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THE STEAM HEATED FLUIDIZED BED DRYER - A NEW ENERGY SAVING DRYING PROCESS[1]

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SUMMARY

The steam heated fluidized bed dryer is a completely new, low emission and energy saving process for drying of potassium chloride. This process has been developed by K + S and is now running successfully since four years at the Hattorf potash plant.

Compared to the conventional drum dryers this technique reduces the heat consumption by 33%. Taking into account the energy gained by condensing evaporated steam in process water an additional saving in primary energy of 30% can be achieved.

The amount of flue gas is reduced by 80% and dust or HCl content are markedly lower than in conventional drying systems and far below the limits of the strong German environmental legislation.

RESUME

Le sécheur à lit fluidisé chauffé à la vapeur est un procédé tout à fait nouveau à faible émission et demandant peu d'énergie de séchage du chlorure du potassium. Le procédé a été mis au point par K + S et fonctionne maintenant convenablement depuis 4 ans à l'unité de potasse de Hattorf.

Par rapport aux sécheurs à tambours classiques, la technique réduit la consommation de chaleur de 33 %. En tenant compte de l'économie d'énergie réalisée par condensation de la vapeur évaporée dans l'eau de procédé, une économie supplémentaire d'énergie primaire de 30 % peut être obtenue.

La quantité de fumée est réduite de 80 % et la teneur en poussière et en HCl est nettement inférieure à celle constatée dans les systèmes de séchage classiques et très inférieure aux limites imposées par la sévère législation allemande sur l'environnement.

✦ ✦ ✦

I. Introduction

K + S GmbH is the largest potash producer in Western Europe and last year produced almost 11 million tons of potash, magnesium and salt products in its eight mines in Germany (Figure 1).

These consist of the salt mines Bernburg and Braunschweig-Lüneburg in Sachsen-Anhalt and Lower Saxony respectively, the potash mines Sigmundshall near Hannover in Lower Saxony and Zielitz near Magdeburg, Sachsen-Anhalt, the mine Neuhof-Ellers near Fulda, Hessia, and the combined potash mines of the Werra region with the plants Hattorf and Wintershall in Hessia and the plant Unterbreizbach in Thuringia.

In all K + S potash plants the potassium chloride produced are normally dried by using conventional drum dryers. Figure 2 shows the drying plant at Hattorf before the introduction of the new drying technique. The energy for the drying process is transferred directly by contacting the wet product with the very hot stack gases from the gas fired burner. The flue gas leaving the drying drum contains besides fine dust particles a certain amount of HCl which is formed during the drying process by thermal decomposition of MgCl2 contained in the salt solutions.

The dust particles are separated via cyclones and electrostatic separators to dust concentrations below the required 50 mg/Nm^3. The HCl content of about 200 mg/Nm^3 cannot be reduced by these techniques to fulfill the limits of the German environmental legislation (e.g. technical guidelines to the clean air act) which require HCl contents below 30 mg/Nm^3. To achieve these standards K + S had to install additional cleaning steps.

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[1] *Sŭcheur a lit fluidisŭ chauffŭ par la vapeur - un nouveau procŭdŭ de sŭchage ŭconome en ŭnergie*

II. Technical Alternatives

The traditional way to reduce the HCl content of flue gas is to employ secondary wet or dry cleaning steps (Figure 3) with caustic soda or lime and then removing the reactants using wet scrubbers or bag filters. This technique is used in several of our plants successfully to fulfill the environmental requirements. A totally new approach was developed for improvement in:

- Energy concumption
- Limits of emissions

This completely different drying concept for potash is called Domning drying process (Figure 4), a patented process named after one of our former chief engineers.

In this process the drying energy is no longer transferred by direct contact between burner gases and wet product - thus forming the HCl - but by indirect heat transfer. For this purpose dry KCl is superheated via heat exchangers which are connected to a thermo oil heating system. The superheated KCl is then mixed with the wet material in a mixer in which the actual drying process takes place. Stack gases are cleaned in a scrubber and part of the product is recycled to the heating circuit. The advantages of this process are lower HCl and dust emissions and lower specific energy consumption by drastically reducing the amount of flue gas.

Therefore in 1986 we built a pilot plant with a 1 t/h throughput which confirmed the basic parameters but left several questions unanswered mainly concerning:

- Salt heating circuit
- Mixer/dryer system
- Corrosion problems.

III. Steam Heated Fluidized Bed Pilot Plant

As the next step a complete pilot plant was installed in 1989 with a 10 t/h throughput at the Hattorf plant (Figure 5). The fundamental idea of the Domning-dryer, the separation of the hot burner gases from the wet product, was maintained, but the technical concept was completely modified:

The separate salt heating circuit was omitted because of its severe caking problems. Furthermore the mixer/dryer system was substituted by a conventional, indirectly heated fluidized bed dryer which is widely used in the potash plants. Instead of using air as fluidizing medium this process however uses only steam generated by the drying step itself.

The steam heated fluidized bed drying process can be described using the following block diagram (Figure 6):

1. In the thermo oil system natural gas is burned thus heating the thermo oil which is run through heat exchangers to the second part

2. The fluidized bed dryer in which wet potassium chloride is dried by thoroughly mixing it in a bed of hot KCl using steam for fluidizing and then

3. The two-step gas scrubber in which dust and HCl are scrubbed and heat is recovered by condensing evaporated steam in cold process water.

By running this pilot plant for several months we have been able to do extensive corrosion tests in order to find the right construction materials and to gather enough practical experience to plan the new steam heated fluidized bed drying plant.

IV. The Production Plant

The positive results with the pilot plant finally encouraged us to build a 100 t/h steam heated fluidized bed dryer which was completed after 2 years construction time in November 1993 (Figure 7). After a rather short period of the normal start up problems the planned process parameters were achieved:

- The total specific energy consumption is only 42 kWh/t of product which is 33% compared to a conventional drum dryer with gas cleaning systems (Figure 8): the drying process itself only needs 86 kWh/t compared to 128 kWh/t in a drum dryer; taking into account the heat recovery in the scrubber we save another 44 kWh/t.
- The amount of flue gas was reduced by 80%.
- The emission of HCl was reduced far below the limits of the TA Luft (Figure 9) and today it is under 10 mg/Nm^3. The annual HCl freight was reduced from 16,8 t/a to 0,2 t/a.
- The KCl product now contains less fine dust, so the anti-dust treatment could be reduced too.

However, after running the 100 t/h drying plant for longer periods new problems arose, which had not been encountered with the pilot plant.

Figure 10 shows a simplified graph of the fluidized bed, with the chain conveyor for the wet product (1), the thermo oil heated heat exchangers (2), the outlet for the dried product (3), the two outlets for agglomerates (4) and the jet bottom (5).

After a few days the throughput started to decrease and finally the whole dryer was clogged with hardened KCl agglomerates up to 20 cm in diameter. These agglomerates must have grown inside the fluidized bed, since a chain crusher, which was installed in the input line of the dryer, did not solve the problem (Figure 11).

By changing the outlet systems for product and agglomerates and installing of an additional grid, the problem was finally solved. The new steam heated fluidized bed drying process is now running successfully at the Hattorf potash plant for the last four years.

V. Summary

Over a period of seven years K+S has developed the steam heated fluidized bed dryer, a completely new drying technology which is unique in the potash industry. This technology is lower in dust, HCl and CO_2 emissions, and has a markedly lower energy consumption and lower drying costs as well.

This new dryer, which costs more than 13 million DM, is another fine example for our company policy of responsibility to environment for generations to come.

Figure 1

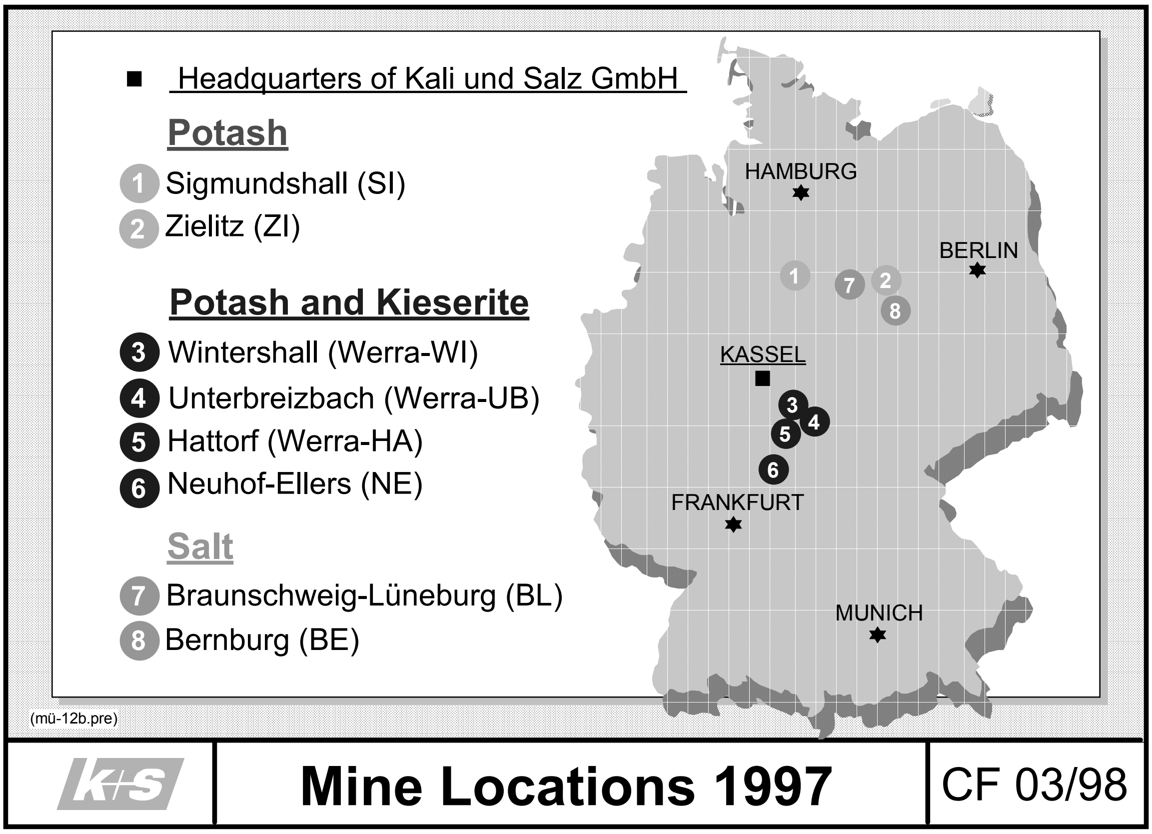


Figure 2

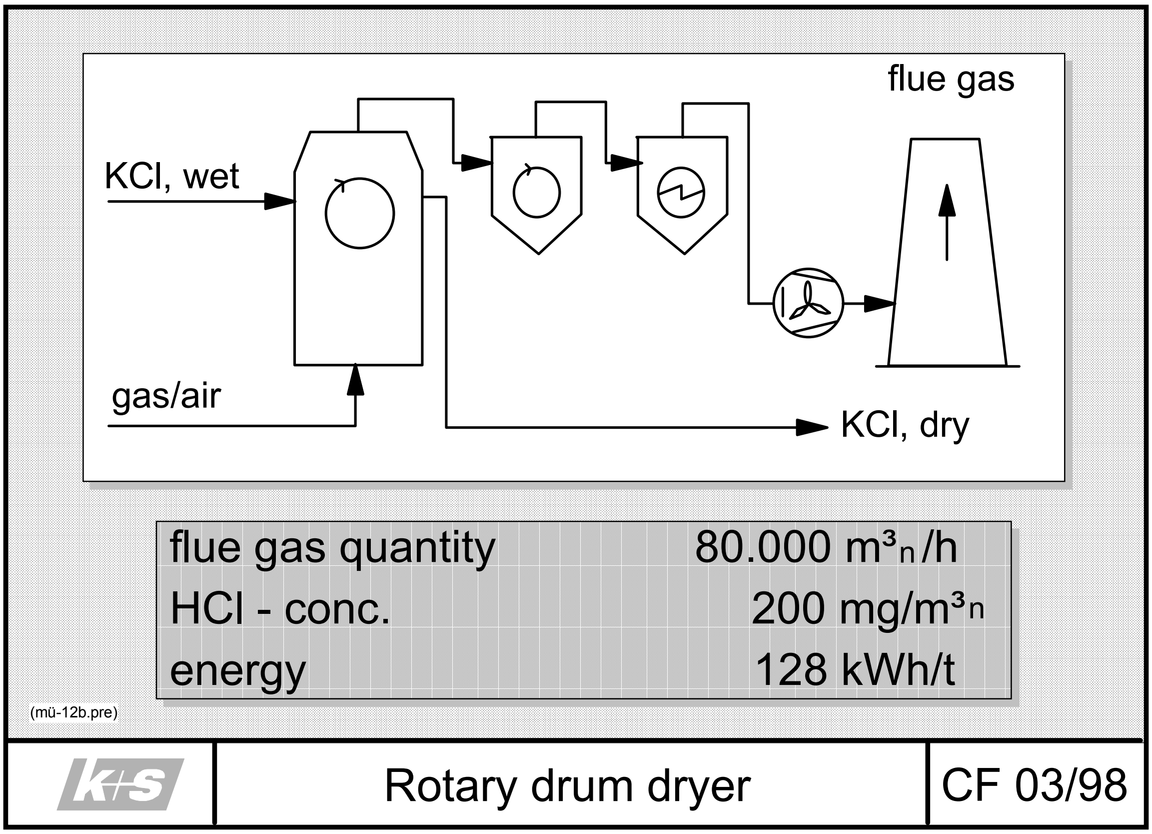


Figure 3

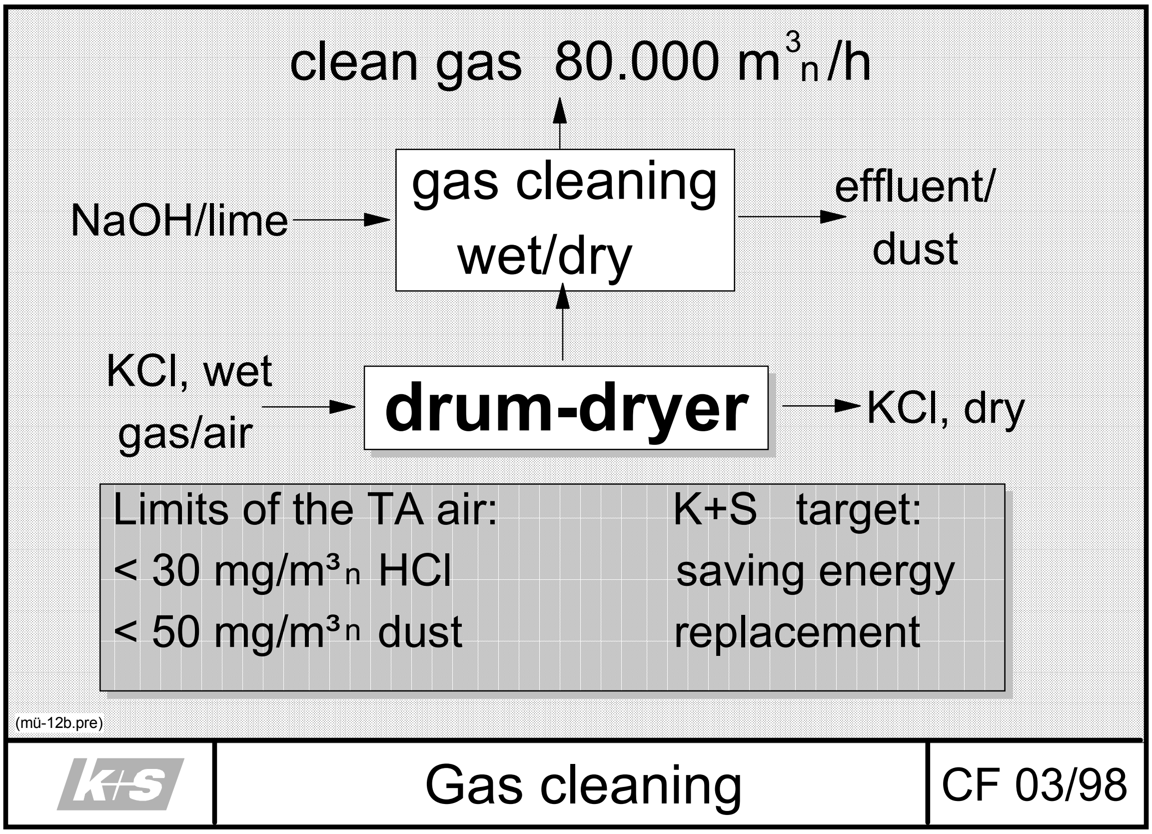

clean gas 80.000 m³n/h
gas cleaning wet/dry
NaOH/lime
effluent/ dust
KCl, wet gas/air
drum-dryer
KCl, dry
Limits of the TA air:
< 30 mg/m³n HCl
< 50 mg/m³n dust
K+S target:
saving energy
replacement
(mü-12b.pre)
Gas cleaning
CF 03/98

Figure 4

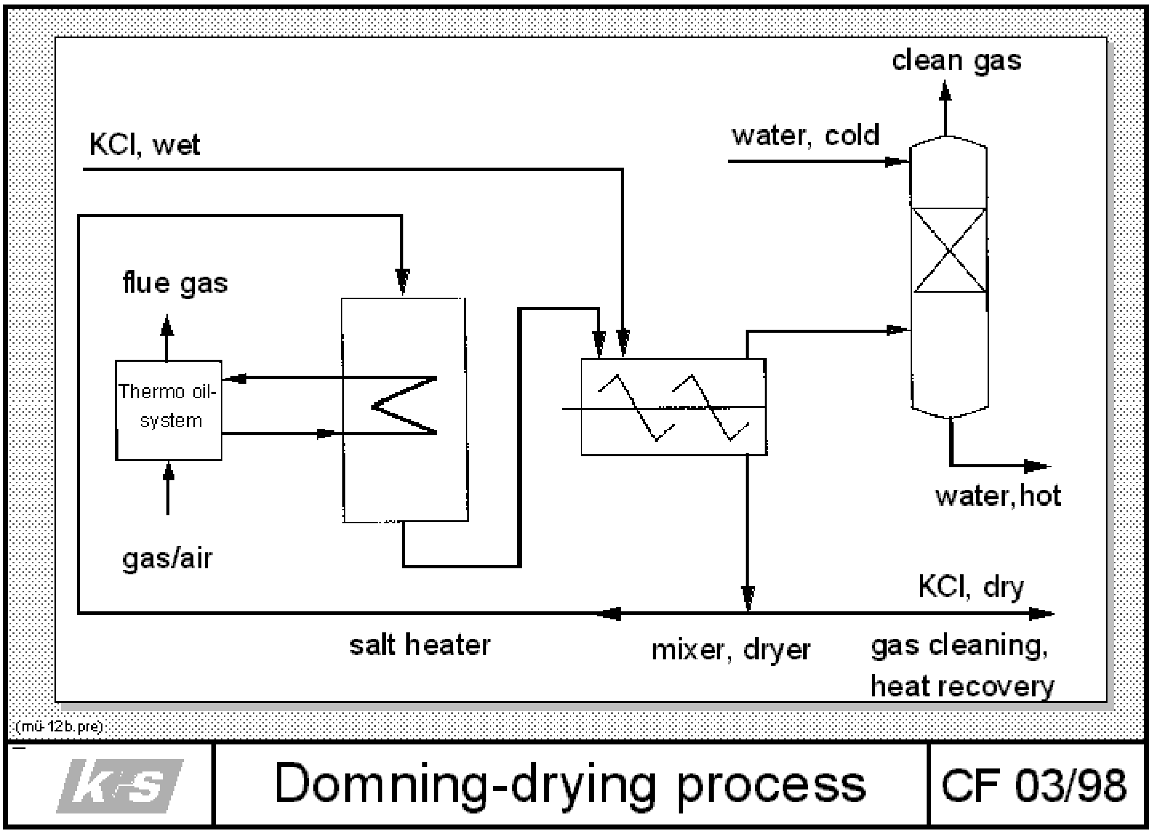

clean gas
KCl, wet
water, cold
flue gas
Thermo oil-system
water,hot
gas/air
KCl, dry
salt heater
mixer, dryer
gas cleaning, heat recovery
(mü-12b.pre)
Domning-drying process
CF 03/98

Figure 5

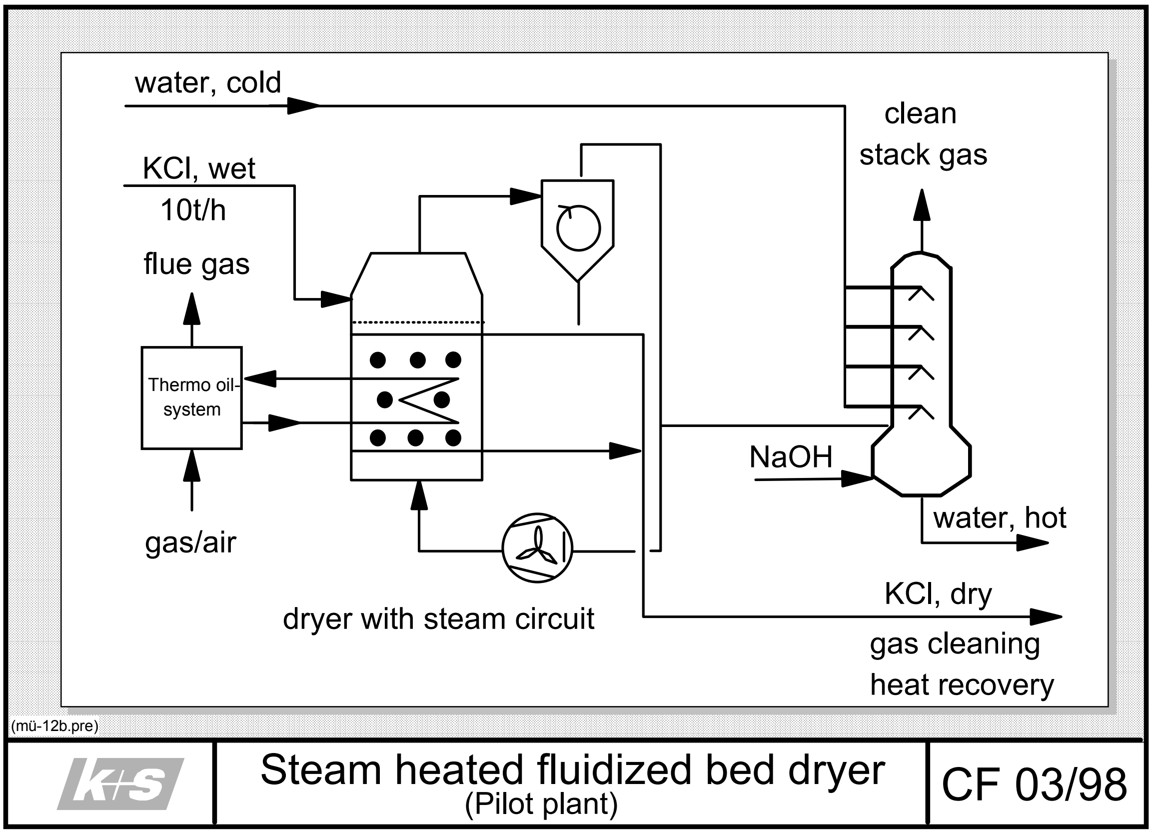


Figure 6

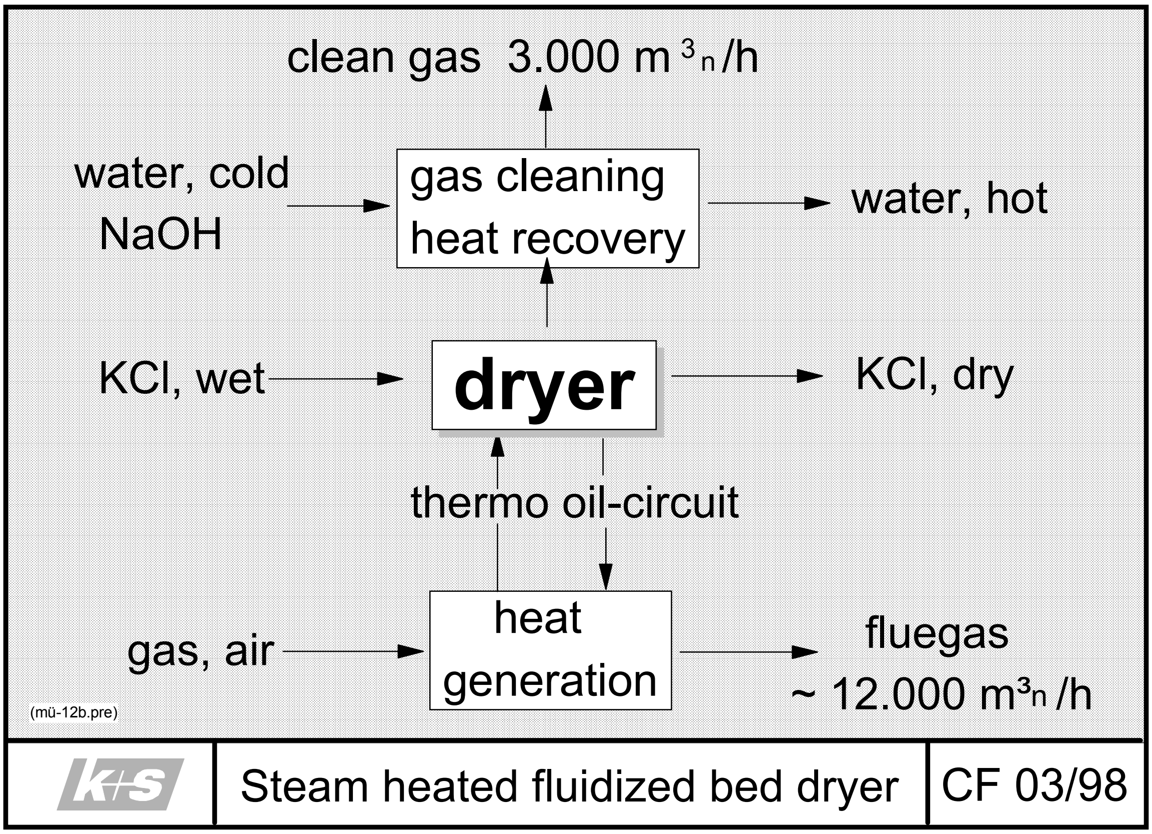
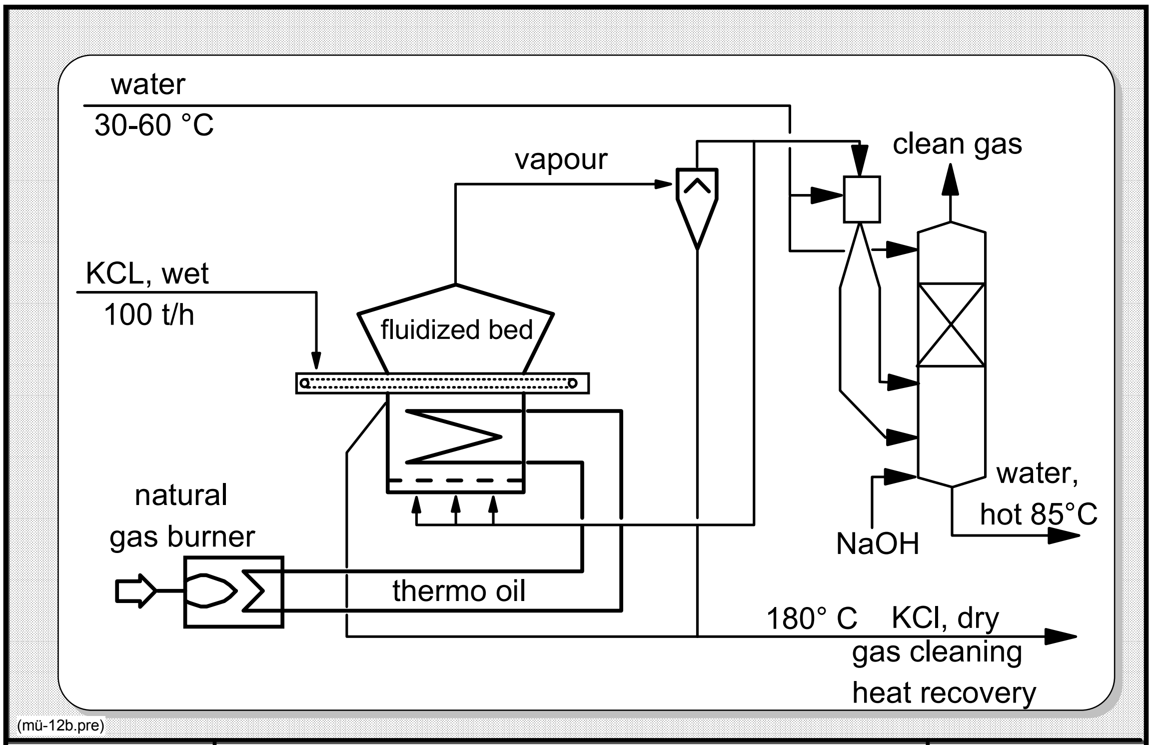


Figure 7



Steam heated fluidized bed dryer
(Production plant)

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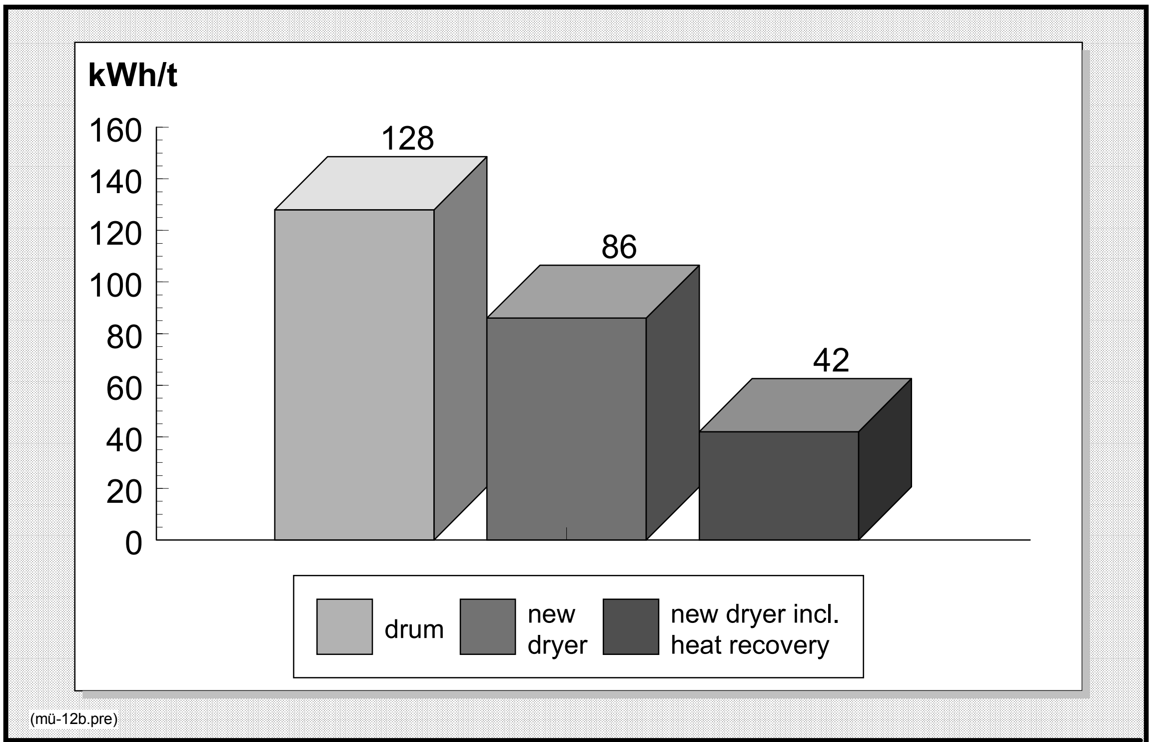
Figure 8



Energy consumption for KCl drying systems

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Figure 9

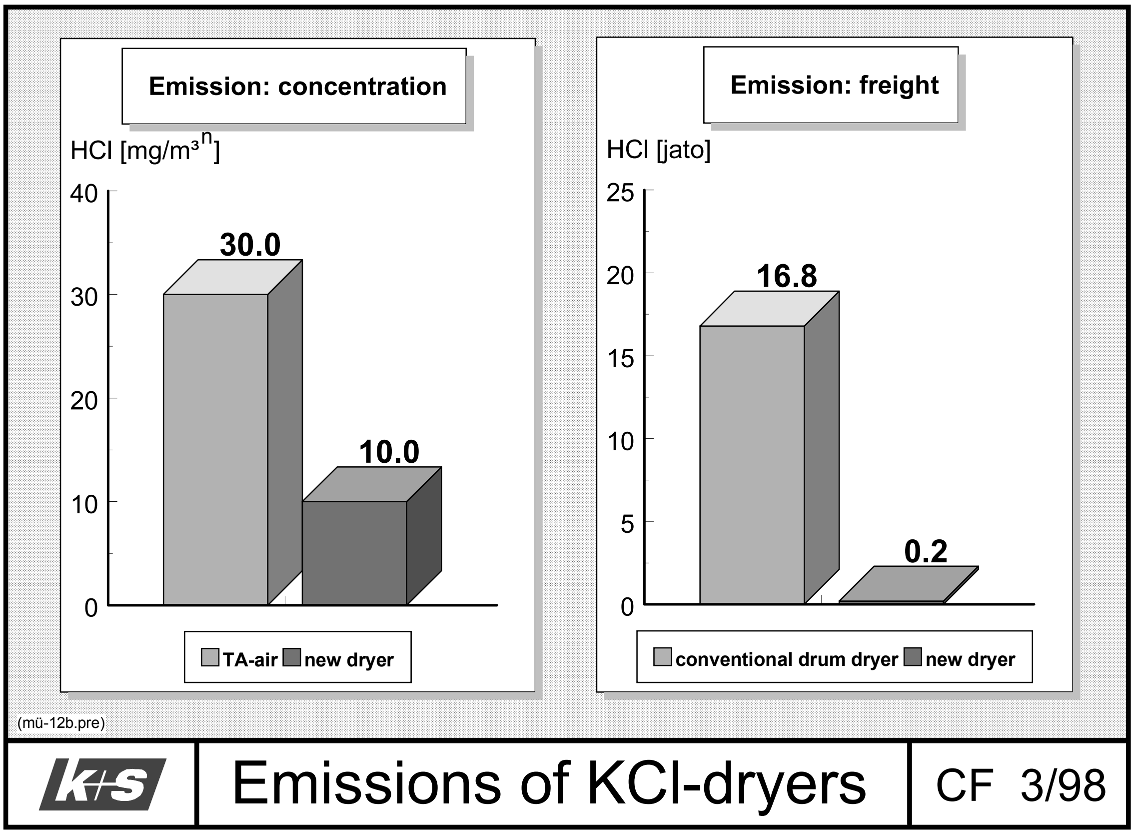


Figure 10

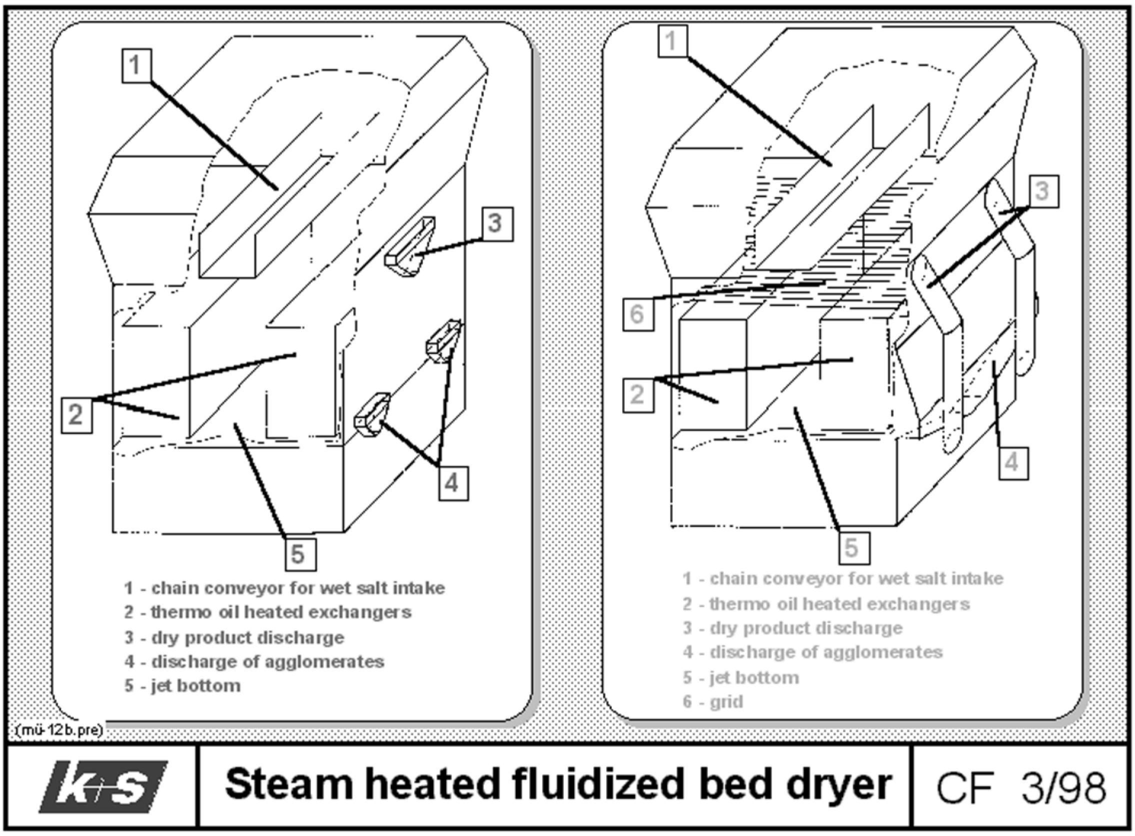
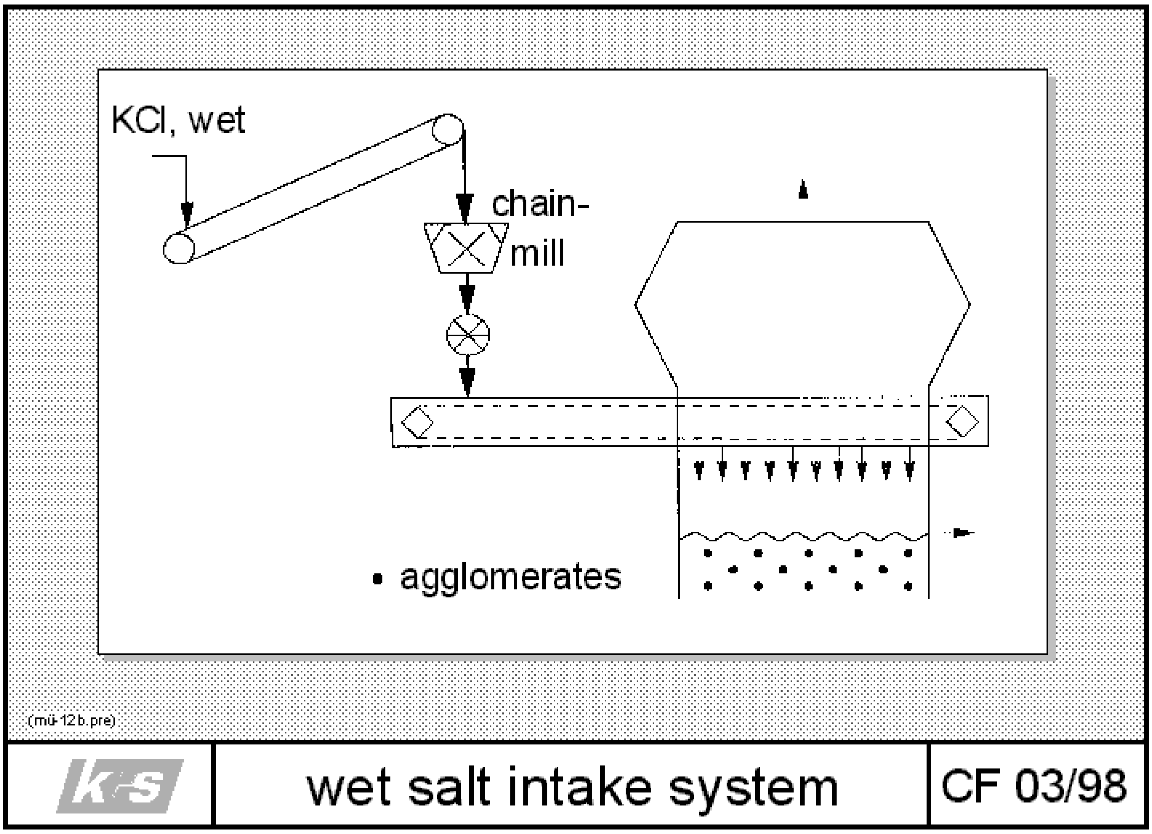


Figure 11


KCl, wet
chain-
mill
• agglomerates
(mü 12 b.pre)
wet salt intake system
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