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Haynie's ONLINE KNOWLEDGE CENTER

Mark Haynie has almost 40 years experience in dryer and desiccant design for plastics and industrial applications. He has helped many processors achieve improved drying performance throughout by consulting with them and understanding their specific drying issues.

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Haynie's Dozen Drying Tips

Proper maintenance is a key to having your dryer perform to your expectations.

Also, dryers need to be equipped differently depending on the resin you are processing and the required drying temperature, high $(225^{\circ} - 300^{\circ} + F)$ or low (below225° F). Here are some factors you should consider to ensure that the dryer performance meets the requirements of the resins you are processing.

- 1 Monitor Dew Point The dew point produced by a dryer is not directly tied to the dryness of the resin, but rather the dryness of the air produced by the dryer. However, knowing the dew point can tell you that the dryer is probably operating up to its specifications. The dryer should have continuous monitoring of the dew point to help you in determining if it's fit for the job.
- 2 *Monitor Air Flow* Proper air flow is important. It is both the vehicle that provides the low dew point air for drying of the resin and it carries the heat from the process heater to the resin. The best practice is to have a continuous monitor typically a pressure drop device –which gives a warning when air flow is reduced.
- **3** *Keep Air Filters Clean* There are filters in both the process and regeneration air streams. The filters should be checked frequently (every 2 weeks) and Always have an extra set of clean filters ready for changing. It's never a convenient time to shut down the dryer to clean and change the filters but operation of the dryer

without filters, even for a short period, can allow plastic dust to get into the heater and can lead to destroying the desiccant or even a fire.

Monitor the Return Air Temperature to the Desiccant - Molecular sieve desiccant dries the process air best at low temperatures. When the temperature of the air returning to the desiccant bed exceeds 140-150° F the dryer will not achieve a -40° F/C dew point. If the return air temperature is exceeding this level, then there is too much process air or too high a processing temperature. A thermocouple or temperature indicator, at this point will let you know this. In some modern systems, this temperature is fed back into the controls so that a VFD (variable frequency drive) can change the air flow rate automatically. Maintaining a return air temperature of 140-150° F also minimizes energy usage.

Take Precautions for Low Temperature Drying - Drying temperatures lower than 160-170 F are difficult to achieve for most standard dryers. These temperatures apply to some nylons, co-polyesters, PLA and a few other resins. Although the return temperature to the dryer may only be 140-150 F, there is a temperature rise as the air passes through the blower and another rise as it goes through the desiccant. For these applications you'll need to add, typically, an extra post-dryer cooling coil in the case of desiccant drying. This is also a difficult thing for twin tower dryers to achieve. They experience a spike in temperature each time the towers switch as the partially cooled regenerated bed comes on line. Another option for these low temperature

resins is the membrane type dryer that can typically get to low temperatures without the need for water. They are limited to throughputs of about 200 lb./hr.

- Take Precautions for High Temperature Drying – When drying resins at temperatures in excess of typically 220 F, there should be a post hopper cooling coil with tower water. This may also have a water saver valve to limit the amount of cooling water used. Remember, over-cooling (below 130 F) the air in the cooling coil will require additional heating in the process air heater and additional load on the cooling water system.
- *Keep volatiles out of your desiccant* Volatiles (organics) can come off of some resins during the drying process. Resins such as PET, nylons, PBT and some others can give off significant amounts of these, over time, and they can contaminate and destroy desiccant. Even more, this contamination can lead to carbon dust and that can enter the drying hopper and contaminate the resin. All systems subject to volatiles should have a well maintained plasticizer system.

Check Moisture Level in the Resin – The moisture in the resin isn't just a function of the -40° dew point from the dryer. Best practice is to use either an on-line or off-line measurement tool to verify that the resin leaving the drying hopper meets the process requirements. Many products can have flaws from under-dried resins and some, like nylon and PBT, can become brittle if over-dried. The only true way to know if you are sending properly treated resins to the process is to measure the resin moisture.

Inspect Your Desiccant - The desiccant types that are typically used in plastics industry dryers are Molecular Sieve beads, Silica Gel beads and Pure Crystalline Molecular Sieve. The molecular beads are typically used in twin bed dryers and produce -40°dew point drying air when functioning properly. They have a base of about 30% clay so they are not as efficient as the pure crystalline desiccant and should be replaced on 2-year intervals. You can check it in the following ways – if it is discolored – replace it. If you gather a handful and squeeze it, you should feel it warming up quickly. If it does not – replace it. Silica gel does not produce -40°dew point air so it is typically used to provide a blanket of desiccated air in the tops of silos. Pure Crystalline Molecular sieve is typically used in desiccant wheel dryers. It produces consistent -40°dew point air for several years.

- Install A Return Air Hopper Screen As a minimum, there should be a screen in the return air (at the hopper) to insure that resin pellets don't leave the drying hopper.
- 1 Check for Leaks Leaks anywhere in a closed loop system are bad. Inspect the system regularly to determine if you have any issues. Leaks generally allow ambient air, with a high moisture level, to enter the "closed loop". Air leaks can lead to significantly high power bills when more moisture has to be "boiled" off of the desiccant.
- **Don't Ignore Warnings** Most dryer controls provide some kind of warning when something is going wrong in the system. Some controls give very simple warnings while others will tell the operator exactly what is going wrong and even offer instructions for a "fix". In either case, the warning is indicating that some correctional action is necessary or greater consequences are going to follow. Simply acknowledging the warning and turning it off is not the correct procedure.

Following these simple tips will help keep your production line running more smoothly, with fewer emergencies – and that increase productivity and profits.



feature

How to Get the Right Dryer for Your Process

Drying isn't something that any

processor wants to do.

A processor wants to make quality products and drying the resin is often a necessary evil to accomplish that. Drying a material correctly, requires an understanding by the dryer manufacturer of the processors requirements as well as an understanding by the processor of the dryer types and the drying system features that are offered. We will cover both sets of requirements so that the reader can get the best fit for their process and the most bang for the buck.

This article takes an in-depth look at:

- Material types
- Resin drying requirements
- Available dryer choices with drying principles
- Energy usage
- Hopper requirements

FACTORS THAT MUST CONSIDERED FOR PROPER DRYING



Polymers attract moisture from the surrounding environment. The amount of moisture that they attract is a function of the moisture in the surrounding environment. Some materials only collect surface moisture while others actually absorb water vapor inside the pellets. Resins do not all attract moisture at the same rate.

• *Hygroscopic Resins* – Materials like PET, PC, Nylons (and many others) attract moisture throughout the pellet as the moisture is attracted to the polymer molecules. These resins require some type of dryer system to remove the water within the pellets, otherwise the end product will have either structural or appearance defects.



- Non-Hygroscopic Resins In these resins (things like PP, PE, PVC and some others) the moisture does not penetrate the pellets outside surface and is only present on the surface of the pellet. If a processor is producing good parts without a high percentage of rejects, drying is not necessary. But, if the structural and dimensional requirements are stringent, either a hot air dryer or even a dehumidifying dryer may be well worth the investment. It should be noted that dryers that utilize de-humidified air remove surface moisture more thoroughly and faster than hot air dryers.
- *New Type of Non-Hygroscopic Resins* Increasingly, we are seeing non-hygroscopic

resins with additives like talc or carbon black added. These additives allow resins like PE and PP to be used for more demanding applications but they have higher moisture absorption and can lead to moisture being encapsulated in the resin pellet. The amount and type additive need to be understood and they must typically be dried with de-humidified air.

2 Material Rate in lb./hr. or kg/hr.

It is important to specify the upper and lower limits for throughput rate. The entire range needs to be considered so that the system is designed to dry the resin at the highest rate but not over-dry and possibly degrade the polymer at the minimum rate. A level control system can be incorporated in the hopper that allows the residence time to be varied. A system is also available to automatically control drying temperature or air flow rate to match the material rate. Having automatic control of at least one of these can insure proper drying without the danger of polymer degradation.

3 Material Type

The type of resin can influence the parameters for sizing the dryer.

• Amorphous Resins – Resins like PET, PLA and some co-polyesters are the primary resins that need special handling. In many cases, if the quantity of amorphous material is

over 15-20% of the total blend, it's necessary to crystallize these in an agitated hopper (known as a Crystallizer) instead of in the main drying hopper.

A crystallizer with rotating agitators prepares amorphous PET for drying. Crystallizing the amorphous resin separately allows drying in a standard hopper without having sticky material cling to the sides of the drying hopper. Crystallizing a material may take 1 hour and drying it in a separate system may take another 4-5 hours.

• Nylons and other Moisture-Sensitive Resins-Other resins, such as nylons, are very moisture sensitive. Poor part formation may result if the resin is under-dried but over-drying can produce brittle parts. In these cases, automatic control of the drying temperature, in combination with specialized moisture-control features can insure the performance characteristics of the resin are maintained without operator intervention. Managing the drying process is very important in these situations.



Drying of moisture-sensitive materials should be carefully controlled.

• *Polymers such as PBT* can be damaged by overexposure to heat. Some grades will significantly lose their properties to be molded or extruded after 8-10 hours exposure to heat.

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4 Special Considerations

There are a number of factors that can change what would be the standard recommendation for a dryer system. These special factors can significantly change the vendor's recommendations:

- Excess Surface Moisture Often, there is a spin dryer to remove the majority of surface moisture from pelletized or compounded material but the moisture can exceed the specified levels if the throughput rate is too high for the spin dryer or it is not properly maintained. In these cases, the temperature and the amount of process air needs to be higher than the standard sizing would recommend.
- Regrind Often the regrind has a lower bulk density, a higher surface area per pound and can attract higher moisture levels than the base pellets. The amount of regrind and the shape of it may change the drying system recommendation.
- Improper Storage Usually, materials, like nylon 66, come from the manufacturer with a specified range for ppm moisture but this changes quickly after the bag or bulk box is opened. After only a few hours of exposure to ambient air moisture, the moisture level in the material can be several times what was in the unopened bag and, if not sealed properly, can be 10-25 times as high in a month or so.

Air Flow Requirement

The quantity of air required for a particular drying applications is a function of the resin and the heating temperature. Non-hygroscopic resins will require less air flow than hygroscopic resins and both, very high and very low temperature drying applications, can require more air flow rate.

6 Drying Temperature –Pre-cooler/After-cooler

Almost all dryers will provide drying temperatures up to 350°F but when drying at temperatures at the higher or lower end of the range, a cooling coil is required for desiccant type dryers.

When drying resins at temperatures in excess of 220° F, a cooling coil should precede the desiccant (pre-cooler) to ensure that the temperature of the hopper return-air to the desiccant does not exceed 140-150° F because the desiccant's performance declines considerably above this range.

In cases where the drying temperature is below 160° F, an external cooling coil, after the desiccant, is a required option for most desiccant type dryers. This is because there is a temperature rise across the process blower (heat of compression) and also a temperature rise across the desiccant (heat of adsorption). This coil, with tower water, will lower the dryers exit temperature so that the process heater can control the drying temperature properly. Another option would be to use a membrane dryer, like the NovaDrier, that does not have the blowers or desiccant and can typically control temperatures as low as 120° F very well. (Maximum throughput about 200 lb./hr.)

FACTORS TO CONSIDER WHEN **CHOOSING A DRYER**

Throughput range

٠

- Consistent dew point and heating •
- Energy usag- What is the operating power at the material rate (kw/kg or kw/lb.)
- Is an economical gas-fired heater available/advisable?
- VFD (variable frequency drive) control of • regen heater/blower available to reduce energy usage?
- Ease of interfacing with control •
- Level of comfort with the drying technology
- Maintenance requirements & maintenance monitoring
- Whether the dryer meets any special re-• quirements you have
- Pre-cooler/after-cooler availability
- Plasticizer filter/collection included
- Footprint •

•

- Continued fast availability of parts •
 - Availability of well-designed hopper
 - Can your dryer supplier provide lab testing if you are processing a new material?

CONSIDER THE FULL RANGE OF DRYER **TYPES BEFORE DECIDING**

This is important because not all suppliers offer all types of dryers. If your supplier only manufactures one or two types of dryers, they will naturally try to pigeonhole you into one of those.



Dry Materi

Desiccant Wheel Dryers (Rotary Wheel) (Throughputs from <25-5,000 lb./hr.)

Desiccant wheel dryers have become the most popular dryer for many applications because of their more consistent temperature and dew point to the drying hopper. They use a "honeycomb" wheel, impregnated with a pure crystalline desiccant and there is less variation throughout the drying cycle because there is internal cooling after desiccant regeneration and bed-changeover is eliminated. This continuous process typically provides a compact unit with few moving parts and a constant source of -40° dew point drying air.

Wheel Dryer Advantages:

- More consistent drying for improved quality
- Reduced maintenance-more "up-time"
- Smaller footprint
- Reduced energy usage
- May have advanced controls for ease-of-use



2 *Twin Tower Desiccant Dryers* (Throughputs from < 5-3,800 lb./hr.)

Twin Tower (also called Dual Bed) dryers used to be the most commonly purchased type of resin dryer and there are thousands still in use today. While one bed of desiccant supplies dry process air to flow through the drying hopper, the other bed – with saturated desiccant – is regenerated, by forcing hot air through it. When the regeneration is complete, that bed becomes the one supplying the dry



Dual Bed dryers have some disadvantages:

- High energy usage
- Large footprint

•

Clay

Desiccant

Crystals

Typical Twin

Tower Dryer

- Relatively high maintenance due to number of moving parts and desiccant replacement
- Spikes and deviations in temperature and dew point during bed changeover



Desiccant beads include a clay binder that can lead to dusting, and eventual breakdown of the ability to remove moisture from the airstream.

Central Drying Systems (Throughputs from < 200 through 5,000 lb./hr.)

Central Drying Systems incorporate one or more dryers to serve as a central source of -40°dew point dry air which is piped to a number of hoppers. (See Central Drying article on page 20)





Membrane dryers, much like desiccant dryers, produce -40° low dew point air for drying – year round. The low dew point is achieved by drying high dew point compressed air with a hollow fiber membrane that separates the moisture from the airstream. These systems can provide similar economies to a desiccant dryer if equipped with the necessary flow. The membrane has an extremely long life. They

have no moving parts and are very well-fitted for smaller injection molding applications.

25 lb./hr.

Membrane dryer

Ordinary compressed air dryers do not employ a membrane. They depend on a simple expansion of standard compressed air to reduce the dew point. Typically the dew point is lowered by 40-50 degrees so they never attain the -40°dew point air required for resin drying and during hot/humid conditions, they often have to be taken offline.



As air passes through the tiny membrane openings, water vapor escapes and only dry air circulates through the material hopper.

Vacuum Dryers (Throughputs from < 30 – 1,000 lb./hr.)

Vacuum Dryers have come into the mainstream recently because of their speed in drying and low cost of operation. These batch dryers incorporate a heating position, a vacuum position and a material discharge. They use low vacuum to cause the moisture to "boil" off. The 30 lb./hr. models are also well positioned for lab applications.



30 lb./hr. Vacuum Dryer



Step 1Step 2Heats the
resin.Vacuum is ap-
plied to remov
moisture.

Step 2Step 3Vacuum is ap-
plied to removeMaterial held
for processing.

6 Hot Air Dryers (15 – 1000 cfm)

Hot air dryers were the first dryers used for drying plastics but they dry with heated ambient air so they are used only for drying the surface moisture off of non-hygroscopic materials.



Material Hopper with Heater/Blower and temperature control

process air and the first bed goes into the regeneration mode. Dual Bed dryers were typically used because they attained a -40° dew point and general-

Twin Tower Dryers have been around a very long

time but they can exhibit inconsistencies in drying

temperature and dew point as the towers switch. It

uses molecular sieves in ball form with about 30%

ly do a good job of drying most resins.

clay binder.

Infrared Dryers (Throughputs from <500-4,000 lb./hr.)

Infrared Dryers are generally used in drying PET for sheet and some fiber applications. These dryers use infrared heat to crystallize and/or dry PET. They have a higher cost than a typical desiccant dryer but can be very competitive when doing both crystallizing and primary drying. The infrared heat penetrates well to the inside of the resin flake or pellet and drives the moisture out while crystallizing the resin at the same time. These dryers can shorten the drying crystallizing process start up from 6-10 hours to one hour.

OTHER DRYING SYSTEM FACTORS TO CONSIDER

Controls

Dryer systems should have intuitive, easy-to-use controls. The dryer should need no more than a "quick start card" for normal operation. Complicated codes and look-ups should not be required. (See Controls Article page 26)

2 Energy Usage

The energy usage of various dryers varies widely, as you can see by this chart. You can minimize the ongoing cost of ownership by considering energy costs before purchasing a dryer. Depending on the dryer throughput, the operational hours/year and your cost/kwh, the additional operating cost may amount to several thousand dollars/year/dryer.

\$0.27 NovaWheel[™] with Adaptive Control For PC \$0.30 NovaWheel[™] w/o Adaptive Control Vacuum Dryer NovaDrier[™] Membrane Dual Bed Compressed Air Drver w/ membrane opt

Typical Energy Costs/100 lb. of Throughput



4,000 lb./br. Infrared Drver/ Crystallizer -Dries and crystallizes in one hour.

4 Lab Capabilities

If you have a new

about getting some test-

manufacturer. Often this

is done with no cost if the

application has special-

ized requirements.

ing done by the dryer

resin that may have

"Right-Sizing" the dryer minimizes costs

A rotary drum

infrared rays.

with a helix move

material beneath

One of the best ways to minimize the capital and utility costs in the plant is to just use a correctly sized dryer. In trying to be safe, most people end up putting a safety factor on top of a safety factor and the power used by the dryer is far above what is necessary. Consider adding a VFD (variable frequency drive) to your dryer if you are faced with this scenario. The VFD will, generally, have a payback of only months. Just be sure to discuss this with the dryer's manufacturer to insure that the flow isn't reduced so far as to cause any overheating in motors. Reducing air flow as much as 50% will be available to you without any issues. With this, you can have the dryer operate at the flow rate that's correct for the application. Some modern dryers have this "Adaptive Control" system and are able to automatically adjust for changes in material or moisture loads.



A dryer supplier should be able to provide test results for drying unusual materials.

HOPPER CONSIDERATIONS

1 Basic Design – Mass Flow

The hopper is sometimes overlooked but this is the point where all the drying happens. It's a critical point in the entire process. A well-designed hopper ensures that the air flows up through the material uniformly and the resin moves down to the hopper exit uniformly.

Bulk Density/Residence Time

The volume of the hopper is primarily based on the bulk density of the resin and the residence time (drying time) for a particular resin. In some cases different materials will be dried in the same hopper and this may include regrind. When the range of materials and throughput rates is taken into account, the hopper should be suited for having the volume to run at the maximum rate but not to damage the resin when running at the lower rates. Ignoring these factors can lead to material property degradation or changes in color.

3 Moisture Level of the Resin

The moisture level of the resin can lead to a very significant change in the residence time (drying time) required. Some nylons that can be dried (out of the bag) in 3-4 hours can take 24 hours to dry after they have reached their saturation level.

Ease of Cleaning – cross contamination and material incompatibility

There should be an access door large enough that a complete air cleaning and/or wipe down is possible. Also, unnecessary seams can result in places than cannot be adequately cleaned.



The hopper should be designed such that all seals, gaskets and materials are adequate for the widest range of its operation. This includes any vacuum receivers and take off assemblies. High temperature seals and flex hose should be used, when necessary.



Insulation – Heat Loss

In general, the hopper should be designed such that any energy introduced to the hopper stays in the hopper. No exterior surface should ever exceed 120 F.

Cone/Discharge requirements -Flow/Bridging/Regrind

There are several types of cone/ distribution systems that provide good air and material flow. Drying cannot be done in something similar to a silo or surge bin. Below is an example of an adjustable -height cone that provide good distribution.

1 Level Control

Some resins are very temperature sensitive and over exposure to heat and/or dry air can cause either resin degradation or a color shift. An elongated sight glass can be used to allow a capacitance sensor to vary the level of the resin.

Summary:

- Don't assume that all drvers are alike-they are NOT!
- Be very specific about your drying requirements-now and in the future
- Give details of any current drying problems you are experiencing
- Ask lot of questions and don't hesitate to call the manufacturer's drying expert.

The inverted cone... helps to spread heat and material to flow

evenly



Why (and What) You Need to Dry

In most plastics processing plants, resin dryers are a standard piece of equipment. The notable exception to

this would be facilities that exclusively process polyolefins such as polyethylene and polypropylene. These are among the few polymer families that do not require drying because these material families are not hygroscopic. Materials like polyethylene are non-polar, while water is a highly polar substance that acts like a small magnet with a negatively charged and a positively charged end. Water has no affinity for non-polar polymers. Exposing polyethylene or polypropylene to water is like placing oil in water. The two substances separate immediately because they have nothing in common chemically.

But almost every other commercial polymer exhibits some level of polarity and therefore is capable of absorbing a certain amount of moisture from the atmosphere. The amount of moisture that any given polymer can absorb depends upon the chemistry of the polymer and the atmospheric conditions to which it is exposed. Polymers such as blends of PPE and HIPS are only slightly polar and even at saturation can only hold 0.07% moisture. At

the other end of the spectrum is nylon, a highly polar polymer that when taken to the point of saturation can absorb 8-9% water or over 100 times as much as PPE/HIPS compounds.

However, even moisture levels of 0.07% can cause cosmetic problems on a part surface if the material is exposed to the temperatures of melt processing. The resulting defect, known as splay or silver streaking, is an indicator that the material being molded contains too much moisture. Drying is a necessary preparative step to prevent this defect.



A DSC scan of PET bottle resin reveals that it goes through a glass transition, evident as a step transition in the thermogram, at around 70-75 C. At this point it will soften. When it reaches a temperature of about 110 C the polymer begins to crystallize. At 245 C these newly formed crystals melt. If the amorphous form of PET were heated from room temperature to the required drying temperature, it would agglomerate into one large mass and would then crystallize in that same large mass. To prevent this, PET must be constantly agitated while it is heated through its glass-transition temperature and its solid-state recrystallization. PLA exhibits similar behavior.

While many materials are dried solely to optimize surface appearance, some polymers undergo more significant changes if they are processed in the presence of too much moisture. These materials actually enter into a chemical reaction with the moisture—called hydrolysis. This mechanism breaks the covalent bonds in the polymer chain,

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reducing the molecular weight of the polymer and potentially resulting in a significant reduction in mechanical properties.

Table 1 classifies polymers according to their behavior in relation to water. Hydrophobic materials cannot absorb any significant amount of moisture. Any moisture that could be present in these materials will remain on the surface of the pellets and seldom rises to a level greater than 0.01%, not enough to cause any cosmetic or structural problems.

On rare occasions there are reports of cosmetic defects in parts molded in polyethylene or polypropylene that are traced to excess surface moisture deposited due to rapid changes in the temperature and humidity of the plant. But these are usually easily rectified by simply allowing the raw material to come to equilibrium with the surrounding atmosphere so that the surface moisture can evaporate.

Hygroscopic materials break out into two subsets. One group experiences only cosmetic problems if not properly dried. Members of the other group suffer irreversible structural damage due to hydrolysis. Table 1 does not present an exhaustive list, but it includes many of the commonly used polymer families. It is also important to emphasize that blends need to be treated with the care required of the most sensitive polymer in the blend.

For example, a polycarbonate/ABS blend needs to be treated with the same care as polycarbonate. Sometimes seemingly subtle changes in formulation can change the importance of drying requirements. For example, it is generally considered unnecessary to dry acetyls (POM); however drying is recommended for impact-modified POM because the impact modifier is typically polyurethane, which is subject to hydrolysis.

There are other important differences between the hygroscopic materials that exhibit only cosmetic defects and those that can degrade. With the exception of nylon, all the materials in the column with performance concerns must be dried to lower moisture contents than those materials with only cosmetic concerns.

TABLE 1 Polymers' Interaction with Moisture				
Hydrophobic	Hydroscopic Cosmetic Concerns	Hydroscopic Performance Concerns		
Polyethylene	ABS	PET Polyester		
Polypropylene	SAN	Polycarbonate		
Polystyrene	Acrylic	Nylon		
Butadiene– Styrene Copolymer	PPE/HIPS	PBT Polyester		
Polymethylpen- tene	PPS POM PVC	Polyurethane Polylactic Acid (PLA) Polyimides (PEI, PAI)		

Most of the polymers in the "Cosmetic Concerns" column can be successfully processed at moisture contents of 0.05-0.10%. However, the majority of the materials in the "Performance Concerns" column should not be processed at moisture levels higher than 0.02% and some of these materials achieve optimum properties when dried to levels as low as 0.005%. The optimum moisture level depends not only on the polymer but also on other processing parameters such as melt temperature and residence time in the molten state.

The type of process may also have an influence: Profile extrusion, for example, may require a lower moisture content than injection molding. Secondary operations such as plating or ultrasonic welding may also dictate a need for tighter control of the material's moisture content.

Proper drying requires attention to detail in the following areas: temperature and moisture content (dew point) of the inlet air, volumetric flow rate of the air across the pellets, time the material is in the drying hopper, and temperature of the return air coming back from the hopper to the drying unit. There are other areas of concern related to the design and maintenance of the system. This also assumes that a desiccant dryer is being used.

There are other methods, like vacuum and compressed-air drying. Other technologies such as infrared and radio frequency have been explored, but most commercial systems today still utilize some variant of desiccant technology. However, many systems still use hot air without the aid of a desiccant. While these systems are less complex, they lack the ability to consistently provide dry air to the material in the hopper.

Most material suppliers make specific recommendations for drying times, temperatures, and the dew point of the air being supplied to the drying hopper. Commonly recommended dew points fall between -20 and -40 F. These levels can be achieved only by passing the inlet air over or through a drying medium (desiccant or membrane filter). Otherwise, the dew point of the air will be whatever it is in the plant. On winter days in cold climates this number might be as low as 0 F, but on hot, humid days it can rise to 70-80 F.

At these conditions it is not possible to bring the moisture content of a raw material down to the levels required for the "Performance Concerns" group in Table 1, regardless of how long the drying process may be. It should be understood that much of the plastics material processed in Asia is not dried in desiccant systems and a significant amount of that material falls into the "Performance Concerns" category.

The conditions for effective drying are dictated to a significant extent by the polymer being processed. An elevated drying temperature is desirable since it increases the rate of moisture removal. However, the drying temperature must remain below the softening or melting point of the material. This is more likely to be a problem in amorphous materials, where the recommended inlet air temperature may be reasonably close to the softening point, or glass transition temperature, of the material.

Table 2 compares recommended drying temperatures with the softening or melting points of some commonly used polymers. It can be seen that for amorphous materials like ABS, polycarbonate, and acrylic, the difference between the drying tempera-

TABLE 2 Comparizon of Drying & Softening/ Melting Temperatures				
Polymer	Drying Temp., F	Softening Temp., F		
ABS, SAN, ASA	170-180	200-220		
Acrylic	170-180	200-220		
Polycarbonate	250	290		
Polyetherimide	300	410		
PBT Polyester	250	420		
Nylon	180	320-600		
PPS	300	530		

ture and softening temperature is relatively small. Anyone who has spent time in a molding plant has likely experienced the unpleasant consequences of a temperature override in a dryer when working with these materials.

The rules become a little more complex for polymer families where softening temperatures vary as a function of composition. One example is PPE/HIPS alloys. Grades with a high polystyrene content may have softening temperatures as low as 190-200 F and must be handled more carefully than high-PPE grades where the softening point may be as high as 330-340 F. Similarly, elastomers such as TPUs will exhibit a range of softening temperatures related to the Shore hardness of the grades.

PET, PLA: SPECIAL STEP REQUIRED

There are two materials in Table 1 where special steps are required during the drying process. These are PET polyester and PLA biopolymer (also a polyester). These materials go through a change from amorphous to semi-crystalline before ultimately melting. Figure 1 shows a DSC (differential scanning calorimetry) scan for the PET used to make beverage bottles. It goes through a glass transition, which appears as a step transition in the thermogram, at approximately 70-75 C (160-170 F). At this point it will soften.

However, when it reaches a temperature of about 110 C (230 F) the polymer begins to crystallize. If the sample could be viewed during this process you

would see the material turn from transparent to cloudy and then opaque. This process is complete by the time the temperature reaches 140-150 C (285-300 F) depending upon the grade of material.

Finally, at a temperature of 245 C (473 F) these newly formed crystals melt. PET requires a drying temperature range of 135-165 C (275-330 F) and I have seen temperatures as high as 180 C (356 F) utilized in an effort to optimize performance. If the amorphous form of PET were heated from room temperature to the required drying temperature, it would agglomerate into one large mass and would then crystallize in that same large mass at temperatures high enough to ensure effective moisture removal.

To prevent this, PET must be constantly agitated while it is heated through its glass transition temperature and its solid-state recrystallization so that it can then be heated to the appropriate drying temperatures without agglomeration. PLA exhibits essentially the same behavior, although the specific key temperatures are somewhat lower than they are for PET. And the stakes are very high for both polymers. Moisture levels as low as 50 ppm may be required in order to successfully process the material into product that has the desired properties.

This brings us to discussion of the real object of resin drying: moisture removal. There are a lot of parameters in the drying process that are monitored, but the actual moisture content of the dried resin entering downstream processing is really the only thing that matters. Many material suppliers provide guidelines for the moisture content that their resins must have to ensure good property retention. The problem for the industry is that very few processors measure moisture content.

A majority of processors simply follow drying guidelines or their best interpretation of them and assume that this is sufficient. Many processors incorrectly believe that if a material is processed with excessive moisture the parts will exhibit cosmetic defects.

A small percentage of processors employ a device that measures moisture content as a loss in total weight of a sample heated to a particular temperature for a prescribed time period. Unfortunately, these instruments measure all of the volatiles that evolve from the sample. They cannot distinguish between moisture and all of the other volatile constituents that may be in the material. A much smaller group of processors use an instrument that is sensor based and therefore is moisture specific. This is an appropriate strategy and results in processes that are much more reliable and less likely to produce parts with reduced mechanical performance.

But the best approach involves making accurate moisture measurements in the drying hopper. This has become possible within the last two to three years using measurements of dielectric properties in real time. There is a well-defined relationship between the moisture content of a polymer sample and these dielectric properties. This bypasses the need for off-line measurements conducted in the laboratory and allows for continuous real-time documentation of the only parameter that matters. In addition, the monitor can be interfaced with the dryer controls to regulate the drying conditions. This potentially saves energy and can prevent oxidation of the polymer and corresponding damage to the additives.

We can hope that this is the new face of resin drying. Whle no systematic studies have been performed to assess the lost time and money associated with substandard drying practices, it would be reasonable to estimate that it totals in the billions of dollars annually worldwide.

Improvement begins with an awareness of the shortcomings of current methods and practices. Once they are understood, greater knowledge of the myths and science associated with resin drying can be gained and many of the product failures that are experienced every year can become a thing of the past.

ABOUT THE AUTHOR

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Press-Side vs. Central Drying

How To Select whether Press-Side or Central Drying Works Best for Your Processing Location.

There are, of course, reasons why press-side dryers may be best for some processors but more and more are converting to central systems because their production requirements have changed over the years. Once they make that change, they will never go back because the economic advantages of a central system are very favorable to most processors profit margins.

Let's examine:

- Reasons for maintaining a press-side arrangement
- Reasons for considering a Central Drying System
- Economic benefits of a Central Drying System

Press-side or press-mounted dryers are commonplace where processors have fewer than 10 process machines and have low throughputs on those machines (under 25 lb./hr.). It also helps if the processor is running the same material on the same machine day-after-day, making very few material changes. This requires that there be a vacuum loader at each machine and a source of material (usually a bulk box or drum of resin). Processors learn to live with fork lifts delivering material to the presses. Note that if access is ever required to the machine throat, the dryer and loader have to be removed, then re-mounted. Still, this arrangement seems to work for this group of processors.







The interim move to a Central System for most processors is to introduce multiple portable dry/ convey units. These dryers are usually mounted on a cart with a drying hopper, a loader or receiver to supply resin to the drying hopper and a machine-mount loader or receiver to deliver material to the machine throat. The throughputs range up to about 200 lb./hr. The bulk boxes and forklifts are still present - clogging up the production area. If multiple material changes are required, processors often have extra dry/convey units in an area off the production floor that can be wheeled into place beside the process machine. This adds to the confusion on the production floor and the whole process often results in material being left in the bulk bins and or contaminated and simply wasted.

Yet another scenario occurs when a processor needs higher throughputs than 200 lb./hr. and larger stationary dryers are introduced to the production floor – taking up even more floor space. Or, worse yet, they will be mounted on racks above process machines. In these cases, routine maintenance will probably not be performed – ultimately resulting in excessive rejected parts and higher energy bills.

It should be noted that even when you are drying the same material in different dryers (even of the same model) you may experience variation in the levels of drying. Differences in the age of the desiccant, heaters, blowers or even condition of the filters may cause this.

WHAT IS CENTRAL DRYING?

Central Drying allows one dryer to provide -40°dew point air to multiple material hoppers of different sizes. An adjustable heater and blower are mounted on each hopper so the heat and air flow can be adjusted to the material in that hopper. So you have custom drying of multiple materials from a single central dryer. That is sized to match the requirements of that bank of hoppers. Central Dryers are available with throughputs from <200 lb./hr. through 5,000 lb./hr. so a wide range of processor needs can be easily met. Processors often have more than one central dryer – each serving a bank of hoppers with a back-up central dryer for times when a dryer may be taken offline for maintenance.

YOU ARE A GOOD CANDIDATE FOR CENTRAL DRYING/CONVEYING IF...

- You have dryers on 10 or more machines
 You have a single material that reauires
 - You have a single material that requires drying at multiple machines
- You have frequent material changes on your machines
- You use more material types than you have machines
- You have dryer to dryer quality issues when drying the same material
- You want to expand, but do not have sufficient space
- You need flexibility to serve the needs of your customers
- You have a Just-in-Time objective to reduce inventory
- You need to reduce operating costs

.

You want to improve safety for your workers



Compact Drying, Blending and Conveying area

WHAT ARE THE BENEFITS OF CENTRAL DRYING?

We will discuss specific savings but here is an overview of benefits:

- Space savings
- Fewer materials handlers
- Energy savings (Rebates often available)
- Increased machine uptime (no waiting for material to pre-dry)
- Material control reduces waste (small inventory to clean)
- Improved product quality (drying consistency through your plant)
- Fast payback of investment (because there are multiple sources for savings)



Unclog your production floor

NOTE: These figures were not picked out of the air! They are based on typical results of before and after plant surveys of processors who moved from press-side drying to a Central Drying/Conveying System.

Based on 12 machines -

Average throughput 200 pph - Dry	ing Nylon/ABS/P	C
Example:	Press-Side	Central Dry/Con-
Energy Costs:		
Press-Side-\$.10/kwh x 11 kw x 8,000 hr./yr. x 12 dryers	\$108,000	
Central -\$ 10.kwh x 51 kw x 8,000 hr./yr. x 1 dryer @		\$41,000
Material Changes: Press-side dryers require 30 minutes to 4 or 5	hours for material cha	ingeover.
Press Side-Based on 2 hr. average x 3 changes/machine/week	\$180,000	
Central-Based on .25 hr. average x 3 changes/machine/week x		\$22,500
Labor:		
Central Conveying typically eliminates at least one	\$ 30,000	
material handler/12 machines.		\$0.00
	\$318,000/yr.	\$63,500/yr.
Central Drying/Conveying Savings: <u>\$254,</u>	<u> 500 /Year</u> – EVER	
24 Machine plant: \$509,000 Savings/Year! • 36 Mac	chine plant: \$763,0	00 Savings/Year!

ADDITIONAL SAVINGS NOT CALCULATED:

- Maintenance on 12 dryers vs. 1 Central Dryer
- Brush changes & filter cleaning for 12 loaders vs. just filter cleaning for 12 vacuum receivers
- Energy usage for 12 dryers and 12 loaders vs. 1 dryer and 1 vacuum pump
- Loss of material due to bulk box movement, material contamination and poorly made parts

On this point, let's assume that 10 lb. of material is lost per bulk box and that is not unusual...

Yearly Costs:	
Yearly Costs:	Press-Side Cost/Year
12 Press-Side Dryers – 3 changes/wk./press	
12 x 3 @86 x 10 lb. X 50wks 18,000 lb. /yr. ABS - 18,000 x \$0.74/lb.@	\$13,320
PC Injection, General Purpose - 18,000 x \$1.90/lb. @@	\$34,200
PC – Flame Retardant – 18,000 x \$2.42/lb.	\$43,560

And how about the wrong material being processed? Has that happened at your plant?

Add: Cleanup, disposal and lost machine time and you can easily triple these costs.

LET'S TALK ABOUT SPACE!

Typically, a processor using press-side dryers has to allow and extra 75 sq.ft. per process machine for a dryer, hopper and bulk box. Now add the space required for a fork lift to maneuver in, haul the old bulk box away and replaced it with a new one...suddenly, you are up to about 120 sq. ft.! Multiply that by the number of presses you have and you will see how many additional presses you can fit into that space – that, after all, is supposed to be your manufacturing area – where profits are made.

CENTRAL CONVEYING -ADDS BENEFITS TO CENTRAL DRYING!

Reduced Material Costs - Central conveying may allow you the option of buying materials in bulk for silo storage with a "free" silo from your material supplier or you may be able to increase your purchases to a point where it is advantageous to use bulk bins for storage instead of those pecky bulk boxes. But, even if you have to continue with bulk boxes, for some reason, they can at least be stored in a designated area where one person is responsible for ensuring that the material remaining in the liners is emptied into the new container and they are properly covered to prevent contamination.

Quick and Correct Material Changes - Central conveying is the reason that material changes can be reduced to about 15 minutes and with Auto ID validation of materials, you can be sure that the right material will always go to the correct machine.



Auto ID validation eliminates molding the wrong material

Safety – Reduced material spillage means safer conditions on the production floor.

A Central Drying/Conveying System can pull materials from a combination of silos, bulk bins and bulk boxes to drying hoppers, or blenders or a combination of those.







Central Drying/Conveying improves process flow and reduces costs.

Need Help Making a Decision About Converting to a Central System?

Ask for a plant survey to determine whether, and how much, you can save on energy costs, wasted materials, reduced rejects, labor, maintenance and increased up-time. The usual payback time is 12-18 months so the sooner you act, the sooner you start saving.



What's New in Dryer Controls?

Today, controls can be a real differentiator when it comes to selecting a dryer. It's almost hard to believe that some processors are still buying dryers with controls that were developed in the 80's.

	WELCOME				
	NovaWheel [™] Model # NW-50				
	LANGUAGE	U	NITS OF MEASURE	-	NUMBER OF HOPPERS
	ENGLISH 🔵		ENGLISH 🔵		ONE O
					тwo 🍥
				IN	IITIAL SETUP
A se	welcome scre etup procedure	een es.	walks you the	roi	ugh initial

	INSTALLATION CHECKLIST	Level3	3
\bigcirc	IS THERMOCOUPLE INSERTED IN EACH HOPPER	?	
\bigcirc	WATER LINES CONNECTED AND TURNED ON FO HIGH HEAT DRYING?	R	
\bigcirc	ARE ALL AIR AND MATERIAL LINES TIGHTLY CONNECTED ?		
\bigcirc	ARE ALL FILTERS INSTALLED CORRECTLY ?		
\bigcirc	IS EXTERNAL COOLING COIL INSTALLED FOR DRYING UNDER 170		
¢			
4			

An installation check list is provided as a reminder of setup steps. Touch screen PLC's are prevalent today and it's no wonder why. Depending on the dryer model, they offer:

- Quick start-up instructions
- Recommend a maintenance schedule based on the material being processed
- Store drying recipes for 20, or so materials
- Automatically optimize drying and energy savings
- Provide instructions on solving an alarm condition
- Transmit operational data via Ethernet to Smart phones and computers
- Trending records for up to 14 dryer parameters

...and new Central Drying Controls allow remote drying hopper operating conditions to be changed from a central location.

Color, high resolution touch screen PLC controls are readily available today, and often as standards – not high cost options.

NORMAL OVOLATILES DUSTY O CUSTOM SCHEDULE DOWN INTERVAL			
CHECK HOSES AND HOSE CONNECTIONS	DAYS	WEEKS	MONTHS
CHECK DRYER/HOPPER GASKETS 3	DAYS	WEEKS	MONTHS
UUBRICATE WHEEL DRIVE 12	DAYS	WEEKS	MONTHS
		.[

maintenance schedule will be displayed.





Choose a pre-programmed material or enter your own resin and drying temperature.

They allow dryer manufacturers to provide unparalled Conveniences to processors.

Though it is not shown, this dryer also has phase detection and if the wiring is incorrect, an alarm will advise that it be corrected.

A single screen shows the material being processed, dew point, drying temperature and return air temperature. Note that this control also includes OverDry protection to ensure that moisture-sensitive resins do not get over-dried.



All drying parameters are available at a glance.



This dryer control specifies the cause for the alarm, it tells you possible sources of the problem and shows a pictorial guide which shows how to perform a test.

Drying Done Right

ADAPTIVE CONTROL AND REGENERATION OPTIMIZATION

It seems there are no limits to the creativeness of control designers. Adaptive Control and Regeneration Optimization automatically adjusts air inlet temperatures, blower speed and wheel speed, based on hopper return air temperature, saving energy, ensuring process stability and consistent drying.



* Hopper temperature sensors are for monitoring/trending purposes only and do not control the drying process

- 1 The IntelliPET Adaptive Control system monitors hopper return air temperature to optimize air temperature in the upper portion of the hopper through heater and blower speed adjustments, to reduce energy consumption. Patent # 6,951,065,B2
- 2 Within the dryer, the air is filtered and then enters a blower.
- ³ The air is cooled before passing through the desiccant wheel and subsequently re-heated before entering the bottom of the hopper.
- 4 Air flow and inlet air temperature are constantly monitored and controlled through the Adaptive Control and Regen¬eration Optimization Control using the feedback from the hopper return air temperature.

5 Regeneration Optimization use a variable frequency drive to control blower and desiccant wheel speed. (Patent # 5,688,305)

6 Guaranteed constant temperature of material exiting the hopper.

CENTRAL DRYING CONTROLS

It used to be that drying controls only controlled dryer functions but the latest central Dryer Controls do much more.

This OptiFlex[™] control from NOVATEC shows all the drying hoppers in the bank that the Central Dryer is supplying with low dew point dry air. An authorized operator can choose any hopper in the bank and see a display of what material is in the hopper and the values of all the drying parameters. Changes can even be made from this central control.



Prophecy is the Next Big Thing...

Just announced—Prophecy Sensorlytics[™] has licensed NOVATEC for predictive maintenance analytics so that processors can avoid "run to failure" mode and anticipate issues before they occur. Make sure you see the demonstration at NPE 2015 Booth W3742.





Maximizing Efficiency of PET Resin Dryers

The key to drying PET efficiently is to minimize heat and airflow while meeting moisture and IV requirements...automatically.

Processors are not inclined to put an operational dryer on the trash heap in order to get a new, energy-efficient model. On the other hand, when a new line is being added or when an old dryer just becomes too costly to maintain, smart processors will seek out the type of dryer that will meet their processing requirements...and reduce their ever-rising energy costs as much as possible. This makes good sense in the long term as well as the short term because the initial cost of an energy efficient dryer can often be greatly reduced through energy credits or rebates from federal, state or local power companies.

The performance of any drying system is based on using the minimum heat to raise the temperature to the appropriate drying temperature while maintaining a constant material temperature at the throat of the injection molding machine or extruder. Also the regeneration system should minimize the energy used to heat the desiccant material while dedicating most of the energy to removing the moisture gained during the drying process.

The heat used in the dryer is governed by the equation:

- $Q = mCp\Delta T$
- *Q* = Heat required to raise the temperature of the resin.
- *m* = Mass rate of the medium to be heated. In the case of dryers, it's the flow rate of the air.
- *Cp* = A constant specific heat.
- ΔT = The temperature rise of the air.



The parameters that need to be minimized, to reduce energy usage, are the air flow rate and the temperature rise. All of the other of the components in the equation are constants.

When this is applied to air at near atmospheric pressure, the air can be simplified to:

 $Q(kW) = 0.0003228 * scfm * \Delta T$

- The heat (Q) is shown as kilowatts of power used.
- *scfm* is the air flow rate being heated in SCFM (standard ft3/minute).
- ΔT is the temperature rise of the heating air.

When processing PET, approximately 60-65% of the energy required, is used for process heating to raise the temperature of the resin and remove the moisture. About 30-35% of the power is used in regeneration of the desiccant and only 5-10% is used for operation of the blowers. A good dryer energy management system controls all of these and does it automatically.

If the air flow rate and temperature rise are minimized, the process heating energy can be as low as necessary to heat the resin. NOVATEC provides a patented system (Patent #6,951,065 B2) to minimize the air required so that the minimum energy is used for process heating. This patent allows the temperature of the resin is raised to the appropriate temperature for the operation of the process machine but all of the energy remains in the resin, in the drying hopper and a minimum of the generated heat is returned to the dryer.

To accomplish this, the temperature of the resin and the temperature leaving the drying hopper are measured and the air flow rate is adjusted so that the return air temperature (the temperature returning to the dryer from the drying hopper) is only slightly higher than the temperature of the resin entering the drying hopper. This process is controlled by varying the speed of the blower with a Variable Frequency Drive (VFD) that changes the speed of the blower and thus the flow rate of the air. By minimizing the air flow rate, while maintaining the temperature of the resin, the process heat is maintained at the lowest possible level. We refer to this as *ADAPTIVE CONTROL* in that the power



Figure 1 - Chart shows the energy savings created by holding the return air temperature constant - when operating at less than maximum throughput capacity.

adapts to any changes in material rate, resin moisture and temperature of the resin. The result is shown in Figure 1.

Adaptive Control provides considerable benefit over uncontrolled process heating. In dryers without Adaptive Control, the temperature of the return air from the hopper rises if the material throughput rate is less than the design rate for the dryer or if the resin moisture is lowered or the resin inlet temperature increase.

By measuring the return air temperature and holding it at the incoming resin temperature, Adaptive Control ensures that the energy used can raise the resin temperature to the appropriate level for processing, vaporize all moisture retained in the resin and adjust for variations in resin temperature (whether due to ambient changes or source).

Adaptive control, ADAPTS, to all of these contingencies and provides the same energy consumption, in kW/kg regardless of processing changes and is does this automatically without any action by the processor.

The other important feature of Adaptive Control is that, with a lower return air temperature from the hopper, there is no need for the use of cooling water during normal processing. A cooling coil is provided for start-up but an automatic water saver valve ensures that little to no cooling water is used. This limits the load that the dryer system puts on the processors' cooling water system and also limits the ΔT temperature rise required to raise the air temperature to the required temperature for proper resin heating.

This combination of features ensures proper and consistent resin temperature at the throat of the processing machine, minimal process heat requirements and consistently low resin moisture levels. Adaptive Control is a true energy saving feature.

Adaptive Control contrasts greatly with dryer features like Temperature Setback or Second Set Point – sometimes sold as energy-saving features. Temperature Setback, is often touted as an energy-saving feature but it is not.

Drying Done Right

Temperature Setback lowers the process temperature and thus the resin temperature entering the processing equipment. The result is that the processing machine must make up for the lower heat in the resin by increasing the heat from shear and the band heaters. The processing machine ends up using more energy to overcome the shortcomings of the dryer, resulting in no energy savings, and contributing to product inconsistency.

It's worth repeating that <u>Adaptive Control main-</u> tains the required temperature at the throat of the processing machine.

The other way to reduce dryer energy is to minimize the power used in regeneration of the desiccant. Regeneration can account for as much as 35% of the total power usage. Regeneration consists of heating the desiccant to a temperature at which it releases the moisture gained during the resin drying process. This involves raising the temperature of the desiccant to a point where the moisture retained in the desiccant is "boiled off".

NOVATEC minimizes the power used in regeneration with a system called **REGENERATION OPTIMIZATION**. This patented feature is described in Patent # 5,688,305. There are two parts to this system and each has a specific task. First, the speed (RPM) of the desiccant wheel is minimized which reduces pounds per minute of desiccant media to be heated. This is important because heating of the desiccant media detracts from the primary goal of vaporizing moisture and heat is lost without accomplishing the primary goal of water removal. The wheel speed is controlled by a variable frequency drive (VFD) to no more than that required to adsorb the moisture from the return air. This control is shown in Figure 2.

By controlling the speed of the wheel, the desiccant media is loaded to its maximum while maintaining a consistent dew point of less than - 40° F/C.

The second part of the Regeneration Optimization feature (Figure 3.) is the use of a VFD on the regeneration air blower. The VFD minimizes the air flow to a point that water is desorbed from the molecular sieve but only minimal heat leaves the wheel during the regeneration process.

As the ambient air is heated and passes through the wheel, the discharge temperature is constantly monitored and the VFD adjusts the air flow ensuring that minimal air flow is used to remove all of the moisture gained in drying but no excess air is used.



Figure 2 – The first task of Regeneration Optimization uses control of wheel speed to minimize heat loss.



Figure 3 – The second task of Regeneration Optimization uses control of blower speed to minimize heat loss.



Figure 4 and 5 – Highly efficient pure crystalline desiccant is used in the construction of the desiccant wheel as opposed to desiccant beads with 30% clay filler in dual bed dryers.

The temperature of the air exiting the top of the wheel is just enough to remove the moisture and carry it away but is kept to a constant temperature. This ensures that the wheel will remove all of the moisture from the resin regardless of the resin moisture level and will automatically adjust as the moisture changes due to seasonal variations or changes in the virgin/flake ratios.

This combination of ADAPTIVE CONTROL and REGENERATION OPTIMIZATION are standard in all IntelliPET[™] PowerGuard[™] models.



The basic construction of the desiccant wheel also contributes to energy saving because it requires less energy for regeneration than desiccant beads which are typically used in dual bed dryers. The molecular sieve wheel is nearly 100% active molecular sieve (zeolite). In contrast, desiccant beads can contain as much as 30% inactive clay binder, which requires heating along with the active portion, but provides no moisture removal capabilities. The clay binder is also the primary reason for desiccant breakdown and increased maintenance.

As shown in the illustration (Figures 4 & 5), the pure zeolite crystals are grown in a corrugated form in such a way as to provide a very high capacity for moisture and but relatively low regeneration temperatures of about 300-350°F.

All of the Optimization features of IntelliPET dryers are controlled automatically and trending screens are provided for tracking purposes. The trending information can exported through Ethernet. (See Figure 6)

- Trending data displayed include:
- Hopper Temperatures
- Regeneration Temperatures and Dew Points
- Regeneration and Process Air Rates
- Heater Set Points and Temperatures
- Dryer Temperatures and Set Points (See Figure 7)

The combination of patented energy-saving features described in this article is provided on the IntelliPET series dryers for PET processors only by NOVATEC. The result is process consistency – with none of the power surges and dew point variation associated with the regeneration process in dual bed dryers. Energy savings are unparalleled with total energy usage is as low as 60-70 watts/kg. Both of these factors are increasingly important to PET processors who w ant to remain viable in this competitive market.







feature

Energy Saving Installation

Energy costs are one of the few

things you can control.

You can exert some control over those monthly energy cost whether you continue to use existing dryers or you are planning to replace existing dryers.

Let's examine your existing dryers and hoppers first: Maintenance, maintenance, maintenance!



Clogged filters increase energy consumption

Differential pressure switches can warn of filter clogging

Process & Regeneration Filters - Do you realize how much dirty process and regen filters can reduce the efficiency of your dryers? Would you believe a 30-40% reduction in efficiency? That means you are using a lot much more energy to dry your materials or – your percentage of rejected product is increasing. Most older dryers do not provide an alarm when filters are clogged so it is imperative that a regular cleaning schedule be established and followed by production personnel. The schedule should be based on the dustiness of the material being processed and operators should be required to sign a checklist (like you see in restrooms) when they

perform the cleaning. You should also keep replacement filters in stock for each dryer. Newer dryers use pressure drop indication to alarm when filters need attention.

Plasticizer Filter and Drain – It is equally important that plasticizer filters be cleaned on a regular basis and excess plasticizer be drained to ensure that contaminants do not get into your desiccant – which will cause it to lose effectiveness and require early replacement.

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Drain plasticizer and wash filter regularly

Check and Replace Desiccant – Poorly performing desiccant can also increase energy usage because it does not absorb moisture as readily as it should nor does it regenerate as quickly so process times



increase – using more energy or poor product is produced which also represents wasted energy. A good sign of ineffective desiccant is when the dryer is not consistently producing -40°D dew point process air. One of the easiest ways to check desiccant is visually. If it is discolored – replace it. Also, grab a handful of desiccant of cool desiccant and squeeze it...you should feel it warm up quickly – without crumbling.

- Hose and Hose Connections Every few months, all hose clamps should be checked for tightness and all hose should be examined for holes and cuts in and around the dryer and at the hopper. Air leaking from these points represents energy flying off into the air.
- *Hose Insulation* Be sure that all hoses that carry hot air are well wrapped with insulation. Note that the process return air hose from the hopper to the dryer should not be insulated.
- If the dryer is not attaining the proper process and regeneration temperatures, it could be a sign that a heater needs to be replaced. Any delay, means that poor parts are probably being produced.

Every poor part that is produced represents wasted energy, labor and higher material cost.

Now let's look at energy considerations for new dryers and hoppers:

First and foremost, when replacing an old dryer, talk to suppliers who offer more than one or two types of dryers. If all they have to sell are Type 1 and Type 2 Dryers, they will try to pigeonhole you into one of those. Today, you have many choices and you can find the type best-suited for each application you have.

Drving Done Right

Just like energy usage has been reduced for home appliances and automobiles, energy usage has been reduced for newer types of dryers while older dryer types have lagged in energy-saving features.

Dryers:

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- Compare energy usage for the typed of dryers that meet your processing requirements. Any manufacturer you talk to should be able to show you the kw/lb. or kw/kg of material processed so you can relate that to your cost/kw in your area.
- Ask whether the dryer control includes any special energy-saving features – see article on Dryer Controls.
- Make sure that high temperature hose or ducting is well-insulated.
- Ask whether the dryer you are considering qualifies for an energy-savings credit. Hoppers:
 - A minimum of 2" of insulation should be sandwiched between the walls of the hopper cone, hopper door and hopper sides, but not in the section where the return air exits the hopper. You want relatively low-temperature air to be returning.

Hopper insulation should extend from bottom of cone to just below process return

outlet.

Placement of Process Heater: This depends largely on the size of the dryer.

- For smaller dryers, the process heater is usually in the dryer when the hopper is very nearby.
- For larger systems, where the hopper is several feet from the dryer, the process heater should be mounted on the hopper to minimize heat loss.

Trouble Shooting Guide for Twin and Multi-Bed (Carousel) Dryers

The twin tower is a desiccant dryer. Typically Molecular Sieve. It uses a beaded sieve desiccant. These were the first type of drying developed using a desiccant media. It uses the sieve in a "batch" process with one tower drying and at least one regenerating. These dryer, by alternating beds, experience varying dew points and temperatures, throughout the cycle. Typically the best dew point is towards the beginning of the "on-stream" time.

THE DRYER WILL NOT START

- a. *Power issues* Is there power getting to the dryer and the dryer controls? This could be because the dryer main circuit breaker or disconnect are not turned on. Check to see if the dryer has the proper power and voltage. If the dryer is getting power but the controls are not, check the control transformers secondary fuse.
- b. *Alarm Faults* Did the dryer shut sown in an alarm condition? Dryers have safety features that insure they don't start until there is a corrective action for major faults.
- c. *Phase issues* Is the dryer seeing power on all phases? Is there correct rotation on the blowers? Was there a blower fault such as pulling too many amps?

THE HEATER WILL NOT START

- a. *Safety Interlocks* Most process heaters, have an interlock to ensure that the heater does not come on if the process blower is not running.
- b. *Blower rotation* The heater may not start in the event of incorrect blower rotation.
- c. *Flow Switch* There may be a flow switch so that the heater doesn't come on if the air flow is low enough that there could be an overheat condition. This could be caused by dirty filters or clogged lines with fines or volatiles.

THE DRYER IS NOT MAKING THE CORRECT DEW POINT

- a. *Valve Cross Leakage* Should the seals in the 4-way valve leak, there could be leaks in the valves used to direct the flow. In order to see if this is an issue, turn off the regeneration blower and heater and operate the process air blower. If there is air coming out through the regeneration inlet or outlet, the primary reason is that there is valve leakage.
- b. *Return Air Temperature* Most dryers need no more than a 140 F return temperature to the desiccant so that it operates properly. If the return temperature is too high, it can be difficult to make a -40 dew point. It may be necessary to use cooling water at the return air cooling coil.
- c. *Dew Point Sensor* Generally the dew point sensor needs to be replaced yearly. Ensure it's in proper working order
- d. *Desiccant condition* Is there any dust or volatile contamination of the desiccant? If so, replace it. The beads should be a light cream colored.
- e. High return dew point to the desiccant

 There are limits to how much moisture the desiccant can adsorb. If there is excessive moisture coming from the resin (i.e. surface moisture or from excessive hydration) the desiccant may not be able to achieve the required dew point performance.
- f. Insufficient regeneration heat or flow Check your regeneration filters and the regeneration inlet and discharge temperature. If the filters are dirty, replace them? If the inlet temperature is below that specified by the manufacturer, check to see if the heating element is operating properly. If the regeneration exhaust is less than 300 F, the air flow may be insufficient or the resin moisture may be beyond the dryers design limits. The typical regeneration temperature, to the desiccant, should be 550-625 F.

MATERIAL IN THE HOPPER ISN'T DRYING PROPERLY

- a. *Dirty filters* If the air flow is reduced, the resin may not dry properly.
- b. *Valve cross leakage* If the valves have developed a leak path, there will be less are going to the drying hopper and drying performance will not be efficient.
- c. Hopper Residence Time Is the hopper sized properly? Different resins require different drying times. Not all resins can be dried in 2-4 hours. This is especially true for resins with a low drying temperature or soft resins that can stick together if the drying temperature is elevated.
- d. *Leaks in the System* The hopper and the conveying system need to be isolated from ambient and each other. Any leaks that can cause the dry air to leave the system should be eliminated. This is also true of hoses and ducting.
- e. *Incorrect drying temperatures* Try to follow the manufacturer's recommendations. For instance, not all grades of the same resin class should be dried at the same temperature. (i.e. not all nylon 66's are the same) Also, are all of the elements in the process heater working? At times, this can lead to lower than designed drying temperatures.
- f. *Hopper Level* Is the hopper level being controlled at too low a level for the residence time necessary?
- g. *Dew Point Performance* There must be a driving force for the resin's moisture to leave it for the air stream. Is the dryer operating at it should per the previous section? Dew points higher than -40 can indicate that the dryer isn't performing to specifications.
- h. *Tower Reversal Time* The typical dryer will switch beds ever 3-4 hours. If the time is longer, you will generally see that the dew point performance has suffered and the drying performance with it. Determine if the dryer holds dew point at -40 or less through the cycle.

MATERIAL MELTS OR BECOMES VERY "TACKY" IN THE HOPPER/ DOES NOT DISCHARGE PROPERLY

- a. *Process Drying Temperature* Has the manufacturer's recommended drying temperature been exceeded? Most dryers have minimum temperatures that the can operate. Part of this is because there is a temperature rise across the process blower (heat of compression) and another rise across the desiccant (heat of adsorption). You may need cooling water prior to the desiccant and/or following it to achieve the manufacturer's recommended temperature. This is a typical occurrence with copolyesters and bio-resins.
- b. Drying Temperature is exceeded during tower change – Twin tower dryer are not typically fully cooled prior to tower change. Because of this, the heat remaining in the desiccant can enter the drying hopper at tower change. If you notice that there is an elevated temperature, at bed change, consider using cooler water in the after-cooler or adding a pre-cooler.
- c. Low Air Flow Low air flow could lead to less cooling and higher discharge temperatures. Check your filters and consider adding a flow switch alarm if it wasn't provided with the dryer.
- d. *Resin type* Some resin types, like elastomers, have issues with bridging. Tall hoppers can lead to high pressure on the resin at the bottom of the hoppers, and compression that leads to bridging. Soft resins may require special hopper designs, or agitation, that limit this issue.

Many dryers today give you recommendations for solving issues. Please note the alarms given by the dryers and correct any issues. For further information, check the instruction manual or discuss the problem with the vendor's service department expert.

Trouble Shooting Guide for Wheel Dryers

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The wheel dryer is a desiccant dryer. These are the most predominant dryers in service today. It uses a continuously turning wheel of desiccant that generally provides a very consistent dew point and temperature to the process. However, there are some things you need to know to address issues that you may see.

THE DRYER WILL NOT START

- a. *Power issues* Is there power getting to the dryer and the dryer controls? This could be because the dryer main circuit breaker or disconnect are not turned on. Check to see if the dryer has the proper power and voltage. If the dryer is getting power but the controls are not, check the control transformers secondary fuse.
- b. *Alarm Faults* Did the dryer shut sown in an alarm condition? Dryers have safety features that insure they don't start until there is a corrective action for major faults.
- c. *Phase issues* Is the dryer seeing power on all phases? Is there correct rotation on the blowers? Was there a blower fault such as pulling too many amps?

THE HEATER WILL NOT START

- a. *Safety Interlocks* Most process heaters, have an interlock to ensure that the heater does not come on if the process blower is not running
- b. *Blower rotation* The heater may not start in the event of incorrect blower rotation.
- *Flow Switch* There may be a flow switch so that the heater doesn't come on if the air flow is low enough that there could be an overheat condition. This could be caused by dirty filters or clogged lines with fines or volatiles.

THE DRYER IS NOT MAKING THE CORRECT DEW POINT

- a. **Return Air Temperature** Most dryers need no more than a 140 F return temperature to the desiccant so that it operates properly. If the return temperature is too high, it can be difficult to make a -40 dew point. It may be necessary to use cooling water at the return air cooling coil.
- b. *Dew Point Sensor* Generally the dew point sensor needs to be replaced yearly. Ensure it's in proper working order
 - **Desiccant condition** Is there any dust or volatile contamination of the desiccant? If so, replace it.
 - High return dew point to the desiccant
 There are limits to how much moisture the desiccant can adsorb. If there is excessive moisture coming from the resin (i.e. surface moisture or from excessive hydration) the desiccant may not be able to achieve the required dew point performance.
 - Insufficient regeneration heat or flow
 Check your regeneration filters and the regeneration inlet and discharge temperature. If the filters are dirty, replace them? If the inlet temperature is below that specified by the manufacturer, check to see if the heating element is operating properly. If the regeneration exhaust is less than 212 F, the air flow may be insufficient or the resin moisture may be beyond the dryers design limits.

MATERIAL IN THE HOPPER ISN'T DRYING PROPERLY

- a. *Dirty filters* If the air flow is reduced, the resin may not dry properly.
- b. *Hopper Residence Time* Is the hopper sized properly? Different resins require different drying times. Not all resins can be dried in 2-4 hours. This is especially true for resins with a low drying temperature or soft resins that can stick together if the drying temperature is elevated.
- c. Leaks in the System The hopper and the conveying system need to be isolated from ambient and each other. Any leaks that can cause the dry air to leave the system should be eliminated. This is also true of hoses and ducting.
- d. *Incorrect drying temperatures* Try to follow the manufacturer's recommendations. For instance, not all grades of the same resin class should be dried at the same temperature. (i.e. not all nylon 66's are the same) Also, are all of the elements in the process heater working? At times, this can lead to lower than designed drying temperatures.
- e. *Hopper Level* Is the hopper level being controlled at too low a level for the residence time necessary?
- f. Dew Point Performance There must be a driving force for the resin's moisture to leave it for the air stream. Is the dryer operating at it should per the previous section? Dew points higher than -40 can indicate that the dryer isn't performing to specifications.
 - Wheel Speed Is the wheel rotating at the manufacturer's specified speed?

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MATERIAL MELTS OR BECOMES VERY "TACKY" IN THE HOPPER/ DOES NOT DISCHARGE PROPERLY

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- *Process Drying Temperature* Has the manufacturer's recommended drying temperature been exceeded? Most dryers have minimum temperatures that the can operate. Part of this is because there is a temperature rise across the process blower (heat of compression) and another rise across the desiccant (heat of adsorption). You may need cooling water prior to the desiccant and/ or following it to achieve the manufacturer's recommended temperature. This is a typical occurrence with copolyesters and bio-resins.
- Wheel Speed Generally high wheel speeds lead to higher discharge temperatures. This is because the time in the cooling section is reduced. Discuss changing the wheel speed with the dryer's manufacturer.
- *Low Air Flow* Low air flow could lead to less cooling and higher discharge temperatures. Check your filters and consider adding a flow switch alarm if it wasn't provided with the dryer.
- d. **Resin type** Some resin types, like elastomers, have issues with bridging. Tall hoppers can lead to high pressure on the resin at the bottom of the hoppers, and compression that leads to bridging. Soft resins may require special hopper designs, or agitation, that limit this issue.

Many dryers today give you recommendations for solving issues. Please note the alarms given by the dryers and correct any issues. For further information, check the instruction manual or discuss the problem with the vendor's service department expert.

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