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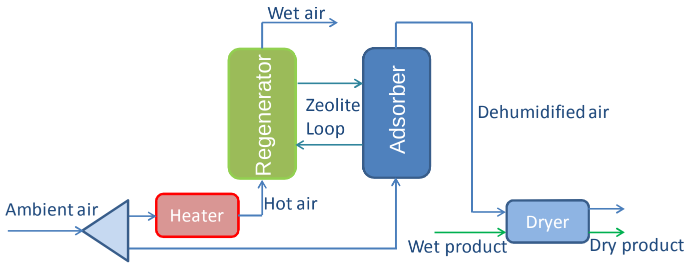
Optimization of the Adsorption Drying Process for Energy Efficiency and Product Quality

J.C. Atuonwu (james.atuonwu@wur.nl), G. van Straten., H.C. van Deventer and A.J.B van Boxtel

MOTIVATION

- Drying is energy intensive: ≈15% of industrial energy consumption
- Low drying temperatures needed to maintain food quality
- Adsorption drying capable of drying efficiently at low temperatures
- Modeling and optimization expected to improve energy efficiency



Drying system with adsorbents

Case 1: Sequential optimization: Drying, then heat recovery

Phase 1

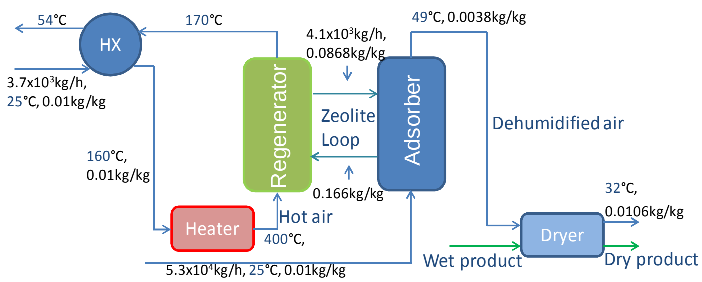
- Maximize adsorption drying process energy efficiency using:
- Drying air flowrate
- Zeolite flowrate
- Regeneration air flowrate
- Regeneration air Inlet temperature

- Subject to:
- Product temperature constraints
- Final moisture constraints
- Regeneration temperature constraints

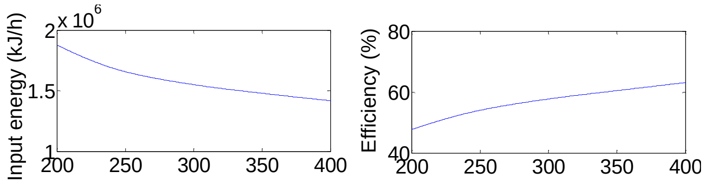
Phase 2

- Maximize heat recovery from the exhausts of the optimized process (from Phase 1) using pinch analysis
- Hot streams – Regenerator outlet air and zeolite
- Cold stream – Ambient air to regenerator

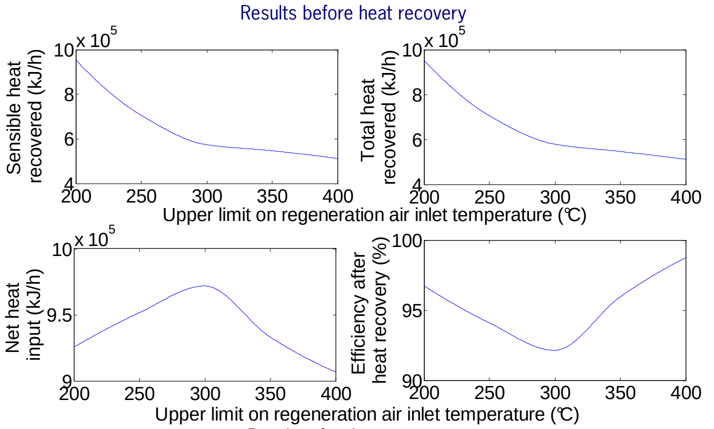
RESULTS



Heat recovery from optimized process at regeneration air inlet temperature of 400°C: Overall efficiency 98%. Conventional dryer under the same condition, 51% efficient



Results before heat recovery

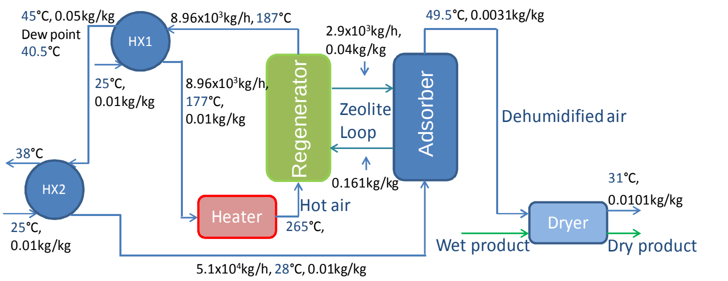


Results after heat recovery

Case 2: Simultaneous optimization: Drying and heat recovery

- Simultaneously maximize energy efficiency of drying process with integrated sensible and latent heat recovery using the same decision variables (as Case 1) and pinch point optimization

RESULTS



Simultaneous optimization gives opportunities for latent heat recovery through heat exchanger HX2: Overall efficiency 113%. Simultaneously optimized conventional dryer 54% efficient

CONCLUSIONS

- Simultaneous optimization reduces energy consumption by 53% relative to equivalent simultaneously optimized conventional dryer
- Sequentially optimized system consumes 48% less energy than equivalent conventional system for the same evaporative load
- Improvements by simultaneous optimization traceable to better manipulation of stream energy variables e.g. flows & temperatures
- Simultaneous optimization, a “look ahead” approach! Anticipates heat recovery while process is being designed!
- Simultaneous optimization important to determine new optimum operating points when retrofitting systems with heat recovery

Wageningen University, Agrotechnology and Food Sciences, Systems and Control Group
Postbus 17 Wageningen 6708WG
Tel: 0317 – 483 364 - Fax: 0317 – 484 957
E-mail: james.atuonwu@wur.nl