Design and operation of energy-efficient fluid bed systems

Integrated approach saves costs

Systems for agglomeration, spray granulation and coating in the fluid bed are used in nearly all industries involving the production and refinement of solid product forms. In addition to the material and application properties of the products themselves, manufacturing costs can also be significantly influenced by the design of the fluid bed systems.

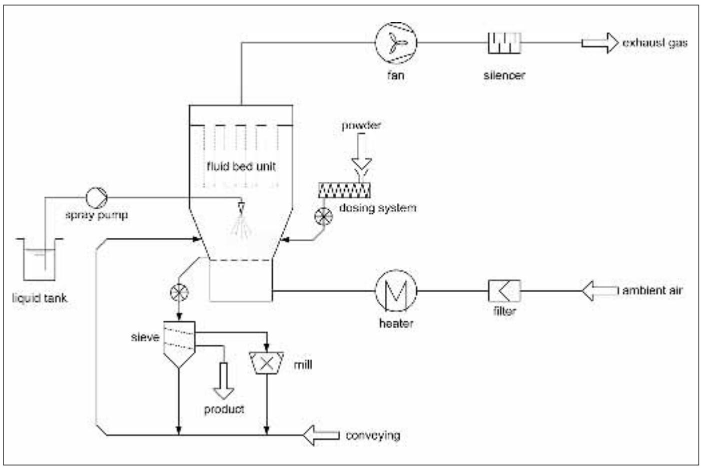

Figure 1: Flow diagram of a continuous, standard fluid bed granulation system (fresh air operation)

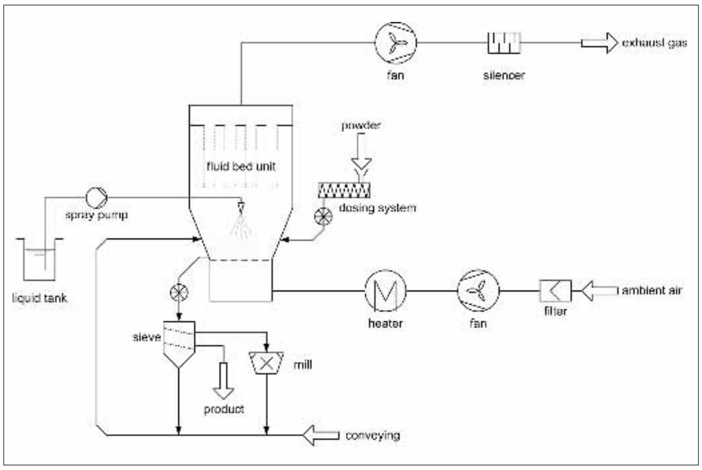

Figure 2: Flow diagram of a system with one suction and one pressure fan (fresh air operation)

Different methods can be employed for energy optimisation in complex systems. Glatt Ingenieurtechnik has been using flow schema simulations for many years, for example, in order to carry out comprehensive studies of different system configurations, investigate the effects of changing process parameters or compare alternative system concepts. These analyses must be performed dynamically if the process conditions vary according to a time factor, as is the case with batch or semi-continuous processes. Energy optimisation is hence very complex and elaborate. In addition, cyclically recurring start-up and shut-down processes leave virtually no scope for sizing to an optimal operating point. Fluid bed systems with continuous operations, on the other hand, achieve a steady state where the process parameters (temperatures, air volumes, pressures, mass flows, etc.) remain constant over time. The operating point of a process is thus clearly defined, making simulations much more straightforward and allowing reliable optimisation studies.

A typical simplified flow diagram of a continuous fluid bed granulation system is shown in figure 1. In the basic scenario, the required process air volume can be provided by a single fan. Although this solution is technically uncomplicated, it may demand powerful fans with high ratings for large systems. Dividing the total specified pressure increase between two fans to limit the fan sizes and utilise the energy supplied by the pressure fan for the process (Figure 2) is therefore often more efficient from both the technology and the energy point of view. Recovering waste heat from the fluid bed apparatus has become increasingly common practice during the past year. Two fundamental principles, illustrated in figure 3 and figure 4, exist. The version to be preferred in a particular application depends on the system's temperature profile as well as on the room environment and safety aspects.

The optimal concept must be defined based on case studies that consider not only energy savings and the associated investments but also

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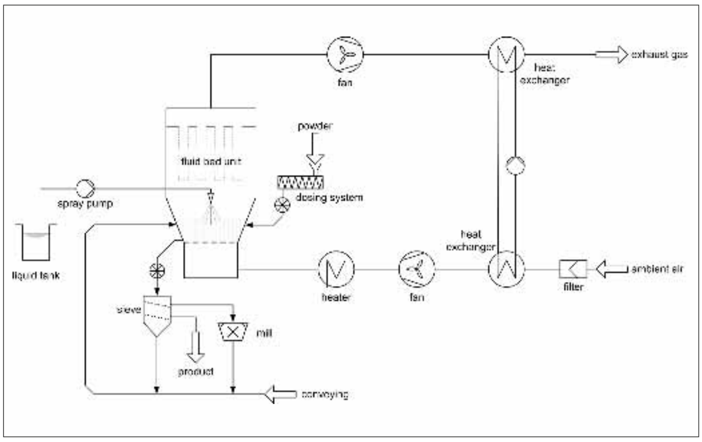

Figure 3: Waste heat utilisation with indirect air-fluid heat exchangers

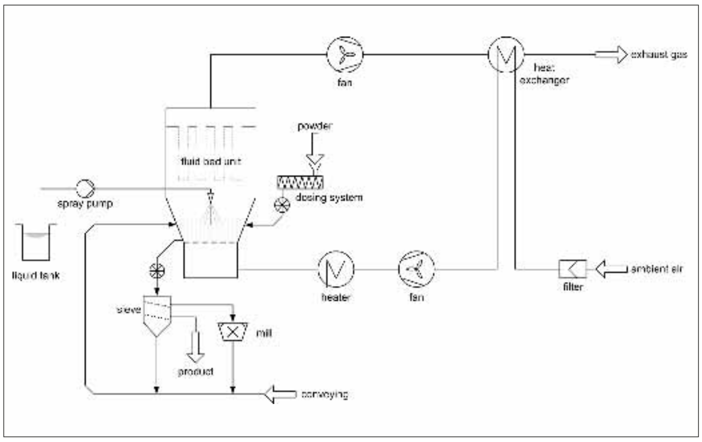

Figure 4: Waste utilisation with indirect air-air heat exchanger and heat transfer circulation

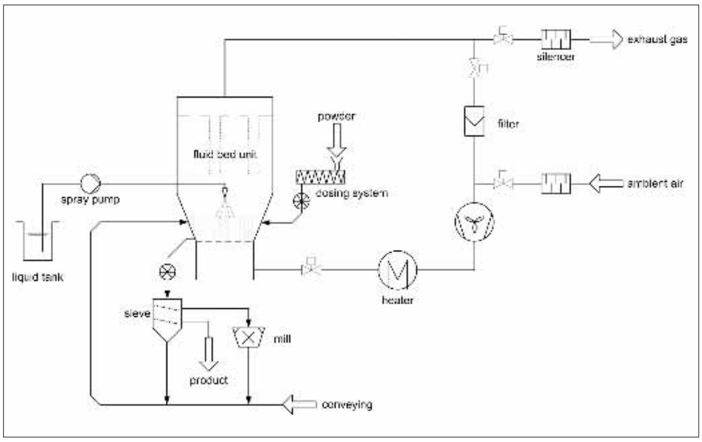

Figure 5: Flow diagram of a system with partial flow return of the exhaust air

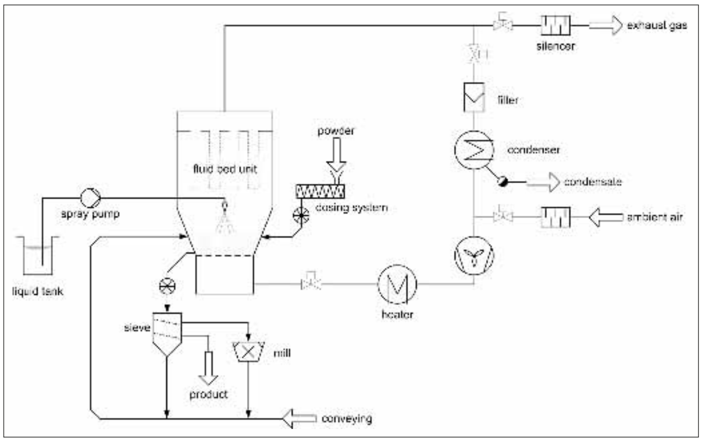

Figure 6: Flow diagram of a system with circulation of the process air

the physical conditions prevailing in the plant. Aspects such as temperatures below dew point, winter operation, maintenance, corrosion and ease of cleaning are all relevant. Process air circulation represents another approach for reducing a fluid bed system's heating energy demand. Part of the exhaust air from the fluid bed apparatus is utilised and added to the generally fresh air. Figure 5 shows how an adjustable portion of this exhaust air is used to minimise the heating system's energy consumption. When investigating overall energy efficiency, account must be taken of the repercussions both for the sizing of the entire air handling equipment and for the granulation process. The return of a partial flow, for instance, causes the relative humidity to increase at the granulator intake. It is therefore important to examine whether this will affect the particle properties and, depending on the sorption properties, the achievable product moisture. By contrast, figure 6 depicts a system configuration where the entire process air volume is circulated. This mode requires the moisture that is introduced into the granulation system by liquid spray (usually water or organic solvents) to be removed again by a condenser. Only a minimal fresh air supply (or inert gas volume) is needed here. The amount of air or gas to be removed from the circulating flow is essentially determined by the volumes supplied from external sources or by spray.

Customer-specific optimised solutions

The choice of concept depends very much on the application and the particular scenario. For example, the decision regarding partial or complete circulation of the process gas can be based on:

- Material properties of the product (e.g. oxygen sensitivity, sorption behaviour...)
- Safety aspects (e.g. explosion hazard, product protection, emissions...)
- Energy optimisation (e.g. reduction in the heating capacity...)
- Limitations on the exhaust air volume (e.g. maximum emissions, connection to downstream systems for exhaust gas cleaning...)

Case studies have been performed to identify the potential savings. The results are summarised in figure 7. To facilitate a comparison, all values have been normalised, i.e. shown in relation to the fresh air system (figure 1).
A constant air mass flow of 10,000 kg/h in the process was defined for the comparative study and a water evaporation rate of 500 kg/h calculated. The required intake temperature for the fluid bed apparatus was computed for each configuration according to demand to ensure a constant fluid bed temperature of 75 °C. The different air volume flows and the required heating capacity were correlated. The fresh air mode served as a reference. It became apparent that a partial flow return without condensation (Figure 5) can significantly reduce the emission values and heating energy consumption.
The possible circulation volume varies with the material properties of the product concerned as well as with the thermal conditions in the system. In the example described here, the partial return flow corresponds to approximately

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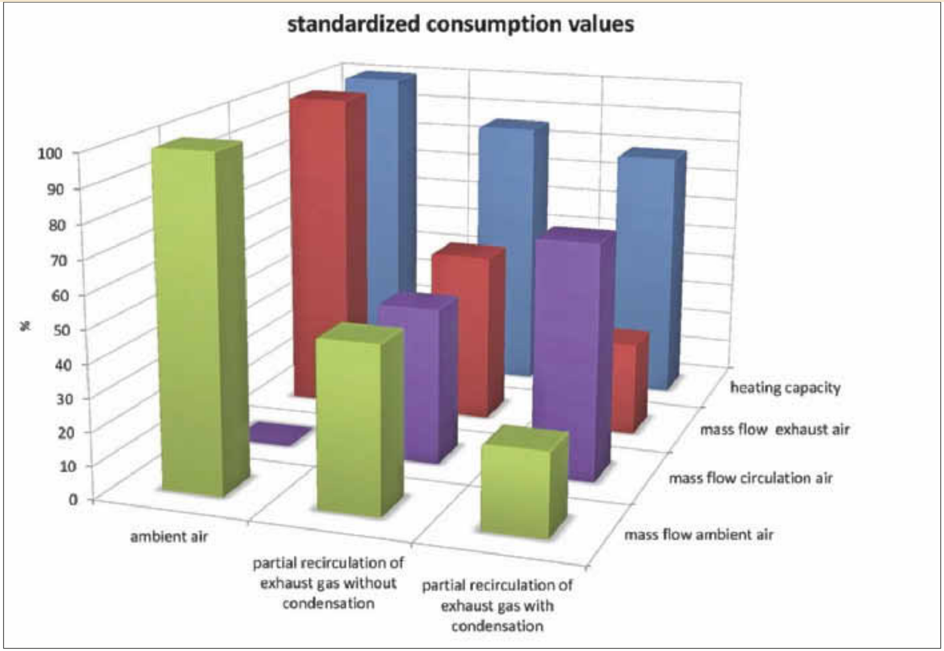

Figure 7: Comparison of different system configurations

50 % (version 1) or 70 % (version 2) of the total air volume. The required heating capacities can be respectively reduced to 86 % or 79 % of the demand in fresh air mode. This reduction directly influences the process costs. Additional savings are generated by the lower inlet and exhaust air volumes because the essential equipment is smaller and the investment and operating costs go down. The basic conditions for a concrete application must be determined during the project development phase by means of experimental studies with laboratory and pilot systems. Supplementary laboratory analyses (e. g. DVS, TGA, DSC...) can be used to define the possible parameter range for process management. This combination of analysis, trial operation and process simulation results in optimised solutions that meet each customer's individual requirements. Glatt Ingenieurtechnik, an integrated system provider, offers a full range of services from the initial concept through the process development work and the engineering for the system equipment and buildings to the delivery of the complete production facility. This integrated approach creates additional potential for energy optimisation beyond the actual process technology. In many cases, for instance, waste heat from the process can be used to heat fluid flows or for air conditioning and ventilation. Conversely, coupling the media supply systems with regard to energy also opens up several options for utilising waste heat, amongst other things to preheat the fluid bed system.

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