HARPERLOVE

ADVANCED ADHESIVES REPORT

YOUR CORRUGATING NEWSLETTER FROM HARPERLOVE

February 2018

Adhesive Viscosity

Adhesive viscosity can have a significant impact on starch consumption, bond strength, combined board warp, and corrugator performance, so maintaining optimal and stable adhesive viscosity is essential to efficiently producing quality board.

What is Viscosity

The dictionary defines viscosity as "the property of a fluid that resists a force causing the fluid to flow." More simply, it is the measure of fluid's resistance to flow—motor oil has a higher viscosity than water.

Starch-based corrugating adhesive is typically composed of 20% - 30% solids and 70% - 80% water. To make corn starch-based adhesive with a stable viscosity (i.e., resistant to loss of viscosity over time), a portion of the starch is completely cooked, which sets the viscosity of the adhesive. The cooked portion is referred to as carrier starch because it keeps the raw starch in suspension and carries the uncooked starch through the pipes and to the glue line for gelatinization by heat on the corrugator. Making adhesive this way is called the Stein Hall method and has been the basis for most corrugating adhesives since the 1940s. The carrier portion of the adhesive is generally only 3% - 6% of the total adhesive, but it is key to the process. This fact is very evident on automatic high-shear starch mixers, where the amount of carrier is easily changed, and the resultant change in the finished batch viscosity is easily observed.

Measuring Viscosity

There are two main methods to measure starch adhesive viscosity in a box plant: Love cup and Stein Hall cup. Both methods measure the time for a defined amount of

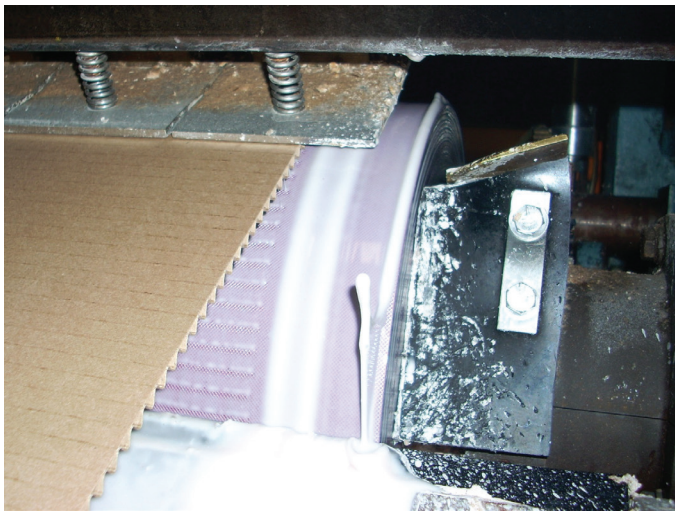
adhesive to flow through a specific-sized orifice. To get an accurate result with a Stein Hall cup, the cup must be pre-heated with adhesive before the actual measurement is performed. The cup has a wall of 3/16" solid brass that, if colder than the adhesive being measured, will cool the sample and alter the viscosity before the measurement is completed. When filling the Stein Hall cup, the adhesive must first be strained to remove any debris that could plug the 0.10" hole which the adhesive passes through. Failing to strain the adhesive can yield a viscosity measurement that is higher than the true viscosity. The viscosity is measured by the time it takes for the adhesive level in the cup to drop from the top pin to the bottom pin. This time is recorded as "xx seconds Stein Hall." The Love cup method is similar but does not require preheating the cup or straining the adhesive because the cup construction, wall thickness, and orifice size are designed to simplify the measurement process. For calibration and reference, the viscosity of water is 15 seconds Stein Hall (+/- 0.5 seconds), or 7 seconds Love cup.

How Does Viscosity Affect Corrugator Performance

Changes in adhesive viscosity can influence the application rate, penetration into the paper, bond strength, and ultimately, corrugator speed and board quality. An increase in viscosity will increase the amount of adhesive carried on the glue roll and consequently applied to the flute tips—even if the gap between the glue roll and metering roll remains constant. This potential variability increases the importance of maintaining consistent and stable viscosity.

The viscosity of the adhesive can also affect the penetration of the adhesive into the paper, which has a significant impact on the strength and quality of the bond. Viscosity can be used to compensate for the absorbency of the papers, particularly when the liners and medium exhibit similar tendencies. When running unbalanced papers (e.g., a very absorbent medium and a highly sized liner), it is difficult to achieve the appropriate absorption simply by adjusting the viscosity. In these situations, it is far more effective to adjust the adhesive chemistry through the use of appropriate additives.

Because adhesive viscosity can have a direct impact on the application rate and the absorption into the papers, it ultimately can have an impact on corrugator speed and board quality. Too little adhesive can lead to a poor-quality bond. Too much adhesive can lead to a green bond, warp, and having to slow down the corrugator.



Optimal Viscosity

The optimal adhesive viscosity depends on the specific design and condition of the corrugator, the starch system, and the papers being run. For example, glue machines (double backer and single facer) with restrictive piping may require lower viscosity to ensure sufficient adhesive supply during high-demand operating conditions. An anilox glue roll with cells may need an adhesive with a different viscosity than one with a sandblasted surface. Single facers can tolerate (and sometimes benefit from) lower viscosities than double backer glue machines. This is partly due to the difference in how the bond is made, with higher pressure and temperature. Older, fingered corrugators run better with lower viscosity adhesives that can flow and bridge the gaps left by the fingers (i.e., the finger lines).

There are indicators and diagnostic tools that can aid in determining whether the adhesive viscosity is optimal. Glue line iodine stains are particularly useful in identifying viscosity related problems because glue line integrity is compromised by improper viscosity. Other indicators are slinging, foaming, and glue pans that run out of adhesive when the corrugator is running at high speeds.

Viscosity Changes

Viscosity can easily be manipulated through formulation, but achieving consistent viscosity requires good process control and a starch kitchen that is clean and in good mechanical condition.

The starch kitchen must deliver precise and repeatable amounts of each ingredient in every batch. Variability in the ingredient addition amounts will lead to inconsistent viscosities. Steam leaks, water leaks, dirty or clogged hoppers, and scales that are not calibrated can all lead to imprecise or varying formulations. Furthermore, bacteria in the starch system will affect the stability of the viscosity as the bacteria attack the starch over time.

Viscosity will change significantly with even small changes in temperature. For every 2°F drop in adhesive temperature, there is ~10% increase in viscosity. Additionally, an adhesive with a lower temperature will require more time to gel because of the larger temperature differential between the starting temperature and the gel temperature. The higher viscosity will also cause excess glue application which further exacerbates the time to gel.

The mechanical design and setup of the starch system can also affect the viscosity of the adhesive. Older mixing equipment with marine-type propellers will make adhesive that will lose viscosity due to mechanical stresses. Adhesive loops with constant circulation, numerous elbows, or gear-type pumps will shear adhesive over time and lead to decreased viscosity.

Correcting Viscosity Issues

If you are seeing changes in viscosity, it is important to identify and remedy the source of the problem. Don't simply compensate for the problem by altering the formula. The most likely causes are temperature changes, dilution from a water leak, and bacteria attacks.

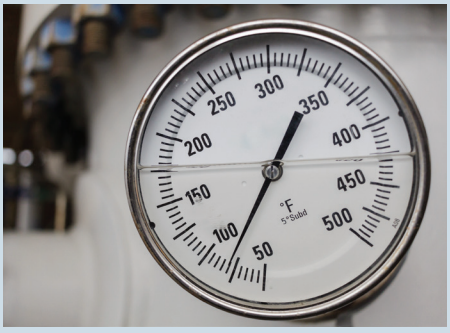
Every plant should have procedures in place that prescribe what actions to take when a batch of adhesive has the incorrect viscosity. A batch with a small deviation from the standard may still be runnable with special attention from the operators and adjustments to the application rate. A larger deviation may require making a new batch and mixing the bad batch with it to yield a more acceptable viscosity. Although high viscosity can be corrected with the addition of water, care should be taken to avoid major additions because the water dilutes the chemical properties and may lead to bonding problems. There is no acceptable way to correct low viscosity adhesive other than to mix it with a higher viscosity adhesive. Adhesive that is out of spec because it is several days old (e.g., it was made on a Friday and sat unused over the weekend) is often segregated in a separate tank and slowly mixed in with fresh adhesive as the machine runs. If you adopt this practice, take care to avoid blending it when running challenging board combinations, such as heavyweights or doublewall. To assist the operators and ensure consistent practices, the procedures for correcting out-of-spec adhesive should be formally documented along with the viscosity ranges at which each corrective action should be taken.

Summary

Adhesive viscosity is one of the many factors that can significantly impact the performance of a corrugator and the quality of the board produced. Changes in viscosity will affect application, penetration, and bonding, and will adversely impact overall corrugator performance. Maximizing corrugator performance and board quality requires determining the optimal viscosity, accurately measuring the actual viscosity, and addressing the plant conditions that can adversely affect consistency and stability.

Temperature / Viscosity Control Systems

Maintaining the viscosity of starch adhesive at a constant level is critical for consistent application and performance. Because the viscosity of starch adhesive changes dramatically with temperature, it is important to control its temperature with a TVC (Temperature/Viscosity Control) system. To ensure optimal corrugator speed and to maintain steady viscosity, most corrugating plants try to maintain starch between 100°F and 105°F in storage. The starch temperature is usually maintained by running heated water through a series of coils located inside the storage tanks. These coils are typically made from 2" inside-diameter carbon-steel or stainless-steel tubing connected to a steam-heated open water tank or an industrial water heater. TVC systems are controlled by a temperature sensor in the storage tank, and a setpoint is entered for the desired temperature. If the temperature drops below the setpoint, a centrifugal pump pushes heated water through the coils while the storage tank agitator circulates the adhesive. When the setpoint is reached, the pump is stopped. The heated water is maintained at a temperature ~15°F below the gel point of the starch to prevent gelling near the coils. Most TVC systems also have controls and timers to run the agitators intermittently. It is important to keep the heating coils clean and free of encrusted starch because the hardened starch acts as an insulator and sharply reduces heat transfer from the coils to the adhesive. It is also important to ensure there are no leaks in the TVC system because leaking water will dilute the adhesive and adversely affect the viscosity. If you suspect a leak in the TVC system, you can add a dye to the water to help troubleshoot the issue.



HARPERLOVE

11101 Westlake Drive
P.O. Box 410408
Charlotte, NC 28241-0408

704.588.1350 • www.harperlove.com
email: salestech@harperlove.com

IN THIS ISSUE:

40 YEARS
HarperLove.com

HARPERLOVE