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ADVANCED ADHESIVES REPORT
Your corrugating newsletter from Harper/Love Adhesives Corporation

# Dual viscosity systems, then and now

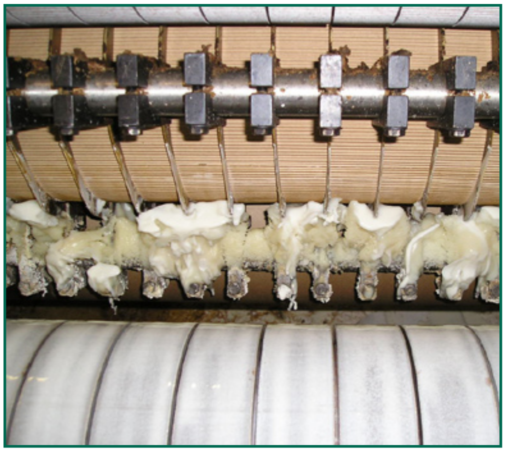
## *Why and how we adopted the practice, and what it can do for us today*

By Chris Polster

I should start by saying that the goal for dual viscosity formulas is or was very rarely if ever to run two separate adhesive viscosities. Rather the goal is to run two formulas with different gel temperatures for the two separate types of machine in a common corrugator (single facer and double backer). The fact that this would sometimes lead to the two formulas having different viscosities is how the practice got its name. The following lays out a capsule history of how and why our industry started this exercise and how it affects us today.

### Early low-solids, high-viscosity formulas had their drawbacks

One of the major runability issues on early single facers, which employed fingers to hold the medium against the corrugator rolls, was adhesive gelling on the fingers. This gelling would lead to various problems creating web at the single facer. The machine would then have to be shut down, and the fingers cleaned, in order to produce good web. At some point the industry realized that running a higher gel temperature formula at the single facer would combat this problem. So we started using two separate formulas, and dual viscosity was born.



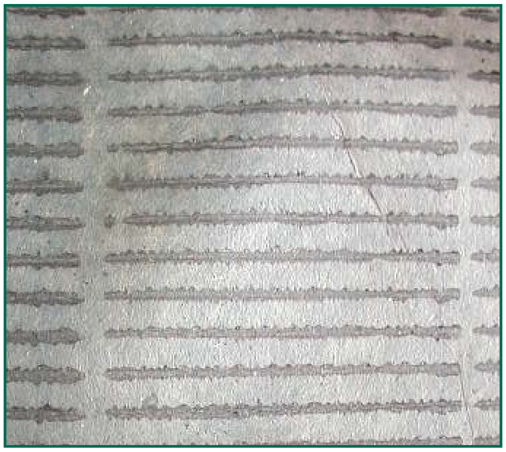
*Finger-type machines were often troubled by low gel-temperature adhesives gelling on the fingers.*

As run speeds slowly increased, two things were discovered: these relatively high adhesive viscosities had their drawbacks in areas of application and ultimately machine performance, and that the cooked portion (carrier) of the adhesive not only kept the uncooked cornstarch in suspension, but also improved adhesive performance by affecting water holdout at the glue line and helping control how the adhesive gelled. The desire to increase the amount of dissolved or cooked solids in the adhesive led to the birth of modified starches.

### Modified starches allow higher dissolved solids, better water holdout, and greater control

Modified carrier starches are just that: starches that have been modified so they can be substituted for pearl starch at a higher addition rate in the cooked portion of the formula while maintaining similar viscosity. These are often referred to as 200- or 300- pound carriers (although it is not at all an exact scale and is, in fact, rarely even close) because in theory a 300-pound carrier is developed to replace 200 pounds of pearl starch.

This allowed the industry to increase the ratio of cooked starch in an adhesive and also made possible lower adhesive viscosities in general. The average adhesive viscosities across the industry were still in the high 40-second to 55-second range. It was still very difficult to make smaller changes to an adhesive formula because these modified carriers usually came in 50-pound bags, so you made changes in 50-pound increments. The practice of running a higher gel temperature at the single facer gained recognition and popularity during this time as these adhesives made it easier to produce board at the higher end of the machine capabilities and offset the gelling of adhesive on the finger assemblies.



*Adhesive gelling on the fingers prevented starch from being applied in that area, creating finger blisters.*

### Fingerless single facers and high-shear mixing allowed return to a single formula

The next big industry change was the introduction of higher speed single facers that used positive pressure or vacuum rather than fingers to hold the medium against the corrugating roll. Gelling at the glue unit was still an issue but to a far lesser degree; gelled starch would build up on water jackets and glue dams, especially on vacuum machines that held more heat around the glue pan. This gelling

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would result in delamination problems at the single facer and the machine would need to be shut down for cleaning. So many facilities continued the practice of running two formulas so that they could have a gel temp of around 150$^0$ F at the single facer.

At the same time, adhesive suppliers were developing an understanding of how they could take advantage of the higher agitation and shear of adhesive mixers to reduce the finished batch viscosity while maintaining an optimum percentage of solids and still be able to cook out enough starch to keep the raw starch in suspension. As they did so, they found that the lower viscosity formulas had a far greater impact on gelling at the glue unit than did running a higher gel temperature on the single face formula: the lower viscosity formula had much better flow and movement in the glue pan and was not nearly as susceptible to gelling as it did not spend enough time up against a heat source to build up.

Lower viscosities also aided a plant's ability to optimize application. Reducing adhesive application meant that we were now able to run higher single facer speeds because reduced glue lines needed to be exposed to energy for less time to achieve bond. So dual viscosity formulas became less and less popular. Many plants began running a single formula, which meant they could run both stations out of one tank. This meant using fresher adhesive, which also had a positive impact in adhesive quality—but everything is a cycle.

***Today, a facility may have a good reason for running two separate formulas, but the most important thing is to understand exactly why.***

## Chemical additives allow the use of pearl starch without sacrificing higher dissolved solids

The next big impact on corrugating operations was chemical additives. Adhesive companies started developing liquid chemical additives that could take the place of modified carriers and would be much easier to manage. These liquid additives once again allowed the use of pearl starch from a silo in the cooked portion of the adhesive and kept the adhesive in suspension at lower viscosities while, in most cases, increasing adhesive and corrugator performance. The fact that starch could be easily supplied to a mixer in 1-pound increments, rather than 50-pound increments as with bagged modified carrier, meant that a plant could develop an adhesive exactly tailored to it needs depending on machine layout and order mix. This led to even higher machine speeds—and the cycle continues.

As machine speeds increased, one of the most common constraints plant would run into was a green (wet) bond on the bottom liner after the double back process. We were simply outrunning our double backers.

The double backer bond on most high-speed machines is the more difficult of the two bonding processes (double back and single face). This is due to the difference in pressure applied at the two different processes. At the single facer, we measure the amount of pressure applied at the bonding nip in hundreds of pounds per square inch. At the double backer we measure the amount of pressure applied in tens of pounds per lineal foot. Although the single face bond is a low time/high pressure bond and the double back is a high time/low pressure bond, the largest difference in the two processes is pressure.

## Dual viscosity, revisited

As we began to outrun the capabilities of our double backers, we started to see a green (wet) bond on the double back side when pushing speeds (especially on heavier-weight combinations), someone popped up and said, "What if we ran two formulas with a lower gel temperature on the double back formula." To which, I'm sure, someone replied, "Yes, we use to do that back in the day and then got away from it for no good reason," not remembering that we previously used dual formulas for an entirely separate issue (gelling at the single facer). So the cycle is complete.

## Theory versus practice: does this really work?

Theoretically, running a lower gel temperature at double backer glue unit makes sense to us. However, when the practice was introduced, there was no real scientific data to support this theory. Then around the year 2000 Bill Nikkel did a study on how different gel temperatures affected the bonding process. His study (using some very ingenious equipment along with cameras and computer graphs) showed that lower gel temperatures had little to no impact on the time it took to achieve a bond.

Shortly after seeing the Nikkel demonstration, I was blessed with the opportunity to become involved with a company that had quite a few facilities across the country and was looking for ways to gather data on how to identify and develop action plans for constraints on the corrugator. I became part of a team that had access to several machines of every possible layout configuration. Together, we ran a series of what we eventually called Top Speed/Nonstop trials. These trials consisted of getting a small team together at a plant and push corrugator speeds until we reached the top speed of the machine, or until we ran into an issue that reduced the quality of the board. We would then develop an action plan for addressing whatever issue we saw, then would repeat the process. We did this over several years.

One of the limiting factors was the green (wet) bond after the double backer when pushing machine speeds. With the latitude we were given to develop solutions for these problems, we started out by seeing how a lower double backer gel temperature would affect the issue. We tried lower gel temperatures in incremental steps to as low as 135$^0$ F with very little to no impact. We also tried adding heat through the double back process, still with little impact. We finally had some major impact when we greatly increased the amount of ballast pressure at the double backer.

## Flute tip temperature and contact pressure are more important

Using this information in subsequent trials, we found that two things had the most impact on green bond. One was maintaining the temperature of the flute tips (where web exits the glue unit and enters the double backer) at or above the gel temperature of the adhesive. The other was contact pressure.

We examined the dual gel temperature practice to see

# How to get consistently accurate readings from your infrared heat guns

***Be aware of the distance-to-spot ratio of your gun, as well as the emissivity of the object being measured. You'll get more reliable temperature checks.***

by Ronnie Littleton


Handheld, noncontact infrared (IR) thermometers are widely used on the corrugator to measure paper and vessel temperatures. They allow for quick, safe measurements without physically touching either. These devices reveal an object's temperature by measuring the amount of infrared energy it is radiating.

## Laser-assisted aiming

These guns usually have some sort of laser pointing feature. The laser is there only for aiming and has no function in sensing temperature. Some guns project a circle of laser dots outlining the area being measured.

## Distance-to-spot ratio

The IR thermometer collects the infrared energy from a circular area and focuses it on the detector. The gun sees in sort of a cone shape: the farther the object being measured, the larger the area (or spot) that the gun measures. The reading is a result of the combined temperatures within this spot.

The optical resolution of the gun can be expressed as the *distance to spot* ratio. For example a gun with a D:S Ratio of 12:1, when held at a distance of 12" will measure a circular area of 1"; at 36" it measures a 3" spot.

To achieve accurate readings, the target area should be larger than the gun's spot size. For heated vessels it is best to paint a spot of at least 4" and hold the gun as close as practical, certainly no farther than 12" to 24". Taking measurements from distances farther than this will not yield consistently accurate results.

When measuring web or paper temperatures it is preferable to measure it from both sides of the machine, if safe, rather than trying to shoot the opposite side from across the machine.


*IR heat guns usually have D:S ratio information printed or embossed for easy reference*

## Consider emissivity

For our purposes emissivity can be thought of as how much IR energy an object emits in relation to its temperature. Objects painted flat black, organic materials such as kraft paper and oxidized metals all have an emissivity of about 0.95. Conveniently, nonadjustable IR thermometers have a fixed preset emissivity calibration of 0.95.

Shiny things, such as polished preheaters have much lower emissivities so we must paint them with *flat* black paint to obtain accurate readings from them. (Low-gloss black paint is not as reliable as flat black paint and can give a lower temperature reading by as much as $20^0$ F.

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what impact it had on machine performance. The team found that running dual formulas, so that a lower gel temperature adhesive could be run at the double backer, made no noticeable difference to machine or bond performance. In fact we found that in most cases, plants with fingerless machines, could run a formula with a gel temp between $142^0$ F and $148^0$ F, and run it at both stations without issue. This would lead to the adhesive being turned over much quicker, allowing fresher adhesive to reach the machines. Data from these trials showed that the sweet spot for gel temperature was in the $142^0$ F to $148^0$ F range and that when we went below $140^0$ F, the plants had difficulty keeping viscosities, and therefore application rates, stable.

In some cases, with ultrahigh speed machines running close to gear speed (1000 fpm or more) we did see some advantages to running gel temperatures at the single facer on the lower side of the aforementioned sweet spot. Most of these machines used a pressure belt rather than a pressure roll.

## Dual viscosity today: yes, no, or maybe?

Running separate formulas for the single facer and the double backer may offer a plant some economic advantages. In some cases, the type of machine and order mix can allow a facility to take advantage of the enormous pressure at the single facer nip to run a more economically attractive formula there. But the savings realized through this practice might be negated by the added cost of adhesive management, which is a much more difficult number to get one's head around.

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