New Urea Plant Construction in the USA

plan to use indirect Coolers

to reduce Energy Consumption

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Summary

A new generation of urea granulation plants are planned for the USA over the next few years, with the first of these already in the construction phase. The principal motivation for the plants is low and sustainable natural gas prices, coupled with a very large domestic market.

Many of these plants are considering using an Indirect Cooler as the final step before the product goes to storage. The indirect cooler would replace the fluid bed cooler which to date has been the industry standard in new plant construction worldwide. The principal advantage of the Indirect Cooler is the much lower energy consumption compared to a fluid bed cooler.

Two factors lead to the smaller energy footprint: eliminating the fans, but much more important is the energy requirement for the chillers required to chill the air. In a comparison made for a recent project, this combined energy saving was approximately $500,000 per year.

Some of the companies planning to construct new plants in the USA already have direct experience operating Indirect Coolers in their plants and so regard this equipment as fully proven technology.

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New Urea Plant Construction in the USA plan to use indirect Coolers to reduce Energy Consumption

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Keywords: Fertilizer; Cooling; Heat Exchanger; Urea, Ammonium Nitrate`3

1. INTRODUCTION

Approximately 20 years ago a new technology was introduced to the fertilizer industry, an indirect plate-type heat exchanger as the final cooling step before product storage. This method of cooling provided an alternative to the fluid bed or drum cooler which to that point was the industry standard.

The Indirect Plate Heat exchanger offers several major advantages compared to the fluid bed cooler (FBC) or cooling drum. The principal ones are significantly lower energy consumption, very low air volumes (a small air purge is required to prevent condensation) & a small footprint. There are also savings in installed capital cost by eliminating the large air handling system needed for the air coolers with chillers, fans, ducts and a scrubber.

There have been significant advancements in the technology since it was first introduced to the fertilizer industry; of these, the major one was to develop a thorough understanding of the science when a fertilizer product cools. Solex Thermal Science (formerly Bulkflow Technologies) has developed a full understanding of this mechanism and with this knowledge can design a fertilizer cooler to guarantee efficient cooling and long, reliable run time between scheduled cleaning in all climatic conditions. This topic was covered in an article in Nitrogen+Syngas 298 of March-April 2009.

To date the majority of installations of indirect coolers in fertilizer plants have been for retrofit projects and in most cases the primary driver was to provide catch up on the cooling capacity when the upstream plant had been debottlenecked. The technology is a very logical fit in this type of project; low air emissions do not put additional loading on the air scrubbing system and a small footprint fits well into a crowded building.

Recently indirect plate heat exchangers for the final stage of granule cooling have been selected by the major process licensors in new plant construction for some of the latest generation fertilizer plants in the USA. This has come about for 2 reasons; first, the technology is now well proven. It will perform the cooling duty and will operate for long periods between scheduled cleanings. The second reason and major benefit, is the much lower energy consumption as a result of eliminating the high HP fans and air chiller.

2. ENERGY SAVINGS BETWEEN A FLUID BED COOLER AND AN INDIRECT PLATE COOLER

2.1 Energy Demands of an Indirect Plate Cooler System

Figure 1 shows the typical flow sheet of the secondary cooling in a urea granulation plant using an Indirect Plate type Cooler. The power draws for this system are the water pump on the Water Module and the Bucket Elevator.

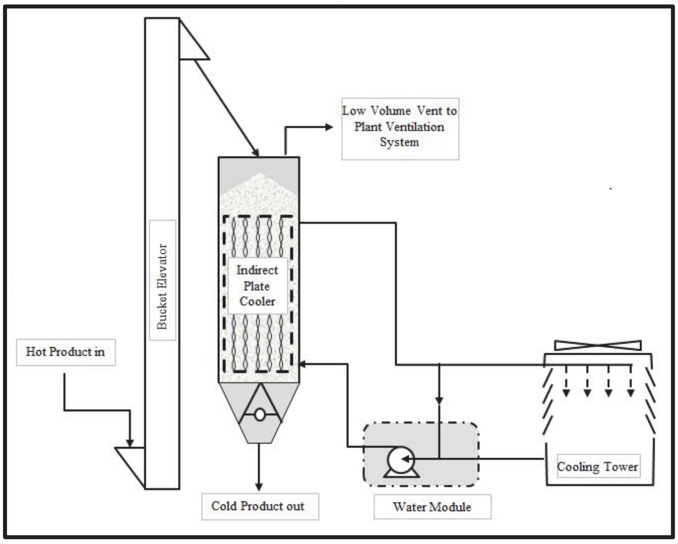

Figure 1

The power draws are all quite small as shown in Table 1.

Table 1

Operating Power Draw - Indirect Plate Cooler		
Water Pump	kW	20
Bucket Elevator	kW	25
Total	kW	45
Power Cost		
Power cost @ $60/MWH	$	21,600

2.2 Energy Demands of a Fluid Bed Cooler

Figure 2 shows a typical flow sheet of the secondary cooling in a urea granulation plant using a fluid bed cooler.

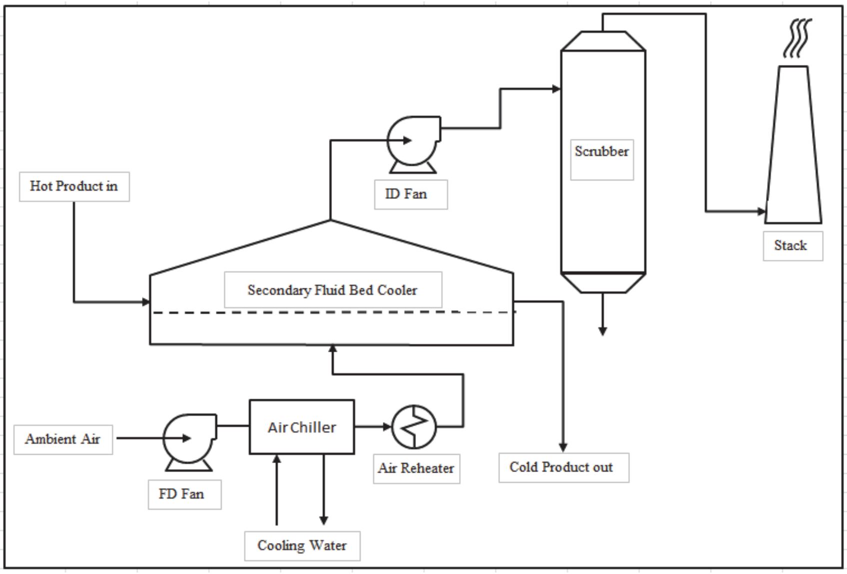

Figure 2

There are 3 main power draws – the forced draft fan, induced draft fan and the air chiller. The fan load is straight forward and is a function of air flowrate and pressure drop across the bed. The air chiller load is more complex and will vary throughout the year depending on ambient conditions. In many cases the air chiller power draw will be the largest of the system.

2.3 Air Chiller

A typical specified temperature of urea for storage is in the range 40 – 45°C. Ambient air cannot be used directly to achieve this temperature. Even in temperate climates such as Alberta, Canada, where summer ambient temperatures can be 30 – 35°C, it is much too warm to achieve specified discharge temperatures. In warmer & more humid climates the problem only gets worse. This means that the air must be chilled. When air is chilled there are 2 components to the heat load: the sensible heat of chilling the air and the sensible and latent heat of cooling and condensing the water present in the air. Furthermore, the air exiting the chiller will be saturated and saturated air cannot be used directly for cooling fertilizer. The reason for this is that if the RH of the air is above a critical value, defined by the critical relative humidity (CRH) curve for the fertilizer, the fertilizer will pick moisture up from the surrounding air. This means that the air must be sub-cooled and then reheated, so that the RH of the air entering the Fluid Bed Cooler is below the CRH curve. Typical process conditions for the air chiller are to chill ambient air to 10°C and then reheat to 20°C; this provides an approach temperature between the air temperature and desired product out temperature of 20 – 25°C.

To determine the heat load for the air chiller, the starting point is the temperature and relative humidity of the ambient air. This is dependent on the geographic location, and for a given location it will vary throughout the year. The worst case conditions need to be used to specify the air chiller; whereas the average conditions month by month are used to estimate typical operating cost.

The following example shows typical operating costs for a chiller system based on a 3600 t/d plant. Air flow to the fluid bed cooler is taken at 180,000 Nm3/h. Air is chilled to 10°C and reheated to 20°C. Plant location is taken as USA Gulf Coast.

Table 2 shows enthalpy and average chiller load on a month by month basis.

Table 2

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Average
Ambient Conditions														
Aver. Temp.	°C	14	15	21	21	25	28	29	28	26	20	14	14	21.25
Aver. RH	RH	70	75	73	72	72	71	75	78	77	71	69	74	73.08
Enthalpy														
Enthalpy - ambient	kJ/kg	31.64	35.20	49.94	49.54	61.62	71.36	77.71	75.74	67.71	46.41	31.38	32.65	52.58
Enthalpy - 10C, 100%RH	kJ/kg	29.60	29.60	29.60	29.60	29.60	29.60	29.60	29.60	29.60	29.60	29.60	29.60	29.60
Enthalpy (delta)	kJ/kg	2.04	5.60	20.34	19.94	32.02	41.76	48.11	46.14	38.11	16.81	1.78	3.05	22.98
Chiller Load														
Aver. Chiller Load	kJ/h	440,640	1,209,600	4,393,440	4,307,040	6,916,320	9,020,160	10,391,760	9,966,240	8,231,760	3,630,960	not in use	658,800	5,378,793
Chiller Power	kW	41	112	407	399	640	835	962	923	762	336	-	61	498

This table contains the following information:

1. Average ambient temperature and humidity on a month by month basis
2. Enthalpy of air at these temperatures and humidities (air inlet to air chiller)
3. Enthalpy of air at 10°C and 100% RH (air discharge from the air chiller)
4. Change in Enthalpy
5. Average chiller load for 180,000 Nm3/h air flowrate.

When we look at a worst case scenario the combination of maximum daily temperature and highest humidity for a USA Gulf Coast location, we have a temperature of 35°C and 94% RH. From this data we can determine the required rating for the air chiller. These conditions are shown in Table 3.

Table 3

		Maximum
Ambient Conditions		
Aver. Temp.	°C	35
Aver. RH	RH	94
Enthalpy		
Enthalpy - ambient	kJ/kg	124.00
Enthalpy - 11C, 100%RH	kJ/kg	29.60
Enthalpy (delta)	kJ/kg	94.40
Chiller Load		
Aver. Chiller Load	kJ/h	20,390,400
Chiller Power	kW	1,887

Table 4 shows that the installed power requirement for the Air Chiller is almost 2 MW, significant in terms of the capital cost of the equipment and the associated installation. Average operating power draw is approaching 500 kW.

Table 4

		Worst Case	Average
Heat Load & Power			
Chilling Load	kJ/h	20,390,400	5,378,793
Compressor power	kJ/h	6,796,800	1,792,931
Convert to kW	kW	1,887	498

2.4 Fans

In a Fluid Bed Cooler system there are typically fans upstream (forced draft) and downstream (induced draft) of the fluid bed. Estimated power consumption is 180 kW for the FD fan and 360 kW for the ID fan.

2.5 Summary of Costs

A summary of the estimated power draw and annual operating cost is given in Table 5.

Table 5

Operating Power Draw - Fluid Bed Cooler		
Air Chiller	kW	498
FD Fan	kW	180
ID Fan	kW	360
Total	kW	1038
Power Cost		
Power cost @ $60/MWH	$	498,240

As we see in this example, the expected annual operating cost is almost $500,000. Referring back to Table 1 where the expected annual operating cost is $21,600 resulting in an overall saving of approximately $480,000 per year. These costs are based on typical North American energy costs of $60/MWH, these are some of the lowest electrical costs in the world, and so in other regions with higher energy costs the savings will be more.

3. CONCLUSION

Indirect Plate Heat Exchanger Coolers have proven themselves as reliable and efficient for cooling fertilizers. There are now over 100 in service throughout the world in every type of fertilizer – urea, ammonium nitrate, NPK's and phosphates, with some in service now for more than 25 years. Developments over the last few years have addressed some of the early concerns with caking; solved by careful control of water temperature and addition of low volume dry purge air to achieve reliable operation and long run times between cleaning.

The low operating cost has been the primary focus of this paper and has shown that there is a significant operating cost saving of about $500,000 per year with the Plate Heat Exchanger option for a 3600 t/d plant. A significant component of cost saving is the elimination of the Air Chiller, due to the heat load required to condense the water out of the air. In addition to the operating cost saving, 3 large drives of 180, 360 & 2000 kW have been eliminated replaced by 2 small drives totalling less than 50 kW. Eliminating the large air handling system, small footprint, lower installed capital cost and very low operating cost offer several advantages for using Indirect Heat Exchanger Plate technology to cool fertilizer.

References

"Not as Easy as it Looks", N.P. Jordison, Nitrogen + Syngas 298, March-April 2009.