VACUUM SALT FLUID BED DRYING AND COOLING

L. NINANE Consultant

Salt Production

Keywords: Vacuum salt, Fluid bed drying, Fluid bed cooling

ABSTRACT

Vacuum salt is produced at very large scale around the world .This salt is usually separated from the mother liquor with a centrifuge and is dried in a fluid bed; this fluid bed is usually coupled with a fluid bed cooler.

The dryer is heated with steam and a heating coil inserted in the heating fluid bed layer compartment; the cooler is cooled with cooling water and a cooling coil inserted in the cooling fluid bed layer.

In most of commercial design, the two compartments are connected by an opening in the thin separation wall between these compartments. The opening is the source of a strong back mixing between the compartments; this back mixing induces a loss of heating efficiency of at least 30 to 40 % and a loss of cooling water of the same level.

This defect can be corrected easily by a simple modification of the connection between compartments. A very simple device may suppress the back mixing.

The result is either a saving in steam or cooling water or an additional capacity for the dryer and cooler.

The saving of steam pays for the modification in less than 2 months.

In case of a compartment used for coating, the quality of coating may be improved considerably by the following type of technical solution.

INTRODUCTION

Vacuum salt is produced at very large scale around the world. This salt is usually separated from mother liquor with centrifuge and is dried in fluid bed; this fluid bed is usually coupled with a fluid bed cooler.

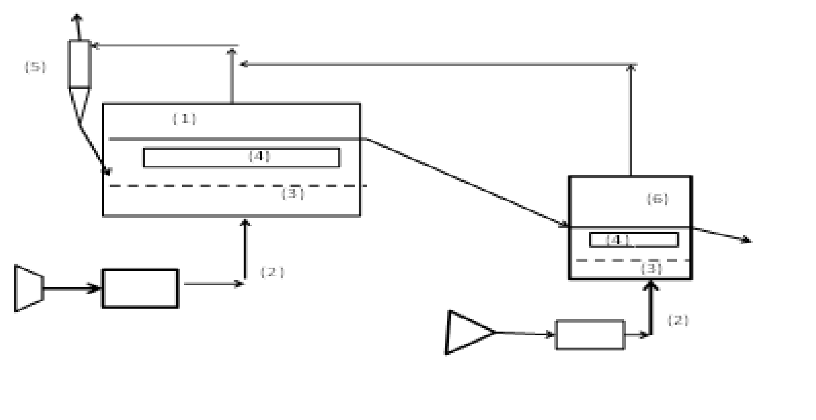

Figure 1: usual system fluid bed dryer + cooler with 2 beds

The dryer is heated with steam and a heating coil (4) inserted in the heating fluid bed layer compartment; the cooler is cooled with cooling water and a cooling coil (4) inserted in the cooling fluid bed layer.

The fines entrained (1) (6) from both beds are separated with a cyclone (5) and recycled to one of the two beds; this is a first source of back mixing

In most commercial design, the two fluid beds are usually side by side in one casing with two compartments. The two compartments are connected by an opening in the thin separation wall between these compartments. The opening is also the source of strong back mixing between the compartments.

This back mixing induces a loss of heating efficiency and a loss of cooling water, which are detailed later.

EXEMPLES OF USUAL DESIGN

Figure 2 describes a usual design of a two-compartment fluid bed dryer and cooler with two types of weirs:

- A weir which is a rectangular slot on the whole width of the bed and at the free level of the bed and operate as a weir
- In another alternative, it can be a rectangular slot located at mid-level of the bed or at the bottom of the bed; in this case, it is a submerged opening in the wall.

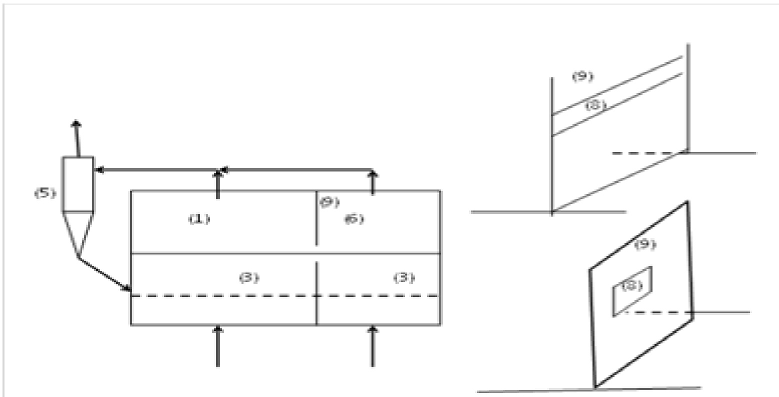

Figure 2: Usual design with 2 compartments and a slot or a square edge

It is well known from the theory of fluid beds (Kunii and Levenspiell: Fluidization Engineering 1977) that an opening in a thin wall allows a flow in both directions of more than 15 t/h for a square of 4x4 inches: this flow can be larger than 40 t/h for a square opening of 8x8 inches.

These flow rates are considerable and are able to decrease the efficiency of drying and cooling salt.

In addition, when the piping separation of fines is common to both beds, and fines are recycled in a single bed, this back mixing is increased.

In another application where a product is coated, the quality and uniformity of the coating can be completely destroyed.

Figure 3 describes another type of weir with a baffle on the whole with of the bed followed by a weir: this is also a common system encountered with suppliers of fluid beds.

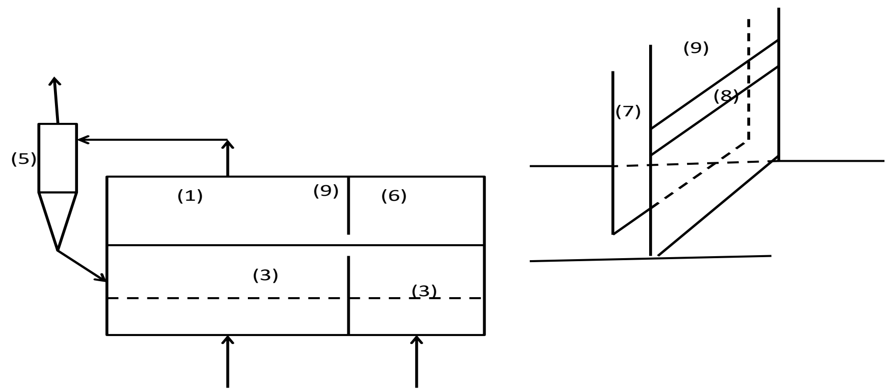

Figure 3: Usual design with an overflowing weir

This system exhibits also a strong back mixing due to the strong bubbling in both beds and to recycling of fines.

PATENT US 6 290 775 B1 (2001) from DEGUSSA described in **Figure 4 is** the most recent known state of the art published on this subject. This patent describes the connection between a granulation bed and a coating bed.

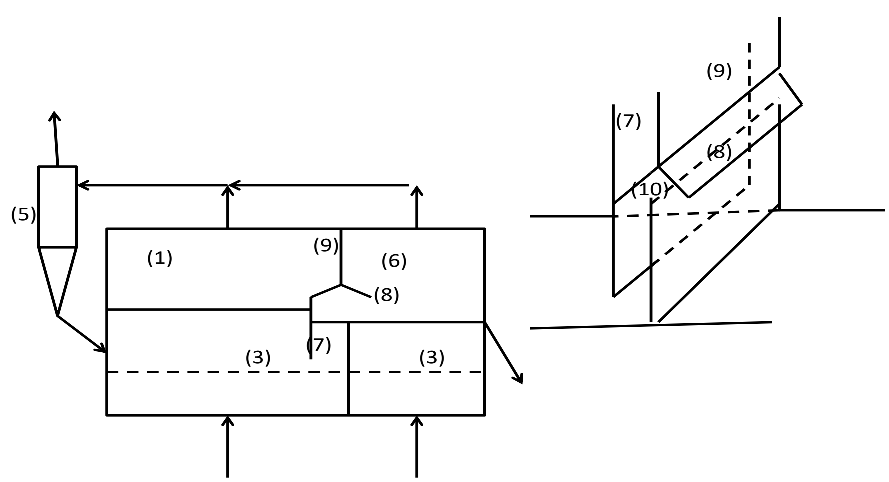

Figure 4: Design patent US 6290775 B1 2001

Fluidized solid from a granulation bed flows under the baffle (7) then rises between the baffle and the vertical wall and then overflows over the weir (10) to reach the coating bed.

This device is an improvement compared to previous devices, but does not cancel the back mixing, still estimated to be a few t/h.

There are still problems of the control of the air flow rate control in the rising leg and the problem of risk of agglomeration present in the salt

MODELLING PROCESS DRYER +COOLER

A model of a dryer +a cooler is shown in the figure 5 below

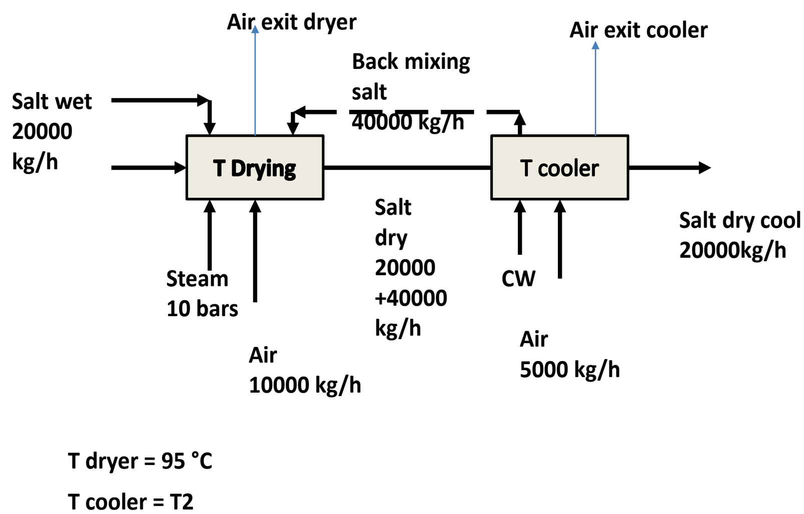

Figure 5 : Model Dryer + cooler with and without back mixing

Results of mass and heat balances computed on a dryer followed by a cooler are listed below:

- Capacity of drying + cooling : 20 t salt/h
- Humidity salt: 3 %
- Consumption of Steam 10 bars without back mixing: 1500 kg/h
- Temperature cooler without back mixing: 48 °C
- Back mixing: 40 t/h between dryer and cooler
- Real Consumption steam with back mixing: 2350 kg/h

- Temperature cooler with back mixing: 70 °C
- The consequences are an increased consumption of steam, but also an increased consumption of cooling water; another consequence is the difficulty of cooling the salt temperature to the desired level due to a lack of cooling capacity and limitations on the size of the cooling coil.

These evaluations are confirmed by measurements in a real dryer + cooler salt plant.

PRINCIPLE FOR DEVICE TO CANCEL BACK MIXING

The principle for a device allowing reduction of back mixing to almost zero is displayed below in Figure 6

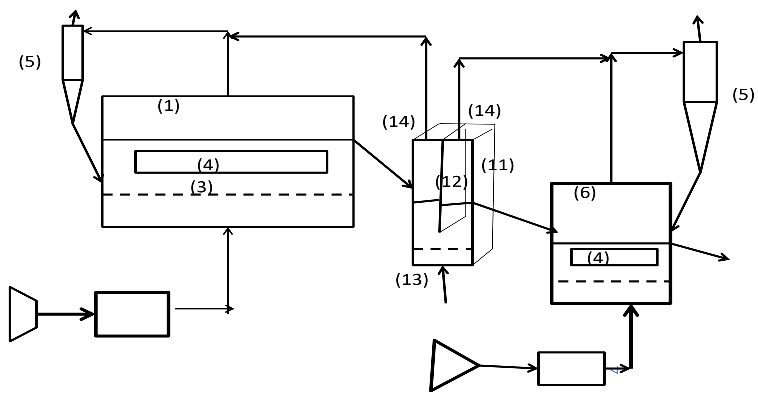

Figure 6: Fluidized air box between dryer and cooler

Production of dry salt feeds a small fluidized bed (11) with 2 vertical compartments, each one being fluidized with rising air and separated by a vertical baffle (12); an opening under the baffle allows the salt to keep moving from the first to second small compartment. Salt overflows to the cooler (6).

This small box (11) has a very small size, for example 10 by 10 inches.

Air may be distributed independently under this box; this air allows to control the density of fluidized layers in both compartments of this box and to control a large range of circulation rate.

This system is self-regulating, very stable and very reliable.

This type of device suppresses back mixing almost completely (for example, practical measures shows a back mixing less than 1 t/h)

The need to separate the fines leaving the dryer from fines leaving the cooler must be evaluated in each case; if the fines circulation rate is smaller than the net production of salt, the separation may not be needed. Only at high fluidization velocity, fines rates are very high and the separation may become necessary to limit this additional of back mixing.

PRACTICAL REALIZATION

Examples of practical adaptation to an existing design are suggested in the Figure 7, 8 and 9 below:

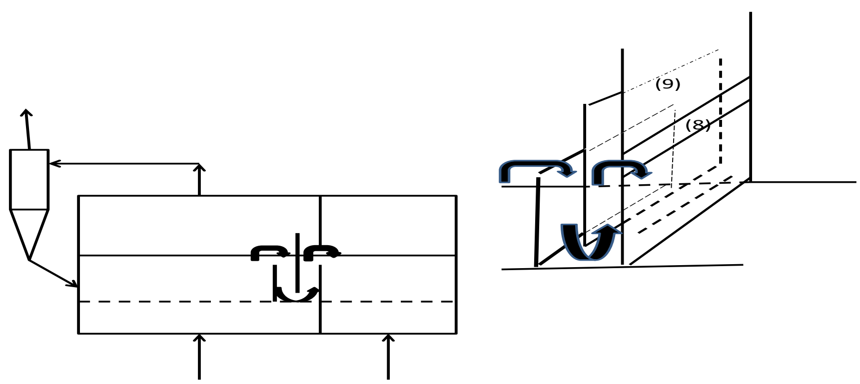

Figure 7: Adaptation inside bed

This figure 7 shows the initial adaptation of a siphon type box occupying the total width. This type is already a significant progress compared to a single opening, but the large fluctuations of bed level on the width can still provoke significant back mixing .

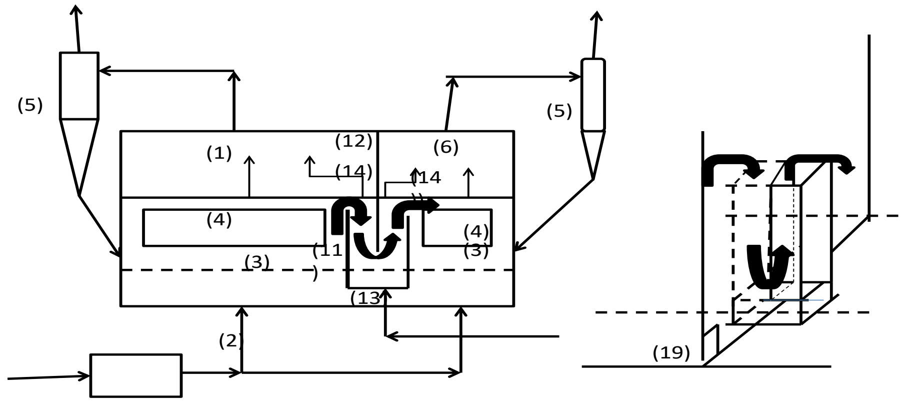

Figure 8: A practical example of adaptation

This figure 8 shows very significant progress compared to previous figure 7: the width of the box has been reduced to a much smaller width and can be inserted inside the bed without modifying the heat exchange coil bank: the cross section is designed to fit the space available between the wall and the coil. This is a very small insert and can be made in the shop during a short down time for small amount of money.

Figure 9 is a variant of adaptation

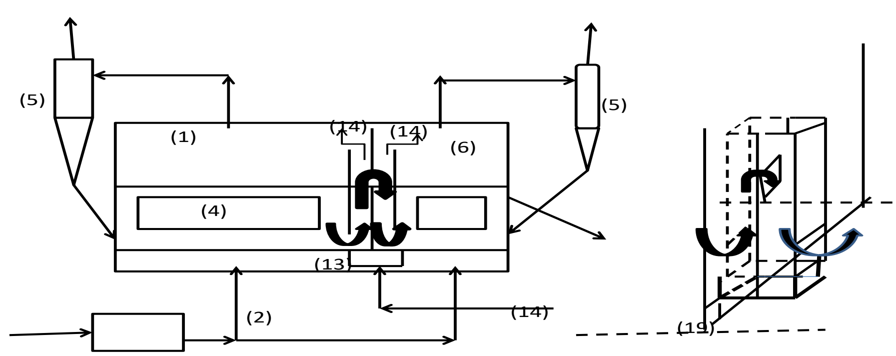

Figure 9: another example of adaptation

PROBLEM SOLVING METHOD

The author may respond to any demand for a detailed design to reach the following goals:

- Analysis of actual data
- Evaluate flow rate of back mixing
- Suppress the back mixing or reduce it by a factor 10 to 50 and the air box
- Design the compartments of the circulating box for a given net flow
- Design the fluidizing conditions
- Estimate the need of a separate fines separate piping and cyclone
- Estimate the gain in steam and in cooling water gain
- Propose a practical and low cost adaptation inside the dryer and cooler

For example, a gain of 1t steam/h is worth about 200,000 US $/y

A gain of 0.5 t steam/h is worth about 100,000 US $/y

CONCLUSIONS

Back mixing is a very common phenomena when two adjacent fluid beds are connected together by a simple opening in the wall between the two beds; this back mixing transfer heat from dryer to cooler and the reverse; the efficiency of the dryer is lowered.

A simple device can be adapted to connect the dryer to the cooler; the back mixing is almost cancelled and the efficiency of the dryer is improved.

The rate of return of this simple device is very high and can be quickly paid back.

POSTSCRIPT

In another process where a product exit of a granulator must be coated, a strong back mixing can suppress the homogeneity of the coating: instead of leaving the coating evenly distributed at the surface of the particles, it returns at the granulator many times and the coating chemical is trapped inside the particle. The efficiency of the coating is null.

When the back mixing in cancelled, the product leaving the granulator goes to the coating compartment and never returns to the granulator compartment. In this situation, the coating material is totally on the surface of the particle to perform the goal expected from it.

The technology of controlling the back mixing is very effective for improving the quality of the coating.

REFERENCES

Fluidization engineering   Kunii and Levenspiel 1977 Wiley 1969 p375

PATENT US 6 290 775 B1 (2001) from DEGUSSA