AIMCAL – Fall Technical Conference

The Role Atmospheric Conditions Have on Your Dryer

Have you ever noticed that your production speeds change in the summer versus the winter? Do you run differently on a rainy day? Just what effect do the outside atmospheric conditions play in production? This paper will go into more detail of the issues that result when atmospheric conditions change, as well as ways to avoid or minimize reductions in production speeds. This will include computer modeling to help resolve these issues or minimize production losses for new projects as well as existing dryers and ovens.

If you run a coating operation in the north or the southeast, it's likely that your production speeds vary depending on the time of the year. The reason for this is that the cold air in the winter has much lower absolute humidity, enabling you to run higher production speeds. If you've ever forgotten to turn on the fan while taking a shower, you realize just how difficult it can be to dry off. The same holds true when humidity levels get too high inside a dryer. There simply isn't enough capacity for the absorption of additional water vapor in comparison to the volume of air in the drying loop. To illustrate this, let's take a quick look at what happens in the drying process.

Drying occurs with the mass transfer or vaporization of the solvent (water, etc) at the surface of the coating. Forced air impingement breaks down the thermal surface boundary layer, allowing more effective heat transfer to the product.

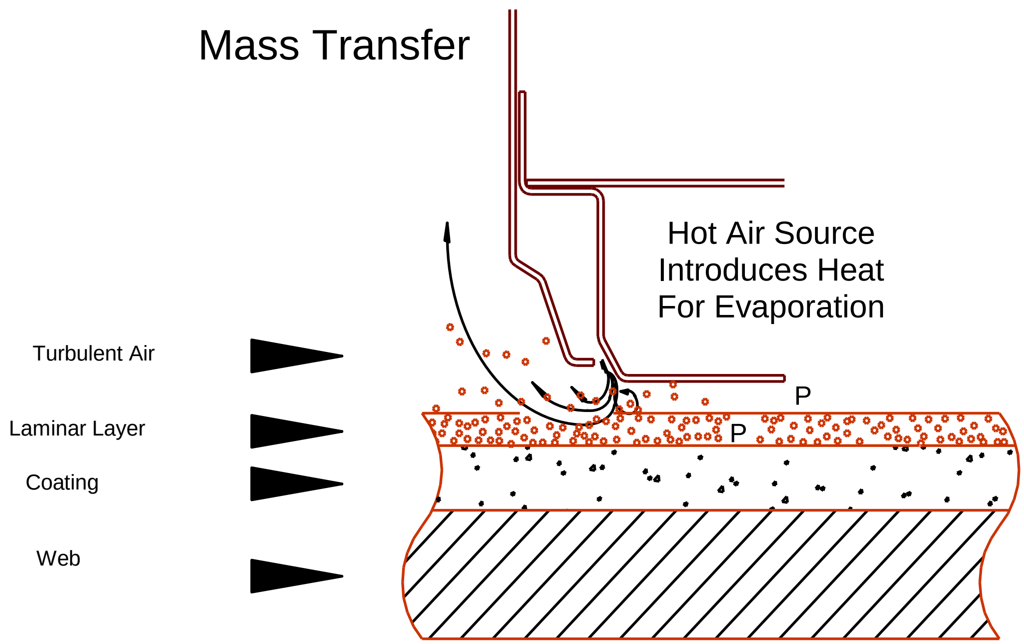

Figure – 1

Additionally, the heat transfer enhances mass transfer by creating a greater partial pressure gradient between the coating liquid and the vapor in the air.

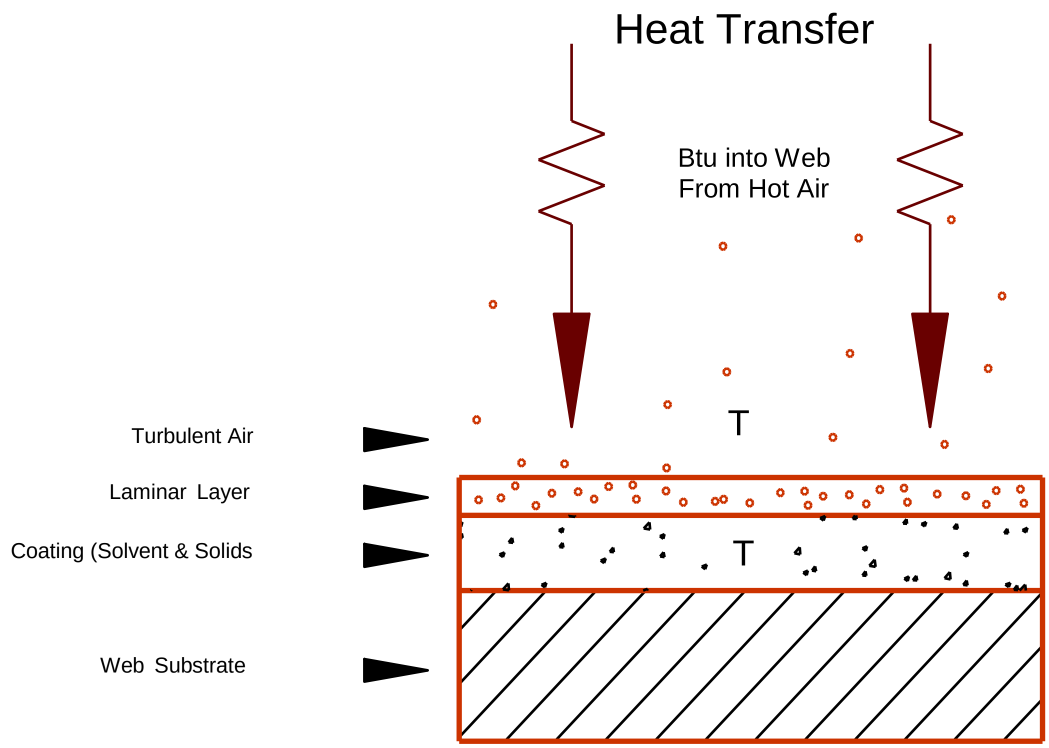

Figure – 2

The drying process, while not overly complicated, does call for a delicate balance of air movement and handling. In addition to the supply air, the air that contacts the surface of the web, there are other aspects that must be taken into consideration. You must also consider the amount of air that will be exhausted in the process, how much will be recirculated, how much new “make up air” (MUA) is going to be required, and how much air will be coming in through the web slots, or the ends of the dryer.

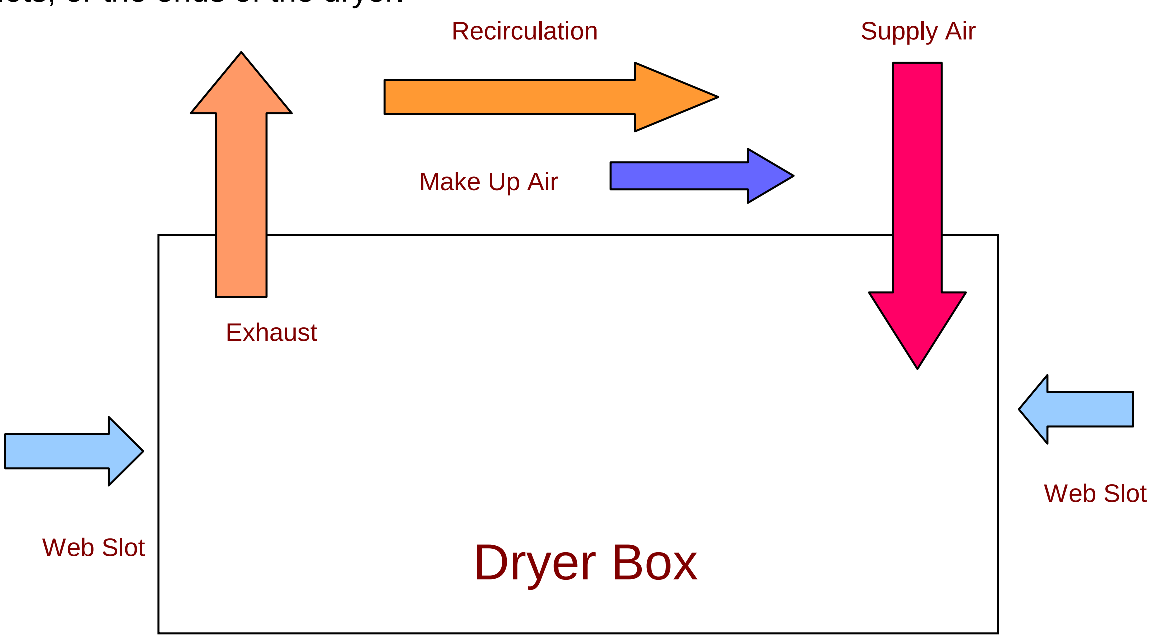

Figure – 3

While there are many factors that can affect drying, some of the most important are: temperature of the supply air, the nozzle velocity of the air impinging on the web's surface, the total air volume being supplied in the process, the exhaust rate and, obviously, humidity.

Initial Product

Let's look at how humidity affects drying in the following examples.

Substrate: 120 pound paper	*Dry Coat Weight: 0.5 mil*
% Coating Solids: 40	*Solvent: Water*
Web Width: 60"	*Dryer: Two Zone (20'/zone), Flotation*

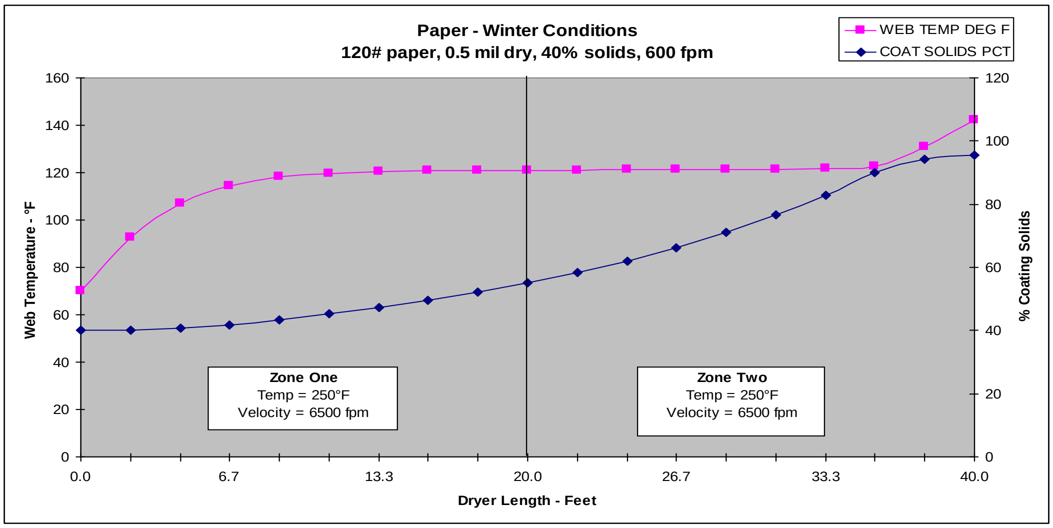

Figure – 4

By considering typical winter conditions, we can run this product at a speed of 600 fpm, attaining a dryness level of over 95%. However, this same product, run under summer humidity conditions, the speed drops to 525 fpm, a reduction of over 10%.

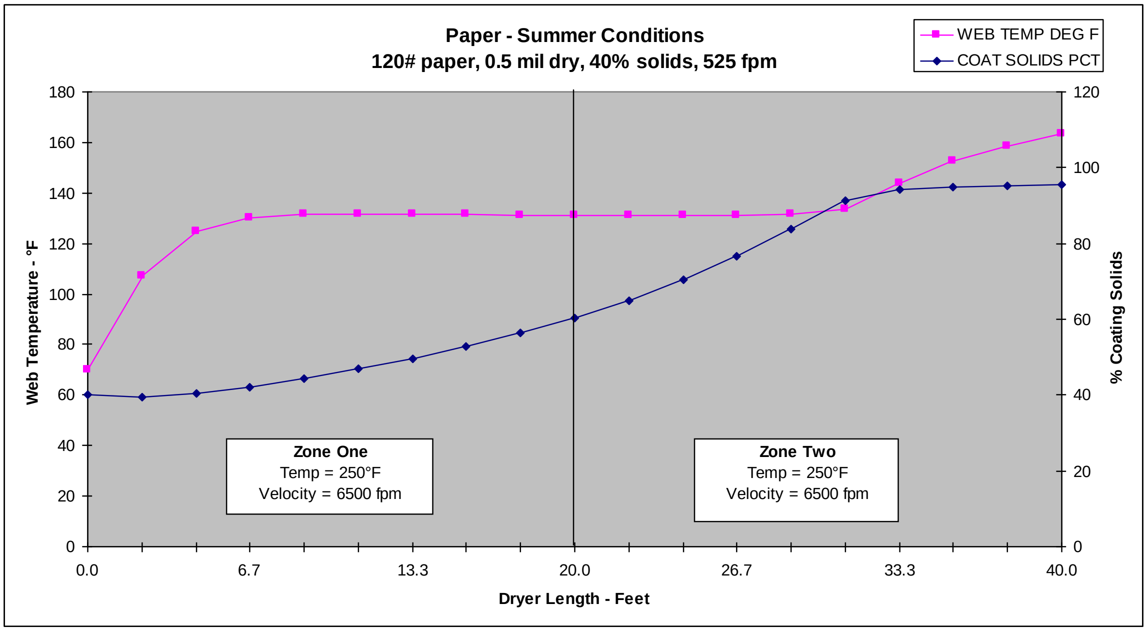

Figure – 5

For the winter conditions, we assumed a make up air temperature of 35°F with an absolute humidity of 0.003 pounds of water per pound of dry air. In the summer, this changes to a make up air temperature of 95°F and an absolute humidity of 0.030 pounds of water per pound of dry air. When air is heated and the amount of humidity remains the same, the ability of the air to absorb water vapor increases dramatically.

The chart below (Figure-6) illustrates the difference between 100% relative humidity (dew point) and 50% relative humidity in terms of water vapor capacity. As the temperature increases, the amount of water the air can hold increases exponentially.

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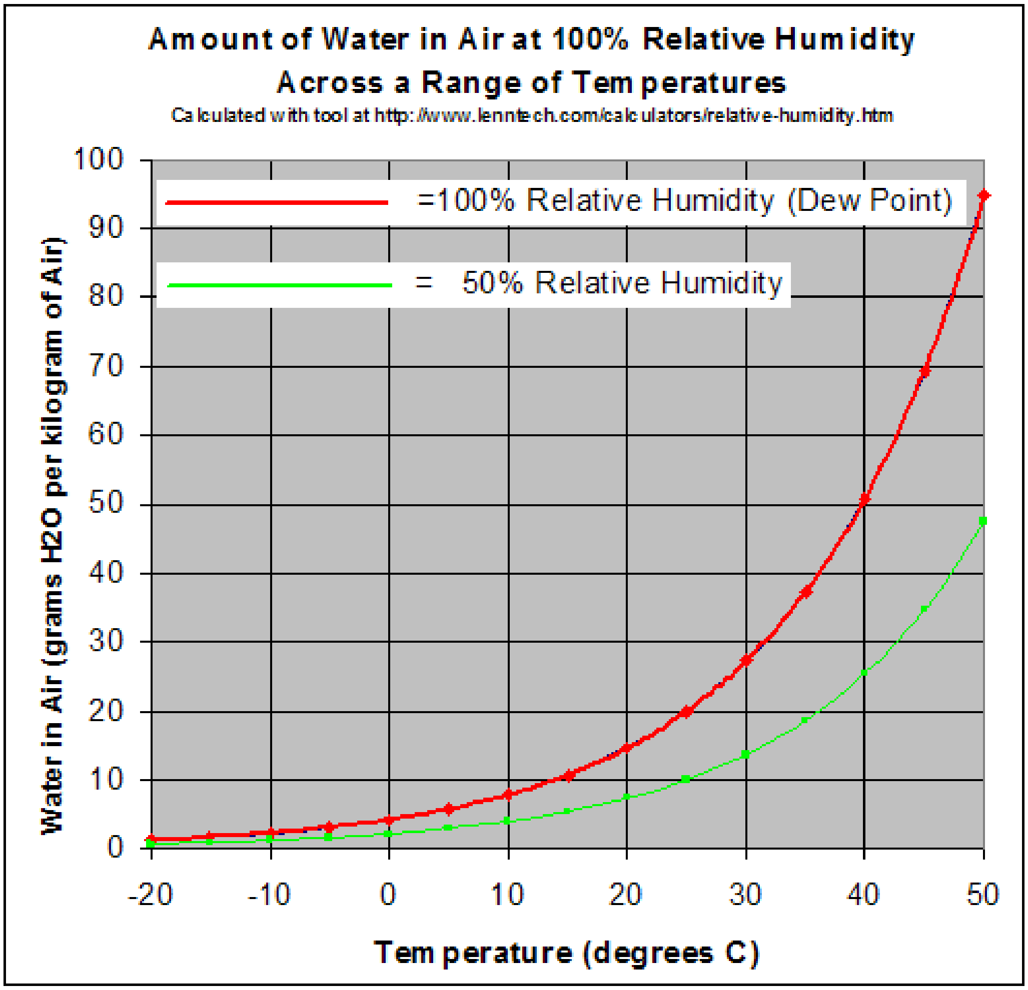


Figure – 6

Increasing the supply air temperature will increase the drying rate and is able to offset any increase in the humidity levels.

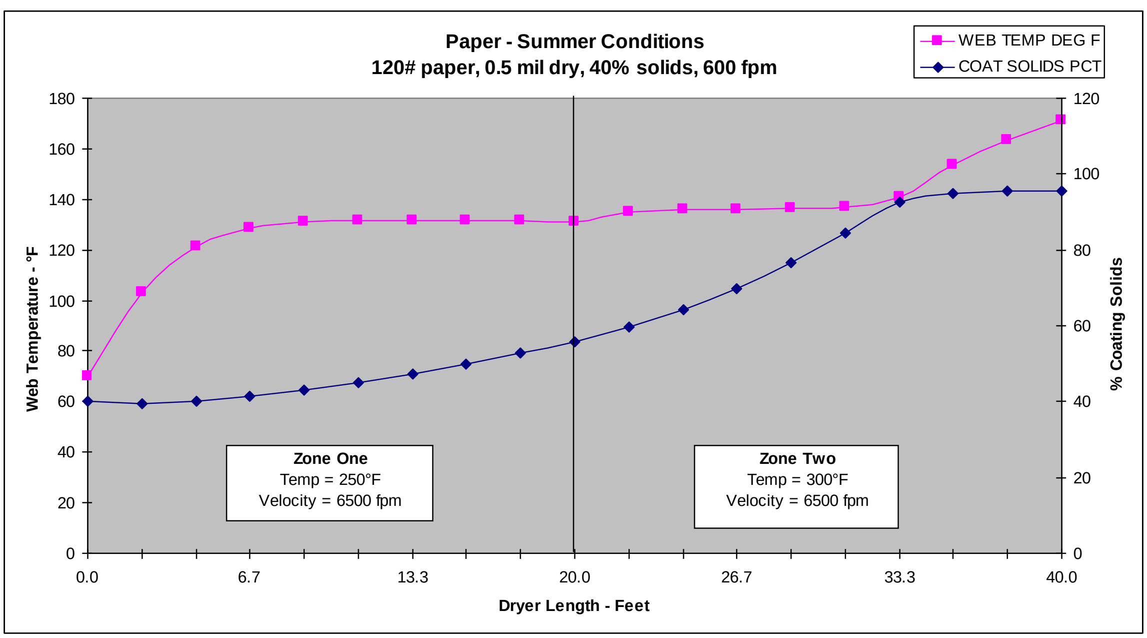


Figure – 7

By increasing the temperature in the second zone, we were able to achieve the same 600 fpm production speed as was indicated in the winter run.

Temperature Sensitive Products

What if your product or coating has a temperature limitation? If your process cannot handle high temperatures or an elevated evaporation rate, simply increasing the supply temperature is not possible. .

Substrate: 0.5 mil PE *Dry Coat Weight: 0.5 mil*
% Coating Solids: 40 *Solvent: Water*
Web Width: 60" *Dryer: Two Zone (20'/zone), Flotation*

With this substrate, we typically limit the web temperature to 160°F, so we are somewhat limited on the supply temperatures that we can use. Using the same make up air temperature and humidity conditions that were used before with the paper substrate, we have similar results – a higher production speed in the winter. The winter result is 375 fpm, while in the summer, using identical temperature and velocity numbers, the production speed drops to 300 fpm, a 20% reduction.

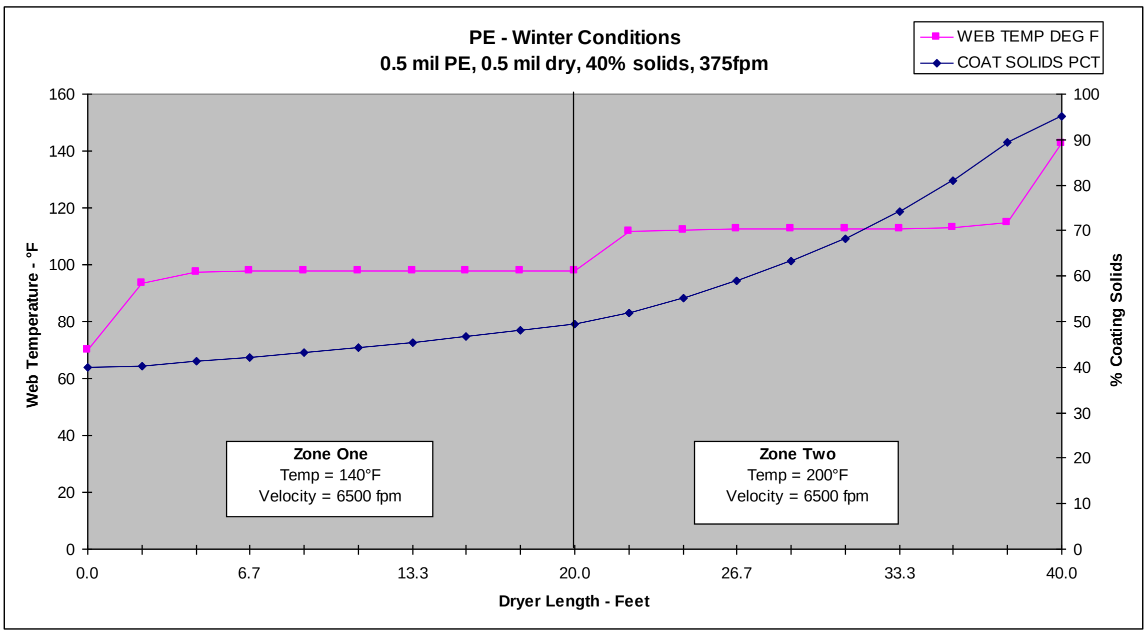
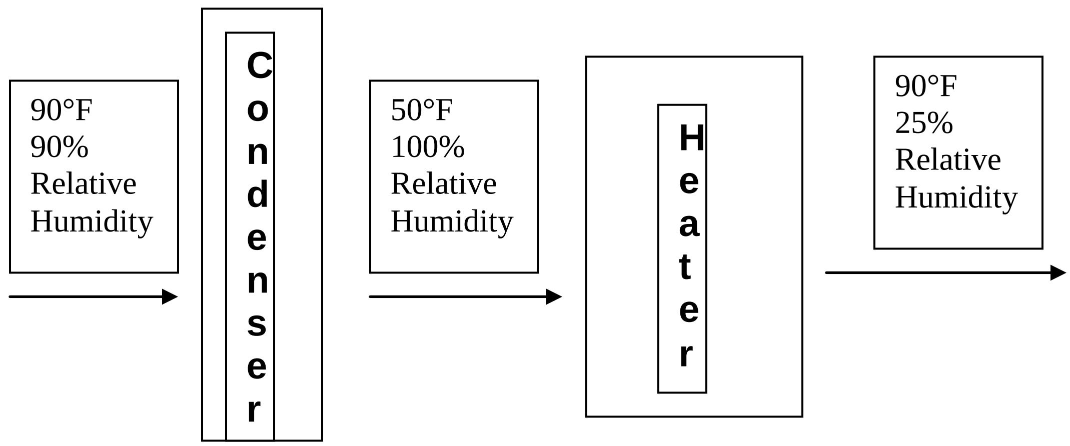


Figure – 8

You can achieve a better result by dehumidifying the make up air. One way to achieve this is by taking make up air from an air conditioned room that is temperature and humidity controlled year round. This may be standard operating procedures for some more sensitive products – medical, optically clear, clean room applications, etc.

However, many existing applications don't have that luxury, and are relegated to taking the make up air from outside the building. This make up air can be conditioned by running it past a simple cooling and heating system prior to exposing it to the main heat source.

For example purposes, let's consider an outside temperature of 90°F with a relative humidity of 90%. Passing this by a chiller will enable you to significantly reduce the humidity level of the air stream. By reducing the temperature to 50°, then passing it through a reheat coil, you will now have very dry (25% RH) make up air.



Since the make up air is now less humid, its drying capacity is much greater.

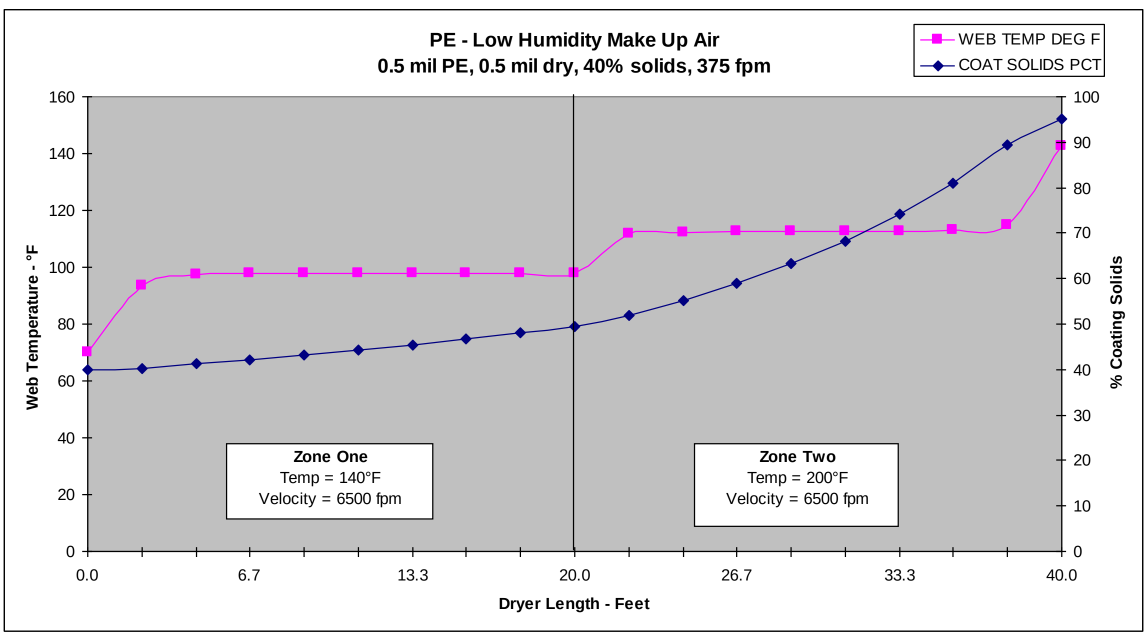


Figure – 9

In this example, we have changed the make up air humidity to make it more similar to the winter condition, in terms of the amount of water vapor in the air.

Increase Exhaust

A third way to enhance drying is through the increase of exhaust volume. If we refer back to Figure-3, the air flow schematic, you will note that the exhaust plays a critical role in the drying process.

If you were to exhaust 100%, you would maintain a very low humidity level inside the dryer, but your operational costs from constantly heating up the new make up air would be quite high. On the other hand, if you don't have a sufficient exhaust, you will eventually have so much humidity in the dryer that nothing will dry. This is where the balance of air flows becomes important.

By increasing the exhaust rates in each of the zones, we can maintain the same temperature, and handle the high humidity of the summer. In this example, the exhaust rates are approximately 74% and 84%, but the result is the same 375 fpm production speed.

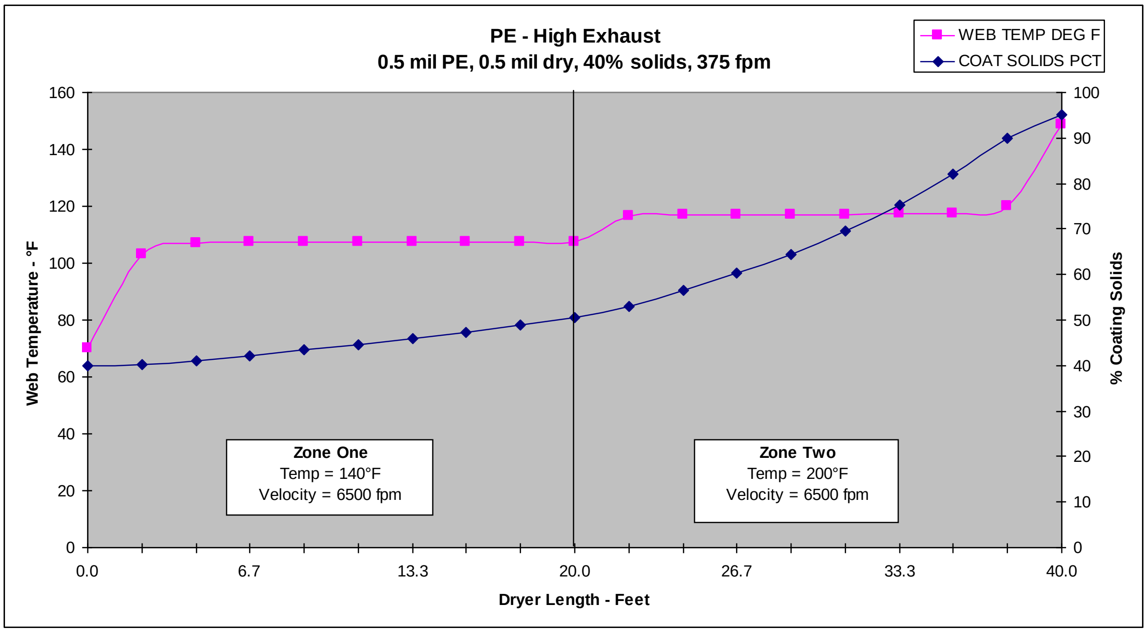


Figure – 10

Conclusion:

This paper looked at three possible ways to increase your production speeds.

1. Increasing the Supply Air Temperature
2. Reducing the MUA humidity
3. Increasing the Exhaust Rate

The simplest and most effective method would be to increase the temperature of the supply air, as increased heat has the most significant effect on the drying of the web. However, you need to make sure that you have sufficient capacity in your existing burners. If not, you may consider upsizing the burners to achieve the higher temperatures. In addition, verify that the plenum is sized correctly for the increased flame length and that the fans are capable of handling these temperatures.

The reduction of the MUA humidity can be as “simple” as taking the air from a climate controlled environment inside the facility, or you could run it through the condenser/reheat loop as indicated above. This will likely add a sizeable load to the existing HVAC system.

Finally, if you plan to increase the exhaust volume, you will need to ensure that you have enough burner capacity to handle the increased load that it will see since it will have to heat up that much more make up air in the process. Depending on your control scheme and age of your dryer, you may have to consider automating dampers and adding VFD’s. You would then be able to control to a box pressure setting and be able to hold this depending on how you were running the dryer that day.

If you are unsure of the capabilities of the existing equipment, most dryer OEMs or consultants offer engineering studies to evaluate the dryer and can make recommendations in regards to what your possibilities are with the current set up, and your future production goals.

If you are putting in a new coating line, this is the time to consider the seasonal changes and what impact they may have on your productivity. This may mean a longer dryer, or the ability to increase your temperature settings as you are making product. This may also force you to look into your crystal ball to see what products (substrates and coatings) may be coming down the road in the future, or where your industry may be headed. You may have to balance several of these alternatives in order to make your process fit your production needs.

In the end, the production gains made by making these changes will come down to the economics. Does the increase in operational, and potential capital, costs justify the increase in productivity?