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FLUID PROCESS CONTROL SYSTEMS

Controlling Orange Peel

BALANCING THE FACTORS WORKING AGAINST YOUR FINISH

If you are like the majority of the companies… supplying painted parts for an industry where finish is critical (for example, the automotive industry) you are making thin margins, breaking even or possibly losing money because you have come to accept certain cost variables as "uncontrollable." Once you decide that the status quo is unacceptable, you'll need to consider what variables you're controlling and how best to manage them.

In this guide we'll look at one of the most common, and most costly issues: **Orange Peel.**

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WHAT IS ORANGE PEEL?

The interesting thing about paint defects is that their names are exactly what you see! A "run" or a "sag" describes well what you see when you look at the defect. "Off-color" is exactly what the name implies…

So, it is no surprise that, "Orange Peel" refers to texture in the painted surface similar to that of an actual orange peel. Though there can be many root causes, Orange Peel is the result of a process in which the paint does not "flow out" properly across the surface of the part in either the application or curing stage.

Factors Contributing to Orange Peel Levels in the Final Product

- **Paint Formulation**
- **Solvent Blend & Content**
- **Application Parameters (and the resulting film)**
- **Part Orientation and Geometry**
- **Booth Conditions**
- **Flash and Cure cycles**

Make no mistake. Orange Peel is expensive. It leads to additional inspection time and rework, throwing off your schedule and hurting your bottom line. As a result, manufacturers suffering from this problem endure the cost of product rejects and often face displacement as a supplier. Today, survival requires finding, and addressing, the source of the problem.

MEASURING ORANGE PEEL

Originally, orange peel was evaluated by comparing the finish to a visual standard. The most commonly used was made by ACT. This set of 10 panels allowed the finish to be graded in 10 steps and was as accurate as the operator and lighting allowed.

But process analysis requires a more reliable number – a more objective number – one that's not dependent on an operator, or ambient lighting, or…

Enter the BYK Wavescan…

This handheld device uses laser light to measure the variations in the surface finish, breaking them down into multiple components. These components are combined into metrics that can be used to objectively define the quality of the surface finish. They include:

- **Short wave**
- **Long wave**
- **DOI (Distinctness of Image)**

Though not the only option available, it is considered the "gold standard" in the industry.

A COMMON STORY

Let's say that you are having problems with the quality of your finish. You are experiencing Orange Peel, and your customers are not happy. Like any good problem solving engineer, you begin to review the variables in the process that could have the largest impact on finish quality, and specifically Orange Peel.

You find that your paint manufacturer is able to produce consistent batches of paint. Spray equipment and robot programs are accurate and repeatable. There is nothing unusual in either your part geometry or part orientation. The parts themselves are consistent and your booth conditions are tightly controlled.

The one thing you probably haven't considered is the temperature of your paint.

So why is that important?

THE FACTORS THAT AFFECT ORANGE PEEL

In order of importance, the three biggest factors determining the consistency of the finish are:

1. Film Build
2. Coating Viscosity
3. Atomization

Most finishers we have worked with do an adequate job controlling #1 and #3. And that makes sense. Film build determines the amount of coating used to cover a part and is the predominant cost in the finishing process. The need to carefully control this variable is obvious. Controlling atomization is as easy as setting the cup speed on your bell.

Many finishers even believe that they do a decent job with #2.

Though controlling viscosity is essential when dealing with high quality finishes (such as Class A automotive), most companies rely on paint formulation, both from their supplier and through solvent addition in their mix room, to manage this variable.

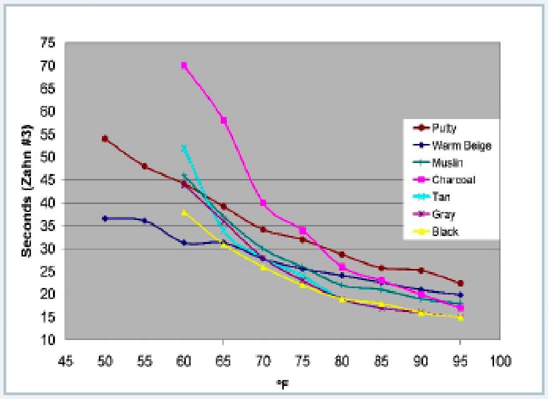
This fails to address the key factor affecting coating viscosity: Temperature.

THE IMPACT OF TEMPERATURE ON VISCOSITY

Most finishers understand that their paints get more viscous (thicker) as they get colder, and less viscous (thinner) as they get warmer. This changes the way that the coating flows out over the surface of the part after it is applied, which has a significant impact on the quality of the finish.

There are three specific temperatures that most painters associate with finish quality:

1. The temperature of the substrate, (the object being painted).
2. The temperature of the material being applied, (in this case paint).
3. The spray booth temperature.



Let's address each of these and their impact on finish quality.

Substrate Temperature

Substrate temperature is important because it impacts the coating immediately upon application and during the period when the coating is flowing out and flashing off prior to curing. Furthermore, most parts have a mass that is many orders of magnitude larger than that of the applied film, therefore the influence of their surface temperature "swamps out" the temperature of coating after it is applied. If substrate temperature varies then finish quality will be compromised. This is why many progressive, modern coaters have taken steps to control the temperature of the parts entering their coating process.

THE IMPACT OF TEMPERATURE ON VISCOSITY

Coating Temperature

Even the most carefully controlled substrate temperature cannot make up for the viscosity variations caused by changes in paint temperature when it is applied. Many coaters believe they have paint temperature under control (see "Booth Temperature" below) and rule it out as a factor in their issue analysis. They are often amazed to learn that their coating viscosity is varying by 30% or more simply due to changes in fluid temperature as it is being applied.

Though stable, predictable viscosity is essential when producing high quality finishes (like Class A automotive), it is the rare company that controls paint temperature accurately as it is being applied.

Booth Temperature

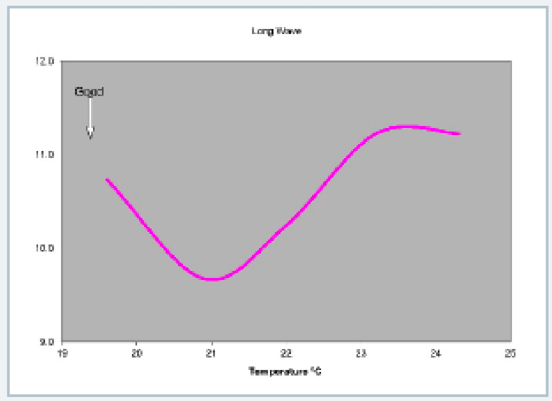
This is probably the most misunderstood temperature of them all. Most coaters believe that they are controlling the temperature of their process by controlling booth temperature and go to great lengths to do so. This is based in the belief that the paint particles are at booth temperature by the time that they reach the part – thus addressing coating temperature as described above. But a study performed at the Carlisle Finishing Technologies lab, using both guns and bells, determined that, even when there is 20°F temperature difference between paint temperature and booth air temperature, the change in paint temperature averages less than 1.7°F!

In short, booth air temperature does not control paint or part temperature and therefore has the least impact on the coating process of these three important temperatures.

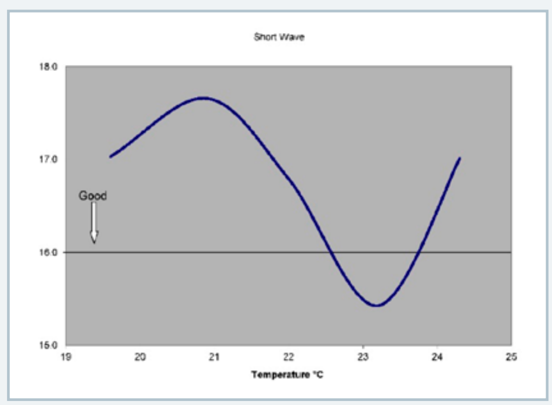
THE IMPACT OF TEMPERATURE ON FINISH

Working with one of our industrial finishing customers, we made measurements in a production environment where parts could be repeated in volume and multiple measurements could be obtained to demonstrate consistency and repeatability.

Longwave results are shown in purple at right. With a goal of minimizing surface variation, it is easy to see that the optimal Longwave results with this setup are achieved at about 21.0°C (69.8°F).



Shortwave results are shown in blue at right. Again, it is easy to see that the optimal Shortwave results are achieved at about 23.2°C (73.8°F)

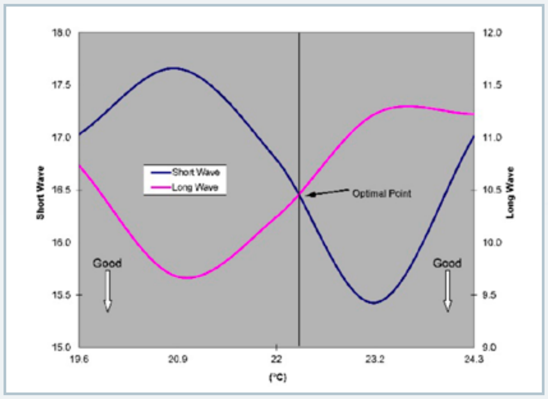


Clearly, there is a direct relationship between coating temperature and finish quality. Controlled lab experiments have shown that clearcoats demonstrate higher shortwave than longwave components, meaning that the longwave components can be attributed to substrate, primer, and basecoat variations.

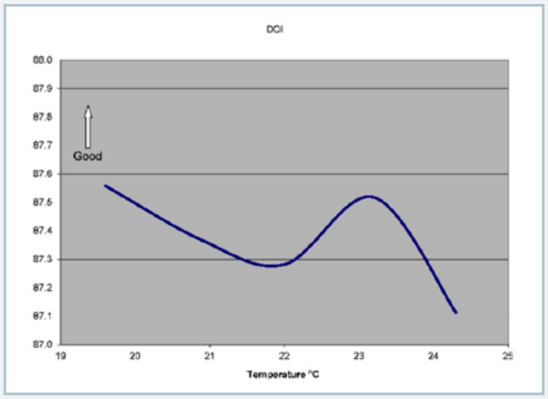
WHAT CAN WE DO ABOUT IT?

While the objective is to minimize these variations, a decrease in short wave value results in a more brilliant appearance making longer waves more visible. To optimize appearance, a "balance" between short wave and long wave leveling is essential.

Placing both data on the same graph (right) allows us to quickly determine the optimal operating temperature. This shows how temperature can be used to shift the performance as desired. The best overall balance is achieved at 22.2°C (72°F) with this setup. Lowering paint temperature toward 21°C (70°F) optimizes Longwave over Shortwave, whereas raising paint temperature toward 23°C (73°F) optimizes Shortwave over Longwave. This control provides the ability to "fine tune" the process while keeping all other variables constant.



Distinctness of Image (DOI) is a measure of how "mirror-like" the finish is. Shown at right, this also varies as a function of temperature. This may limit the temperature range available to "fine-tune" the wave balance above.



TEMPERATURE AS A TOOL

The solution is to control paint temperature – make it a tool that works for us instead of against us. But when it comes to controlling paint temperature, we find that companies generally fall into one of three groups:

#1 "Temperature is a variable we cannot control."

In a joint Detroit Free Press/USA Today article entitled *"Ford, GM Use Tech to Pursue Perfect Paint Job"* published August 22, 2013 by Alisa Priddle and Chris Woodyard, GM Orion Assembly Plant Paint Shop Area Manager, Anton Busuttil, stated, *"The process of painting a vehicle properly is much harder than the average person would assume."* He added,

"We have many different factors that we have to be cognizant of at all times. The weather – including temperature and humidity – is one of those major factors over which we have no control."

His view is not uncommon. Most painters have observed that:

Changes associated with the weather can lead to all kinds of inefficiencies, each of which negatively impacts your cost structure and competitiveness. These include:

- **Adjusting other dispensing variables to compensate for the changes**
- **Summer & winter paint blends**
- **Summer & winter robot programs**
- **Increased inspection**
- **Increased rework**

TEMPERATURE AS A TOOL

#2 "We are already controlling the temperature".

Many companies already use heat exchangers to "protect" the paint in their recirculation system where the paint may go through a pump and backpressure regulator multiple times every hour. This induces shear and adds heat. Combine that with an unusually warm day in the plant and this "process heat" has the potential to damage hundreds of gallons of very expensive paint.

While useful, and in many cases absolutely necessary, this type of temperature control is not nearly adequate to consistently eliminate Orange Peel.

Other companies will control the temperature of the mix room, mix tanks, or both. Then they route the paint out to the booth through the unconditioned plant – often up at the "truss level" where all of the heat in the building collects!

Again, while they believe they are controlling their paint temperature, this type of control is neither accurate enough, nor focused properly to consistently eliminate Orange Peel.

TEMPERATURE AS A TOOL

Another common method is the use of in-line electric heaters, (commonly known as Paint Heaters). Amongst a host of other problems, in-line electric heaters have no ability to cool. As noted above, most processes add heat to the paint via shear or friction. As the paint warms, there is nothing preventing it from getting too warm. You simply shut off the heater and live with the results…

#3 "We are uncertain of the effects of temperature".

Most companies simply do not understand the full impact of paint temperature on their process outcomes. Sometimes it is difficult to conceptualize how relatively small variations in temperature can have a significant impact on finish quality. This typically results in extra "non-value added" processes that have just become part of the normal operating procedure.

Modern temperature control technologies now make it possible to accurately control the temperature of the coating at the point-of-application to assure that it is at it's optimal viscosity independent of changes in ambient conditions from morning-to-evening and season-to-season. This makes the elimination of orange peel more of a reality than ever before.

PROTECTING YOUR BUSINESS

Is your customer consistently impressed with the product you deliver to them?

If you are supplying painted parts where finish is critical and have suffered from finish quality issues, (either caught internally or, worse, returned by your customer), you need to take action to assure that you are your customer's first choice for sourcing finish-critical components. Fortunately, point-of-application temperature control is a cost effective solution.

The point-of-application is the ideal place to start every project.

While often overlooked, the point-of-application is where temperature matters most. Temperature directly impacts paint viscosity which ultimately affects the "flow out" allowing Orange Peel to form in the finish.

CONCLUSION

Learn more about viscosity at viscosity.com

When we introduced the concept of point-of-application temperature control, it was an “obvious-after-the-fact” moment for our customers.

Starting at the point of application and working backwards through the process just makes sense. Controlling the temperature in any other area of the process, like the mix room or mix tanks, or adding in-line heaters or heat exchangers, may have some impact, and in some cases, may even be necessary, but it does not address the issue of variation at the point-of-application.

It is this point-of-application variation that is responsible for Orange Peel.

Our Company

At Saint Clair Systems, we've been in the business of temperature and viscosity control for over 25 years, and have more than 3600 active applications under our belt. We understand your process, and we can work with you to optimize your results.

Just visit www.viscosity.com and click "Contact Us" for a free temperature/viscosity control consultation to learn more about what you could be doing differently to improve your outcomes.

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