MAY 2016

ADVANCED ADHESIVES REPORT

Your Corrugating Newsletter from HarperLove

GEL TEMPERATURE

By Rex Woodville-Price

Gel point or gel temperature - the temperature at which starch based adhesives will gelatinize - is an important parameter in adhesive performance. Understanding the factors that affect gel temperature can be very helpful in managing adhesive performance.

The most significant factor that influences gel temperature is the amount of **caustic soda** present in the formula. Sodium hydroxide (a.k.a caustic soda) provides chemical energy to gelatinize starch. More chemical energy in the form of additional caustic means less heat energy is required to gelatinize the adhesive. In the extreme, excess caustic added to the adhesive will cause it to gelatinize at room temperature.

Starch from **different plant sources** has different natural gel temperatures. Potato starch, for example, has a natural gel temperature of around 156°F while corn will gel around 160°F. Different batches or crops of the same material may even have different natural gel temps. This is due, in part, to the variations in the environmental conditions the crops grew in, including climate and soil type. Furthermore, how the starch is processed will affect its alkaline sensitivity -- the impact that caustic soda will have on its gel temperature.

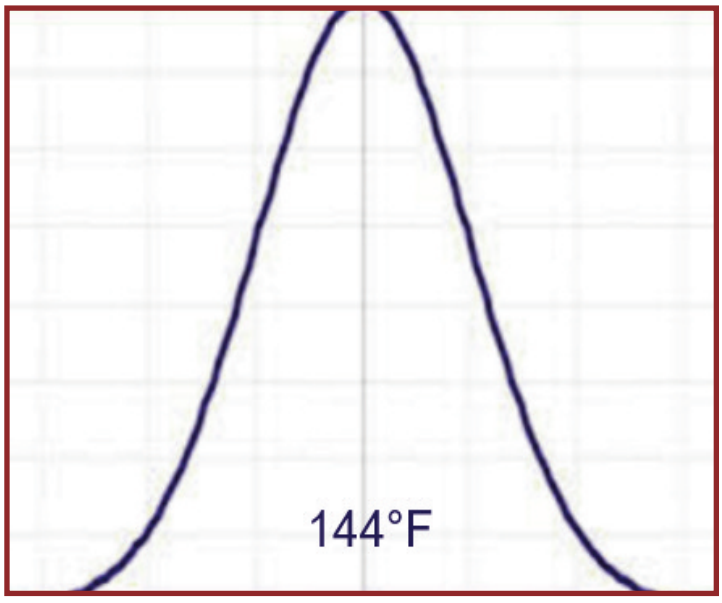
Time affects gel temperature. Starch based adhesive will have its lowest gel temperature as soon as it is made. As adhesive ages, its gel temperature increases. This increase is the result of the caustic reacting and being "used up." This rise in gel temp will continue throughout the life of the adhesive. This is just one more reason to use fresh adhesive.

Adhesive can also swell after it is stored for a period of time, exhibiting a rise in viscosity. This behavior is generally associated with caustic sensitive starch, but can also occur with normal starch if the adhesive formula has a low gel point. As the raw starch in the secondary portion is exposed to the free caustic in the adhesive, it can begin to swell, increasing viscosity. The problem is aggravated by high storage temperatures.

We tend to think of an adhesive gelatinizing as a singular event, all the starch granules gelling instantaneously. However, starch granules are not all uniform and do not all gel at the same temperature. Because they don't gel at the same temperature, they do not gel at the same time. As the adhesive gets near its gel temp (say 144°F), some of the granules will begin to gel. The majority of them will gelatinize at 144°F and the remainder will gelatinize a bit later. If we were to graph the temperatures at which each individual starch granule gelled, we would have a bell shaped curve (similar in shape to the graph shown below).

What we "feel" with the thermometer when we are **testing for gel temperature** is the temperature at which most of the granules swell; this is the peak of the curve and this is what we call the gel point. Because it is not a singular, precise temperature, there is some subjectivity to a gel temp test. The person doing the test has to determine at what point they call the sample gelled. This can vary from when it starts to thicken (soft gel) to when it is almost completely gelatinized (hard gel). A good rule of thumb is to record the temperature when the adhesive sticks to the thermometer as the gel point.

As we heat a sample of adhesive during a gel point test, there will be a steady increase in temperature right up to the gel point. As we approach the gel point, the temperature stops rising momentarily because the available heat energy is being used to gel the starch granules. Once the majority have gelled, the temperature will begin to rise again. The temperature at which the increase pauses can also be used to define the gel temperature.



TEST TEMPERATURE AFFECTS RESULTS

By Rick Bird and Rex Woodville-Price

Obtaining an accurate gel temperature is an essential step in monitoring and controlling the corrugating process. The temperature of the water used to perform the gel temperature test will impact the results, and it is recommended to use boiling water for conducting the test. TAPPI, in their Gel Point tip sheet TIP O304-05, recommends using water between 180°F and 212°F (boiling).

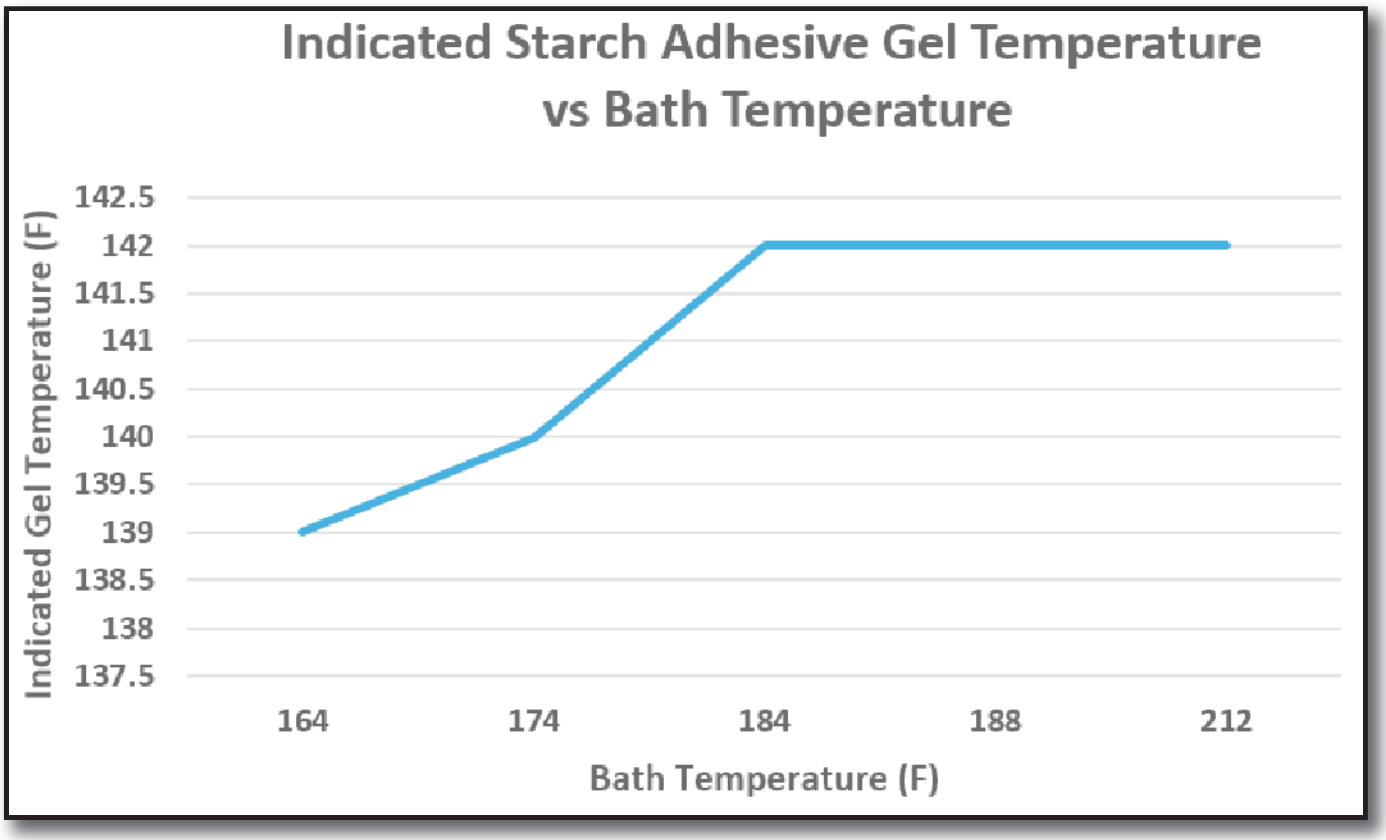
When water below 180°F is used to do a gel temperature test, there is a tendency for the test to indicate a lower gel temperature. If the adhesive is formulated to have a low gel temperature, this tendency is more pronounced. This is because of the higher content of sodium hydroxide (caustic soda) which lowers the gel temperature and also causes the gel temp test to proceed faster. An analogy to this phenomenon is that when beans are soaked in water before cooking, they cook faster. Starch granules behave in a similar fashion by hydrating partially as they "steep" in the caustic adhesive. Remember that this is a very caustic environment, with a pH of 12.5.

An interesting side effect of using water at temperatures below 180°F is that it becomes more difficult to sense the actual gel point as the event is not that "crisp" or precise.

An additional reason to use boiling water for the test is the consistency of the bath temperature. Since water in an open container cannot exceed its boiling point regardless of how much more heat we add, it maintains a consistent temperature. Adding more heat merely makes it boil faster, not get hotter. This is a convenient phenomenon which can be used to ensure a constant test temperature.

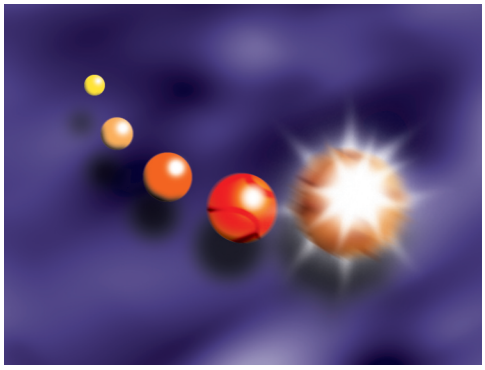
Using a plastic test tube instead of a glass one will have a similar effect of yielding a slightly lower gel temperature. Because plastic transfers heat more slowly than glass, a plastic test tube will take longer to come up to temperature. This delay allows the adhesive to steep a bit longer and results in a slightly lower indicated gel temperature. However, for reasons of safety and durability, plastic is a preferable material to use in a starch kitchen.

While there are several factors which affect the accuracy of a gel temperature test, the easiest to control is water temperature. Make sure that your water is always hot enough (180°F or higher) before taking a gel temperature measurement.



WHAT IS THE REAL GEL POINT OF YOUR ADHESIVE?

By Bill Nikkel



The conventional method of determining the temperature at which a starch based corrugating adhesive gels does not accurately predict the actual temperature at which this adhesive gels on the corrugator. The actual gel point on the machine is, in fact, much higher than the one measured by the test method.

In the conventional gel point test, a relatively large volume of adhesive is heated slowly over a period of several minutes. On the corrugator, a small volume (glue line) gels in a very short time. In a high speed double facer, this dwell time, is just a matter of a few seconds. At the single facer this dwell time is only a fraction of a second.

The gelatinization of a thin film of starch (like a glue line) can be clearly observed under a microscope while this starch is being rapidly heated, closely simulating conditions on a corrugator. Tests conducted in this manner show that in order to gel such a small quantity of starch in just a few seconds, a temperature in the range of 190°F to 210°F is needed when using a starch adhesive which has a conventional gel point of 150°F. This tells us the gelling process depends on time as well as temperature: It takes a certain amount of heat energy to gel the starch and this amount of energy can be applied at a low temperature over a long period of time or at a high temperature for a short period of time. (An analogy would be what happens in a pressure cooker, where cooking time can be reduced by increasing the cooking temperature.)

Test results show not only that shorter heating times require higher temperatures to achieve gelatinization, but also that initial conventional gel point values have little effect on the actual short-term gel point on the machine. Adhesives with conventional gel points ranging from 140°F to 155°F all gel at about the same much higher temperature when subjected to the same short heating period.

As machine speeds continue to increase there is a reduction in dwell time (heating time). This means the real gel point in the machine will be higher. The challenge becomes one of having less time to reach a higher temperature to gel the starch.

To achieve high running speeds, it is necessary to have a rapid rate of heat transfer, which requires elevated heating vessel temperatures and intimate contact between the paper and the heating surfaces. The implementation of better adhesive formulation and the use of performance enhancing additives can help achieve this speed increase while maintaining optimum board quality.

John Fitzgerald joins HarperLove . . . as Research and Development Chemist

HarperLove is pleased to announce that John Fitzgerald has joined the company as Research and Development Chemist in Charlotte, North Carolina. John comes to HarperLove with thirty years of experience in the adhesive and packaging industries, where he has worked extensively in product development, formulation, processing, and technical support. John has direct experience in starch and dextrin-based adhesives as well as PSAs, hot melts and cold glues. He earned degrees in Chemistry from East Stroudsburg University and in International Relations from Lehigh University. Alan Clark, CEO of HarperLove, commented, “John is a great addition to the HarperLove team. His technical capabilities and experience are a perfect fit for HarperLove and will enable us to accelerate our innovation and product development initiatives. We are very excited to have him working with us to better serve our customers’ needs.”

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