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UREA GRANULATION CIRCUIT SIMULATOR
Design, Simulation, Optimization and Control of UFT Granulation Plants

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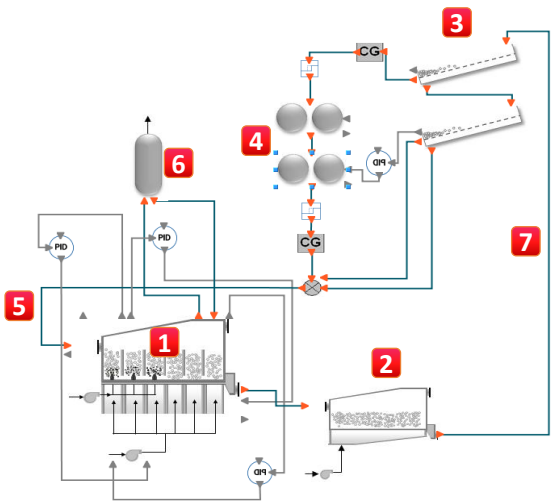
Motivation

Industrial urea granulation is mainly performed in fluidized-bed granulators combined with coolers, crushers and screens to constitute granulation circuits. Unfortunately, this process is usually operated by trial and error with undesired plant shutdowns and far from the optimum capacity. In this context, it becomes critical the design and control of granulation circuits under an integrated approach.

In this context, a simulator for the UFT fluidized-bed granulation technology is presented, which consists of ad-hoc models for the units involved [1]. These models were integrated in the gPROMS® environment and can be easily adapted to particular plant configurations by simply "drag-and-drop" of the necessary units from the established model libraries and connect them to simulate a specific integrated process. Each unit presents a dialog box for the user to set the corresponding design and process variables and parameters.

Implementation in gPROMS Model Builder Environment



1 Multichamber fluidized-bed granulator
- The granulator is constituted by 6 chambers; the first 3 are for particle growth while the remaining are for granules cooling. A growth chamber is a bed of solids fluidized by air, continuously fed with small urea particles (seeds) and sprayed from the bottom with a highly concentrates urea solution. Granules grow by coating due to the deposition of droplets on the seeds, followed by solidification of the urea present in the solution. The cooling chambers do not receive urea solution.
- The model includes mass, energy, momentum and population balances.
- Coating is assumed as the only granules growth mechanism.

2 Fluidized-bed cooler
- Reduces the granule temperature and avoids undesirable lumps formation,
- The model operates as one of the granulator cooling chambers.

3 Double-deck vibrating screens
- They separate the under and oversize particles from the marketable product,
- To represent a nonideal classification operation, oversize partition coefficients for each size class are used.

4 Double-roll crushers
- They grind the oversize material leaving the screens. Gaps of the upper and lower pairs of rolls influence the crushed particle size distributions.
- The breakage parameters are fitted using industrial data.

5 Recycle stream

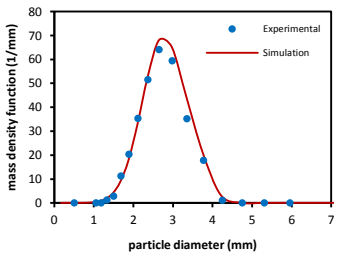
6 Wet scrubbers for the exhaust air conditioning

7 Elevator for material transportation

Results and potential applications

Experimental validation

Experimental and calculated product granulometries:



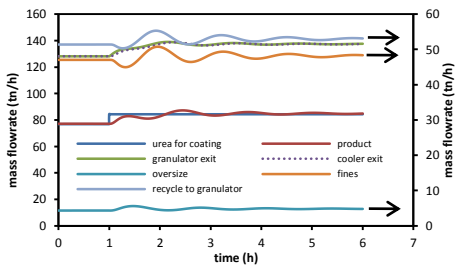
The proposed mathematical model successfully predicts industrial data for a plant that produces 70 tn/h of granular urea

ADDITIONAL FEATURES

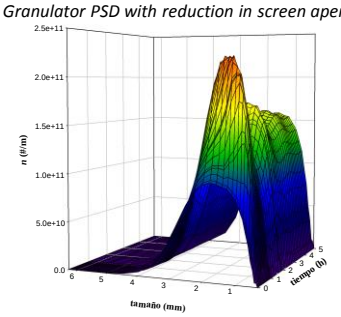
- *Steady-state and dynamic optimizations through the gPROMS inbuilt tool*
- *Analysis of other circuit configurations*
- *Operator training*

The time evolution of all the circuit variables and parameters can be simply tracked

Effect of change in urea flowrate over other streams:

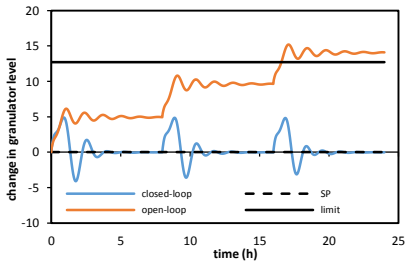


Granulator PSD with reduction in screen aperture:

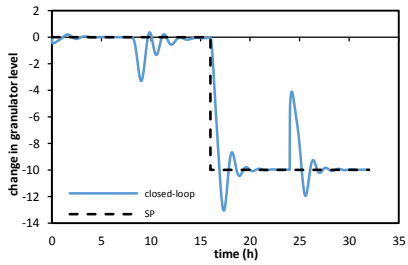


It is possible to customize the desired control loops in order to maintain plant operation under nominal conditions or track new Set Points

Granulator level with change in urea flowrate:



Granulator level with change in desired set point:



Conclusions

1. The tools provided by gPROMS Model Environment allowed to develop a unique simulator for the industrial production of granular urea with ad-hoc models.
2. The simulator can be easily tailored made for urea granulation plants under operation.
3. Further development can be done to include peripheral units (i.e., heat exchangers, pumps, blowers, etc.)

[1] I. Cotabarren, D. Bertín, V. Bucalá, J. Piña, A validated flowsheeting tool for the study of an industrial granulation process, Ind. Eng. Chem. Res. 52 (2013) 15198–15210.