Filippo Colucci, Solex Thermal Science Inc., the Netherlands, compares conventional fluid bed coolers and indirect plate coolers, with a focus on energy consumption.

Fertilizer processing plants have continually been under pressure to revamp operations in order to remain competitive in today’s market. They are also dealing with tight operating margins and the need to comply with current and new environmental regulations.

Just over 20 years ago, a new technology was introduced to the fertilizer industry by Solex Thermal Science Inc. – an indirect plate heat exchanger that was used as the final cooling step before the product was stored. This method of cooling provided an alternative to the traditional fluid bed cooler or drum cooler, which was the previous industry standard. It offered several key advantages compared to the fluid bed cooler, including lower energy consumption, lower air volumes, and a smaller footprint. There were also savings in installed capital cost by eliminating the large air handling system for the air coolers, which were needed for the fluid bed cooler.
There have been significant advancements in indirect plate heat exchanger technology behind the indirect plate cooler since it was first introduced to the fertilizer industry. Of these, the most major advancement was gaining a thorough understanding of the science behind cooling a fertilizer product. Having a full understanding of this supported the design of a fertilizer cooler that guaranteed efficient cooling and long, reliable run times between scheduled cleaning in all climatic conditions.

To date, the majority of indirect plate cooler installations 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 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.

Indirect plate coolers have recently been selected for the final stage of granule cooling by major process licensors in some of the latest generation fertilizer plants in the US. This has come about for two reasons. First, the technology is proven. It will perform the cooling duty and operate for long periods between scheduled cleanings. The second reason is the much lower energy consumption as a result of eliminating the high horsepower fans and air chiller needed with a fluid bed cooler.

So, how do conventional fluid bed coolers and indirect plate coolers match up? This article will take an in-depth look at and compare both units.

The conventional fertilizer cooling process

The conventional process for fertilizer cooling is to use a fluid bed cooler. Figure 1 shows a typical granulation layout. In this conventional layout, there are three main power draws: the forced draft fan, induced draft fan, and the air chiller. The fan load is straightforward and is a function of air flow rate 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.

Air chiller

A typical specified temperature of urea for storage is in the range of 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 too warm to achieve specified discharge temperatures. In warmer and more humid climates, the problem only gets worse. This means that the air must be chilled.
The air for the secondary fluid bed cooler needs to be chilled to approximately 10°C and then reheated to about 20°C so it is no longer saturated. The relative humidity (RH) of the air entering the fluid bed cooler must be below the critical relative humidity (CRH) of the product to avoid the product picking up moisture from the air and becoming sticky.

At 20°C, chilled air temperature is still an adequate temperature difference between the air and the required product exit temperature to achieve effective cooling efficiency. In a hot, humid climate, there is considerable heat load needed to chill the air. There is the combination of the heat load to chill the air, plus the heat load to chill the water vapour in the air and the latent heat of condensing the water out of the air. The air chiller has to be rated for the worst case conditions, otherwise it becomes the bottleneck and production needs to be cut back.

To give an idea, for a typical air chiller in a 3600 tpd urea plant located on the US Gulf Coast on a hot day in July, where the temperature can reach 35°C and 94% RH, the heat load would be approximately 20 million kJ/hr. It will require a chiller drive of almost 2 MW. This is a major drive for the plant and a significant capital expenditure.

Table 1 gives the calculation for the heat load and chiller drive rating for this 3600 tpd Gulf Coast example. The airflow is taken as 180 000 Nm³/hr, chilled to 10°C dewpoint and reheated to 20°C drybulb.

A second consideration is the annual operating cost. This will vary depending on ambient conditions and local power cost. Using the above example, on an average day in January, the ambient temperature is 14°C at an RH of 70%. In these conditions, the chiller is barely ticking over, drawing only about 40 kW for the thermal load, compared to over 1 MW on an average day in July, when the temperatures are approximately 29°C and RH of 75%.

Looking over 12 months, the average chiller load is about 500 kW, and at a power cost of 10 c/kWh, and 8000 hr/yr, this is an annual electrical cost of US$400 000.

Table 2 gives the average chiller thermal load and power draw by month.

### 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 forced draft fan and 360 kW for the induced draft fan. An overall summary of the estimated power draw for a fluid bed cooler is detailed in Table 3.

### Progress in fertilizer cooling

As mentioned previously, the alternative to the fluid bed cooler is the indirect plate cooler system. Incorporating an indirect plate cooler system eliminates the need for a chiller unit and scrubber fans. The typical process flow of the secondary cooling in a urea granulation plant using an indirect plate cooler is shown in Figure 3. The power draws for this system are the water pump on the water module and the bucket elevator, and these draws are substantially lower than a fluid bed cooler, as shown in Table 4.

Making a comparison of the fluid bed cooler configuration in Figure 1 and the newer indirect plate cooler system configuration in Figure 3 in terms of energy consumption, it can be observed that there are substantial energy savings.
with the new configuration. Table 5 shows a comparison of the total energy costs.

**The verdict**

Indirect plate coolers have proven to be reliable and efficient for cooling fertilizers. There are now over 100 in service across the world in every type of fertilizer processing, including urea, ammonium nitrate, NPKs and phosphates. Some of these units have been in service for more than 25 years, and developments over the last few years have addressed some of the early concerns with caking. These concerns were tackled by carefully controlling the water temperature and by adding low volume dry purge air to achieve reliable operation and long run times between cleaning.

Reduced energy costs have been the primary focus of this article and the example suggests that there is significant energy, and thus operating cost, savings per year with the indirect plate cooler. A large component of the cost savings is the elimination of the air chiller. In addition to operating cost savings, three large energy drains of 180kW, 360kW, and 2000 kW are eliminated and replaced by two small pieces of equipment that total less than 50 kW in energy usage. This serves as an example of forward progress within a long-standing industry.