Dryer Islands – The heart of the Industrial Wood Pellet Plant

By Andrew Johnson, Vice President, TSI Inc.

Modern Industrial Wood Pellet Plants convert woody biomass from raw (roundwood) or waste (sawdust, chips and shavings) form into a commodity pellet product that is predictable in terms of its handling and processing properties as well as its energy density. How this transformation takes place is, on the face of it, a relatively simple, two or three step process. In its most complex iteration this three step process involves:
1) Wood Yard – (Log handling, Debarking and Chipping)
2) Drying
3) Pelletising

Sounds simple, and to some extent it is. The technology for all three steps has been around a long time and is well proven. However, experience in the last few years, especially with the new generation of large scale plants in North America, has shown that there are many technical choices and decisions to be made that directly affect the running cost, productivity and reliability of the plant. This article focuses on just one of these areas, the Dryer Island.

The Dryer Island is the most important part of the plant. The wood-yards shortfalls can always be supplemented with bought in chips or other waste streams. The pelletising operation is relatively easy to expand; the addition of one or two pellet mills is not, relatively speaking, such a big deal. However the dryer system will have a finite capacity and changing it after the event constitutes a major upheaval. Therefore, whatever design is chosen at the outset will become the main driver for the whole plant. Dryer Islands are made up of three distinct areas that have to work together as one process. These are:

a) Heat Energy System
b) Dryer
c) Emission Control System

In designing a system there is a decision matrix to go through on technology choices. The first and perhaps most important is the type of dryer. There are two types of dryer in common usage through the industry and several new or experimental techniques that operate on the fringes. For the purposes of this article we shall examine main stream choices only Conveyor Dryers and Rotary Dryers.

Conveyor Dryers [also called Belt Dryers] comprise a metal housing through which a wide conveyor passes. The conveyor is loaded with a layer of wet wood chips. Ambient air is drawn into the housing and passes through a series of heat exchangers to be heated to operating temperature. It is then drawn over and through the loaded belt where it heats/dries the wood chips before being exhausted. The belt dumps the dried chips into screws or conveyors and is then cleaned on the return leg before being loaded again. Some versions may include rotary rakes to...
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Turn the material, other versions have multiple conveyors with “waterfall” transitions to turn the material. This solution is common in Europe but less common elsewhere. It’s main benefit is that it operates at relatively low temperatures and is therefore ideally coupled with a waste heat source as can be found in district heating or power generation applications. Its disadvantage is that it is relatively expensive, takes up a lot of real estate and requires more electrical power to run. On a more controversial note these type of dryers are often promoted as requiring no additional emission control equipment. This may be true in smaller plants, but in the South East US conveyor dryers will still emit enough VOCs in a larger installation to require a mitigation strategy with the corresponding emission control equipment.

The alternative approach is Rotary Dryers. These come in a couple of different varieties but the accepted best technology is now Single Pass Recycle Dryers. These systems comprise a rotating drum that is directly connected to a heat energy source. Chips are introduced via an airlock and are tumbled through the drum as hot gasses are drawn through. The interaction of the hot gas with the wet chips dries the chips. The dried chips are evacuated via either an expansion chamber or cyclones and are then conveyed for further processing. Traditionally this approach has been seen as a much more aggressive type of drying. Temperatures are higher than Conveyor Dryers and in older iterations of the technology there was a tendency to overheat product and produce a lot of VOCs, however in recent years the technology has improved dramatically. The recycle element returns spent gas to the dryer inlet where it is used, instead of ambient air, to blend the products of combustion to the required inlet temperature. This makes the system much more energy efficient as well as reducing the oxygen level in the system and increasing the humidity. Advances in dryer flighting (baffles and flights inside the drum) have further enhanced the system to the point where a well-designed rotary drum now does a very good job of protecting the material from overheating as well as providing a good opportunity for every individual chip to absorb heat and, in the best designs, it will also classify the material giving a varied residence time depending on chip size and moisture. This results in a tight moisture tolerance at the discharge end of the system. Rotary dryers are generally more cost effective and more energy efficient when done as a stand-alone installation but when coupled to waste heat (low temperature heat energy sources) there is a tipping point where the case for Conveyor Dryers becomes better than that for Rotary Dryers.

One problem with both technologies is that there is a multiplicity of manufacturers all of whom have their own specific approach to key design elements. Some manufacturers are significantly more advanced than others and careful technical due diligence is required to fully understand the pros and cons of each system. Certain metrics such as capital or operating cost, and
energy efficiency are relatively easy to establish but more nebulous factors such as durability, reliability and quality of output as measured in moisture tolerance and retained energy can be harder to establish.

Moving on from the dryer one has to consider the heat energy source. In the case of conveyor dryers this is often a waste heat stream from another process, for instance exhaust from power generation. For rotary dryers there is often a dedicated heat energy system. For larger plants operating with round-wood a common approach is to install a bark burner. These systems have to be designed to burn the wet bark from the debarking operation. The most common approach is to have a Reciprocating Grate Furnace.

This comprises a special stepped grate where every other row slowly reciprocates back and to thus moving the pile of fuel further down the grate as the combustion process takes place. Eventually the residual ash will be dumped off the grate into an ash conveyor. The system is fully enclosed with a heavy refractory lined casing. Fuel is introduced via a “stoker” arrangement at the back of the grate. Combustion is controlled by combustion fans that force ambient air and/or recycle gasses above and below the grate (under and over-fire air). The combination of grate speed and the ratios of under and over-fire control the combustion process. The goal is to get complete combustion of all the fuel without dumping unburnt fuel off the end of the grate. It is also important that the temperature inside the Furnace is controlled to prevent slagging and the fan ratio is balanced to prevent creation of excessive fly ash. Gas characteristics are also important. The goal is to maintain an oxygen level of around 9% going into the dryer, without producing too much CO or NOx. The furnace and dryer also have to act in tandem to maintain a balance between system heat demand and dryer loading, taking into account fluctuations in moisture content. A good, integrated control system is essential to smooth interaction between these two key pieces of equipment. Finally ash mitigation is a key consideration. There are strict limits on the amount of ash that can be allowed in the finish product. The best furnaces have secondary combustion chambers for ash drop out or even high temperature cyclones between the furnace and dryer for ash removal.

An alternative to the Reciprocating Grate Furnace is the Fines Burners. These burn dried material such as wood dust in a cyclonic cloud. They can be relatively simple taking a fairly coarse fraction of wood dust or they can be more sophisticated, taking a finer fraction and employing staged combustion to limit NOx. The latter approach generally requires secondary grinders to make the finer dust. In both cases this approach is significantly less capital intensive than a step grate furnace but has the obvious disadvantage that it uses dried material that would otherwise go into the pellet and does not utilise what would otherwise be a waste stream (the bark). For operations based on sawmill residues this approach often makes sense.

Figure 3 – High efficiency cyclones

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The final consideration in a Dryer Island is the Emission Control System. There are generally two main elements to this, particulate and VOCs. All dryer systems will have some kind of emissions and what you do about them depends on local regulation, system design and species of biomass being processed. Allowable amounts of these emissions will vary by country, and, within the US, by State. It may even vary by location within State. Certainly in the US the services of an expert consultant are advisable to establish what the limits are and how they will be measured. In general terms all systems will need particulate control. In its simplest form this means cyclones. Banks of high efficiency cyclones can go a long way to meeting the regulatory requirements and for many smaller and medium sized plants may be all that is required. Much depends on the exact design of the cyclone and on the method of measurement. A step up from cyclones would mean a secondary system to catch the fine particulate that passes through the cyclones. In the past both wet scrubbers and bag-houses (filters) have been tried. The former tend to be energy intensive and not too effective, the latter are prone to plugging and even (in extreme cases) burning down. More sophisticated approaches include electronic filter beds and electrostatic precipitators (ESPs). ESPs come in both wet and dry configurations but the Wet ESPs seem to be the most popular and are certainly excellent for removing more than 90% of all particulate emissions. All Wet ESPs feature a tube bundle through which the exhaust gas is passed. High voltage electrodes inside each tube emit an electronic corona which causes the passing particulate in the gas stream to pick up free electrons and stick to the tube walls (ground). The resulting deposits are periodically flushed by water into a sump and ultimately centrifuged out and disposed of.

VOCs are, for the most part, only regulated in the US. As a rule, hardwoods do not emit enough VOCs to trigger mitigation rules.
Overall there is a lot of technology to understand and choose from, for what is essentially such a simple process – drying. A well designed system will ensure maximum uptime, productivity and quality at minimum operating cost. A badly designed system can severely disadvantage the plant and in the worst cases lead to failure of the operation as a business.

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Figure 5 – Dryer Island at night

but the primary feedstock for many industrial pellet mill producers, Southern Yellow Pine does. The generally accepted best technology for VOC mitigation is a Regenerative Thermal Oxidiser (RTO). This passes the exhaust gas through pairs of ceramic media beds that have a gas burner between them to destroy the VOCs through oxidation. The flow is reversed every few minutes enabling the media beds to alternatively capture then give up the heat generated in the process. This makes the systems 95% thermally efficient. However there is something counter intuitive about burning a fossil fuel (gas) and generating CO₂ to achieve the desired mitigation of something that most other countries don’t even worry about. Near term developments in this area are the focus of much energy at present.

Figure 6 – Inside the furnace

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