using the tool, Hatch phosphate engineers are able to generate converged heat and material balances for different ammonium phosphate granulation product specifications, regardless of how unique or specialized. Hatch's simulation is capable of modeling micronutrient enhanced products. Hatch's tool significantly reduces the time required to produce a converged, comprehensive, and accurate heat and

material balance for an ammonium phosphate granulation plant when compared to using other tools and software.

Plant conversion projects benefit from plant capacity analyses and a detailed evaluation of existing equipment. Before evaluating the converted plant design, a validation process is made much simpler with the use of simulation software. Provided existing plant data and a strong understanding of the existing flowsheet, a validation model can be produced by Hatch phosphate engineers to tune the behavior of simulation. This validation effort enables the Hatch team to better evaluate what challenges may arise when converting a plant's production line, increasing throughput, or making an upgrade or modification to a unit operation.

An example of model validation in an ammonium phosphate fertilizer plant that is critically important to the water balance is around the burner/dryer. Chemical components of a burner's fuel can be selected while configuring the model and a prediction of higher heating value and lower heating value is calculated. With knowledge of an existing plant's combustion air fan operation, quench air fan operation, and burner temperature profiles, an estimate of environmental heat loss can be calculated and programmed into the model. SysCAD also enables the prediction of environmental heat loss given ambient conditions from unit operations.

The use of SysCAD process modelling simulation provides value to the entire lifecycle of projects, including plant operation. An owner's well-maintained mass and energy balance provides a significant challenge to manufacturers due to the ever-changing nature of industrial facilities. The use of simulation software helps to ease this challenge, and if maintained, provides a digital environment to troubleshoot, monitor, and optimize the performance of a plant. Evaluating changes in a digital modelling environment allows the minimization of risk associated with large plant changes as well as daily decisions for production planning and surge/availability analysis.

As mined ore grades continue to decrease in many industries, a more intimate understanding of impurity effects on a process is necessary. Sensitivity analyses, chemistry predictions/evaluation, and flowsheet configurations can be investigated to meet the challenge of declining raw material quality. Consideration of the addition of unit operations for impurity removal and project laboratory test work definition are enhanced with the use of simulation software.

Hatch has been able to employ the SysCAD simulation software to support client needs that range from identifying and resolving plant bottlenecks, to scrubber configuration modifications aimed at meeting environmental regulations, to supporting the design of granulation plant conversions to produce micronutrient enhanced fertilizers. By using Hatch's granulation plant process simulator, we can enhance the analysis of process flowsheets, incorporate improved process designs, and ultimately drive timelier and well-informed engineering decision making for our clients.