Drying and Bulk Handling of Potassium Chloride

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ABSTRACT

The development of a satisfactory technique for continuously drying wet KCL crystals without forming deposits on any surfaces in the drying equipment was accomplished utilizing a pilot unit of 2 sq. ft. cross section. The determination of proper operating techniques and proper geometry of the system became the basis of 14 weeks of field testing. Moisture level required was less than .05% at lowest possible product temperature.

The utilization of Cross-Flo control over hot gas temperatures and flow rates provides an extremely flexible method of producing a dustless dry product.

Bulk movement of the dried material after drying is accomplished utilizing directional fluidizing conveyor with maximum sensitive control.

The Cross Flo Dryer was applied for the first time in the drying of salts in 1967. There was a history of drying crystalline organic materials as well as filter cakes prior to this date. Our experience with inorganic salts was certainly different in a number of respects.

We found that removal of moisture from material containing solutions of the crystal on the surface required a different concept of handling due to more difficult fluidization and the greater cementing properties of the brine coating on the wet crystal.

In the first attempts to successfully dry KCl we found that insulation of the dryer housing, reduction of the relative humidity levels and enlargement of the first compartment were mandatory for effective fluidization and drying. As long as these parameters were met, material could be introduced from a number of different feeding devices without apparent problems. The depth of bed in our test work was approximately 20-24" and the free fall of material was 5-6 ft.

Based on KCl crystals ranging from 10 mesh to 60 mesh we were able to dry at rates approaching 2.25 tons per sq. ft. per hour. This required inlet temperatures of 1500° which do not seem practical in view of our design concept using all metal construction. As a result we decided to limit our design to a peak temperature of 1200° with a normal operating temperature of 800-1000°. The pilot unit provided us with the following general data. It has been determined from a number of applications in salt, rubber, organic crystals, synthetic sweeteners and similar materials that there are two major design variables that the small pilot dryer cannot predict:

(1) Particle migration velocity

(2) Wall effects.

GAS TEMPERATURES

Inlet Temp.	T_1	T_2	T_3	T_4	Outlet Temp.
800	175	180	200	220	190
900	180	185	200	225	195
1000	180	185	200	230	200
1100	185	190	210	240	205
1200	190	200	210	250	210

In every case the full scale dryer will reach lower moisture levels at identical temperatures and feed rate conditions than will the pilot. The full scale dryer will also exhibit a more predictable circulation path down the walls and will usually permit the use of a wider included angle between the walls.

Since drying in the Cross Flo involves handling an average product in the first compartment higher in moisture than in conventional single compartment fluid bed units, we are able to utilize higher air rates in the wet zone to achieve satisfactory fluidization. This provides for intensive mixing and when coupled with a deep bed, permits introduction of wet feed directly from the centrifuge or filter and permits feeding with a vertical fall of 20 ft. It was found that when the fluidized bed level was reduced, deterioration in the first compartment ensued, and that incomplete mixing resulted. As the bed level was raised, temperature differentials decreased across the first compartment indicating nearly uniform conditions existed even though feed density approached 200 tons/sq. ft./hour.

Tests conducted with size distribution curves, indicated breakage of crystals as negligible. As a result of this, creation of dust was minimized. When compared to conventional rotary dryer operation, the lack of agglomeration, crystal breakage, encrustation and reduced energy costs due to higher gas efficiency provided us with our first potash application.

We cannot claim a complete absence of problems. In the case of utilizing high temperatures, expansion of metal surfaces becomes the major design problem. Three-dimensional expansion requires compensation. We feel that our experience in this area gives us the ability to cope with this problem in future designs. Reducing the size of the dryer where possible obviously will help. This is an area in which a pilot unit cannot provide good scale-up information.

In the Cross Flo Dryer the prime areas of design concern are as follows:

(1) Minimizing back and forward mixing.

(2) Providing proper geometry for internal circulation of the bed.

(3) Sizing fluidizing grid to provide sufficient differential pressure so as to maintain uniform gas distribution.

(4) Design control over airflow and temperature so as to tune the dryer to its specific product.

We found that a considerable variation can occur in crystal size. It was our experience that a minimum of 5-7" differential pressure is required to maintain uniform gas distribution.

In view of the ease of fluidizing dry KCl we developed a transfer conveying system which can move one TPH/20 ft. horizontally for .1 HP/hr. We determined that fluidizing the material provided a novel means of putting material into a pseudo-fluid which can under flow a weir either to a second conveyor or to a use point.

In looking back we feel that the general concept of the Cross Flo system has the following advantages over conventional techniques for dehydration:

(1) Elimination of particle agglomeration.

(2) Reduction of crystal breakage.

(3) Elimination of material build-up on metal surfaces.

(4) Ability to vary retention time by changing bed level.

(5) Ability to adjust gas flow and temperature to each of the drying zones for fine control.

(6) Lack of moving parts except for fans and dampers.

(7) Stretch out capability permitting enlargement of dryer if need arises.

(8) Level control Under-Flow gate.

(9) No need to recycle dry product to make feed fluidizable.

(10) Gas circuit can be operated in closed loop permitting drying of cycle-solvent mixtures.

(11) Highest mass transfer rates per unit space.

The Cross Flow drying system has now been built in sizes ranging from 20-300 sq. ft. with the largest dryer in salt service being 150 sq. ft. on KCl. The design becomes optimum in the 50–200 sq. ft. range and we are presently engaged in a standardization program which will permit these units to be applied with a minimum of custom engineering. As a result, materials of construction, included wall angle, expansion details and fluidizing grids will be the only variables that shall affect design.

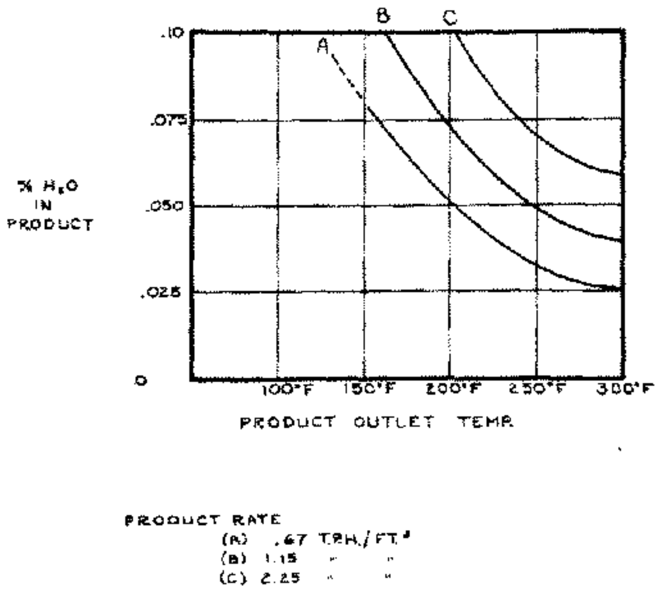

Figure 1. Moisture vs. product outlet temperature.

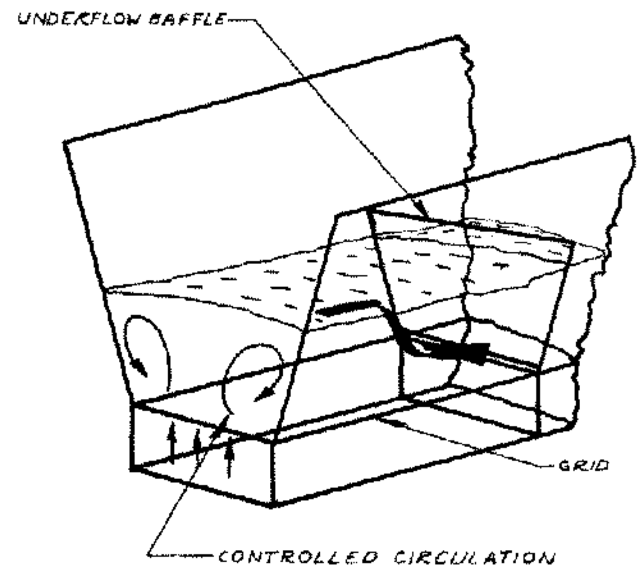

Figure 3. Idealized cross-flo diagram.

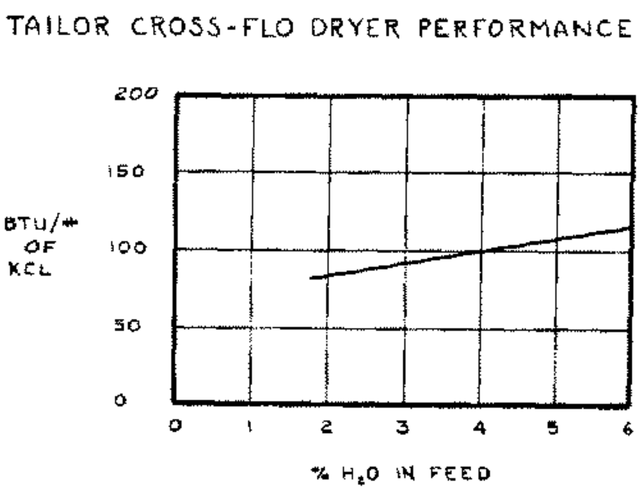

Figure 2. Heat vs % moisture in feed.

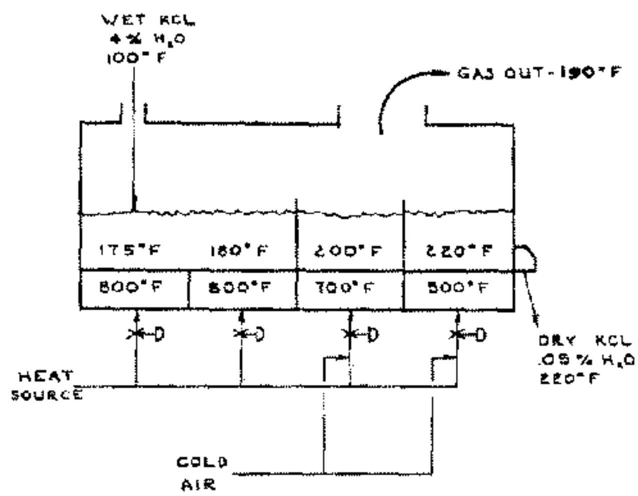

Figure 4. Temperature schematic diagram.