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THE COOLING OF FERTILIZERS DURING MANUFACTURE

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According to a paper by B. Raistrick published in 1956, the problem of fertilizer caking can be readily solved, the material being high-dried so as to reduce its relative humidity to below 30% which generally means a moisture content of less than 1%. In fact, high-drying alone will not give a satisfactory solution of this problem although it is probably the most important factor. To prevent subsequent caking, it is still advisable to include appropriate dusting and cooling in processing. Our experience has shown that dusting and cooling become more important when drying falls below specification, and that fertilizers with a 3 to 4% moisture content lose their bad storage tendencies when they have previously been carefully dusted and cooled.

During cooling the material is in constant motion and both physical and chemical forces are at work to make a more readily stored product out of the hot plastic or crumbly starting material. The most striking change is the rapid hardening of the granules during cooling. Resistance to pressure of the granules may increase by 45% in the cooler, while the moisture content falls by 10 or 15%. Chemical processes of crystallization which occur in traces of saturated solutions which diffuse to the surface of the granules during drying are more rapidly halted when cooling follows immediately, so that this cause of particle adhesion which Raistrick particularly mentioned in his paper is presumably to a large extent eliminated before the material reaches the store. Since the vapour pressure falls with diminishing temperature, this limits the evolution of water vapour in the storage heap and the possibility that it will condense in the more rapidly cooling outside layers of the heap.

Nevertheless, there are economic limits to the amount of cooling which can be done. There is no definite optimum for an efficient cooler, but in general it is required that the temperature of the cooled material should be about 35°C. Efficient and economic coolers can achieve a temperature of only 10° above that of cool air, so that in summer it is difficult to achieve the desired cooling unless the air is pre-cooled.

We have attempted to make a critical comparison of the efficiency of various coolers, some of which have been in operation in our works for a number of years, and we have assumed that the old type of cooler working more or less on the lines of a rotary drier, only without any heating has been completely outmoded by the application of fluidized bed processes to the cooling of fertilizers. High-dried fertilizers can be cooled to 10°C above cool air temperature in this old type of equipment only if the capacity is very small or the apparatus is unduly large and consequently uneconomic.

Following is a brief description of the coolers studied:

1. Rotary drum cooler

   An ordinary rotary drier without heating, 16 m long, 1.8m diameter, with lifting flights

2. Mozer cooling drum

   A conical double-walled drum in which the material is passed between the inner and outer walls; about 7m long and 1.8m diameter.

3. Sectional cooler (Büttner)

   A cooling drum which revolves in a water bath and divided into 3 lengthwise sections, 4m long, 2.5m diameter (see diagram)

4. Hover cooler (Lurgi)

   Consists of a slowly revolving conical upper grid and a fixed funnel-shaped lower grid. Cool air passes from below through the bars to the material and through it and keeps it flowing by fluidization. Height 2.5m, diameter 3m. (see diagram)

5. Fluidized bed cooler (Büttner)

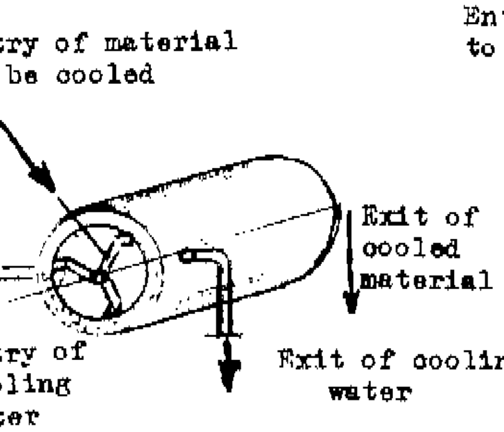
   In this cooler the material to be cooled moves across a rectangular grid made of perforated sheet metal and equipped with balls, the whole being set at an angle. The cool air is blown through the material from below; length 2.3m, width 1m, height 2.5mExperimental.

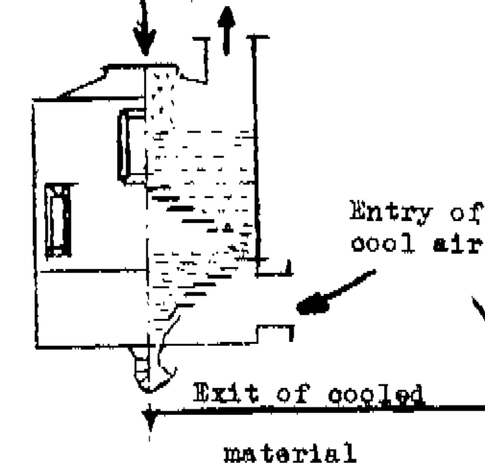
6. Revolving cascade cooling tower (Guano-Werke AG)

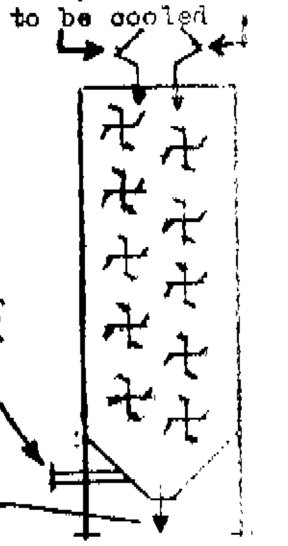
   Consists of two rows of conveyor boxes, one under the other, at opposite angles and turning in opposite directions, the material falling in the course of one revolution into the boxes below and being cooled by the stream of air blown through the tower from the bottom to the top; 2.25 x 2.80 x 9.50 m (see diagram)

Regarding the revolving cascade cooler which we constructed in 1960 and which has been in operation ever since, it should be noted that the original intention was to construct a space-saving and cheap apparatus where the hot material could be in continuous motion for as long as possible to allow it to complete the secondary reactions. Thus, while the first consideration was that there should be a long retention time, it was also desirable that the material should be cooled during this time. The arrangements did not seem to be particularly favourable for this purpose, as the material to be cooled was exposed to the air only during the short time it was falling from one conveyor box to the next and for the rest of the time it lay in the trays. However, the values we obtained were surprisingly good and it ought to be possible by introducing certain modifications in the tower to make it into an efficient cooling system.

The table gives typical measured values selected from a large number of individual measurements made on the coolers under study. Unfortunately these figures are for various reasons not directly comparable. The effectiveness of this table is vitiated mainly by the fact that such variables as different loading of the equipment, particle size, continuing exothermic secondary







Sectional cooler   Hover cooler   Revolving cascade cooling tower

reactions, moisture content and temperature of the material, temperature of the cooling air, atmospheric humidity, etc. in every case gave quite specific values. Nevertheless, the figures do give some indication of the range. If, for instance, we take the amount of heat removed per ton of material, the values obtained show clearly that the fluidized bed apparatus is superior. This gives values of 10,000-15,000 kcal/ton, while the older type of rotary cooler gives only about 5,000 kcal/ton. The revolving cascade cooler is about midway between these with 9,000 kcal/ton.

It is obvious that the cooling effect must be greater in proportion to the amount of agitation conveyed to the material to be cooled. Heat exchange cannot be very efficient in the old type of drum cooler because the greater part of the material to be cooled is always in the same half of the drum, usually in a thick layer on the bottom or in the corners of the flights, while a considerable amount of the flow of cool air in the other half of the drum is not performing any cooling. Since heat exchange always proceeds from areas of higher temperature to those of lower temperature and the rate of cooling with small differences of temperature is proportional to this (Newton's law of cooling), the work capacity of the cool air can reach ideal levels only where the whole of the air used for cooling makes contact with the material to be cooled; these conditions are fulfilled in the fluidized bed cooler. Since here the air is blown through the bed of material, the power requirement for this cooler (7-8 kw/ton) is relatively high in comparison with the others (2-3kw/ton).

The favourable operation of the revolving cascade cooler is obviously due to the fact that the very slow rotation of the conveyor boxes (one revolution every 8 minutes) sends a regular thin trickle of the material through the tower, while the numerous thin-walled boxes are able to cool both inside and out during the slow turning much better, for instance, than can be the case in a rotary drum. Then because of the higher rate of heat exchange on the boundary layers, the cooler is more efficient. Calculations from measurements have shown that the area covered at a particular interval of time by the cooling material as it trickles down amounts to 550 m^2 in the revolving cascade cooler and only 340 m^2 in the rotary drum. From the point of view of space utilization, too, preference must be given to the cooling tower which requires only 6.30 m^2 of floor space and to the fluidized bed cooler which is equally space-saving, rather than to the rotary drum which requires 36m^2. Regarding the results obtained with the fluidized bed cooler supplied by the firm of Büttner, it should be noted that the figures probably do not quite reflect the possible output of the equipment, as there was very little time available for testing and the plant which had been erected in the open had not been operated for some time and was not in first-class condition.

The extraordinarily short retention time in the cooler must give rise to misgivings because this does not allow for any possible secondary reactions to take place before the material goes into the heap, and moreover provides no assurance that cooling has penetrated far enough into the granule.

The Mozer and Sectional coolers are difficult of access and are a constant source of annoyance on the plant because of the length of time required to clean them. The fact that in the fluidized bed coolers the cooling air simultaneously performs the conveying of the material should mean that any tendency to blockage and the need for repairs are kept within modest limits.

Efficiency of Various Types of Cooler

	Rotary drum cooler	Mozer cooling drum	Sectional cooler (Büttner)	Hover cooler (Lurgi) 1)	Fluidized bed cooler 2) (Büttner)	Revolving cascade cooler (Guano-Werke)
Cooling medium	Air	Air	Air/Water	Air	Air	Air
Throughput (tons/hr)	19	8	5,5	20	4	6,9
Material to be cooled °C in	68	72	72	75	59	81
out	50	52	59	25	25	51
Cooling air °C in	9	17		15	11	20
out	30				30	40
Amount m^3	15000	8000	5000	21200	6000	17000
m^3/ton	790	1000	910	1060	1500	2460
Power requirement kw	40	27	10,3	162	28	19
kw/t	2,1	2,7	1,7	8,1	7,0	2,8
Heat removed kcal/ton (3)	5400	6000	3900	15000	10200	9000
Retention time min.	16	8	6	15	2	18

Notes:
(1) Figures from Lurgi catalogue
(2) Experimental plant, tested by us on 10 tons of material
(3) Calculated at specific heat of 0.3 kcal/kg Co