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Recent Developments in Warp Sizing Instrumentation

We would like to thank the ITV for the opportunity to make this presentation to you today. We will begin with an overview of what we presented during the last Sizing Colloquium in December 2001 and then present a variety of developments which have occurred since.

The application of on-line and portable instrumentation in warp sizing processes provides many opportunities for improving product quality and uniformity. Multi-styling demands of today's marketplace require each warp style to be processed in its optimum manner. The goal of optimization can only be realized with the assistance of process instrumentation. Recent new developments in instrumentation should be of great interest to everyone involved in the warp sizing process.

Style-based control of the sizing process has become important for several reasons. The capability to process a particular style in its uniquely optimum manner is most important. The correct stretch and tension distribution and the drying profile through the process can be established and maintained as the set runs out. Optimum settings for residual moisture, wet pickup and size add-on can be maintained through the entire set. This ensures that all loom beams, from first to last, are processed in the same optimum manner.

Digital measurement values with corresponding style-based set points and control tolerances provide the opportunity to achieve the most narrow possible control limits. Each process parameter can be maintained at its style-based set point with the least possible variability.

Style-based control ensures that each style is processed in exactly the same manner every time it is run, day-to-day, week-to-week, month-to-month, and year-to-year. This provides predictable performance in the weave room with the product consistency that customers are demanding.

Digital set-point control also maximizes production speed and efficiency thereby minimizing consumption of energy, water and sizing materials.

Over-sizing has always been a necessary evil to guard against the disastrous effects of under-sizing. In addition to increasing the sizing cost in terms of the consumption of energy and sizing materials, over-sizing can also have detrimental effects on weaving performance. Real-time monitoring of the application of size materials in terms of wet pickup and percent concentration provide a true opportunity to gain control over these costly parameters.

Conventional instrumentation of both analog and digital design was typically single-purpose, single control loop devices. For every new set, the operator would have to manually adjust the set point, or manual position, for each device. As the set began to run, the operator would usually “fine-tune” the settings according to feel. This type of process set up and optimization was difficult for the operator to reproduce. Additionally, the set up strategy and “feel” were never the same for different operators. For this reason, loom beams from the same style from different sets or even sometimes the same set could cause significant variability in weaving performance.

Digital style-based set point controllers have helped reduce variability. One controller, such as the Strandberg Size-Rite Model 2702, will provide style-based set point control for many of the critical sizing process parameters such as residual moisture, stretch, tension, temperatures, and size add-on. The 2702 combines PLC technology for real-time measurement and control together with PC technology for operator interface and data storage, retrieval and reporting. Simple touchscreen recall of a style or recipe number loads all set points and control parameters for the beginning of processing a new style.

The latest color LCD technology displays measurement values with simultaneous display of set points and alarm status. Real time trend lines at selectable time or length intervals show a graphical history of important parameters. Outputs to control devices close the loop for automatic set point control for each parameter. Optional connections are provided for chart recorders and printers that provide reports containing interval, alarm and summary values for critical process parameters.

Each machine can be connected to a network to provide supervisory display of real-time and historical data for all measurement parameters on all sizing machines connected to the network. Beam and set summaries, scaleable trend lines for all process parameters, and statistical quality control charts are easily recalled for any beam or set run over the last year or more. All production and quality data are stored in a popular database format for easy use in other applications.

The measurement of size add-on has received much attention. Flowmeters can be used to calculate size consumption over intervals of warp lengths. Real-time measurements require the use of a microwave moisture sensor at the exit of the size box to measure the wet pickup in the warp sheet after application of the

sizing material. For accurate size add-on measurement, the percent solids in the size solution in the size box must be measured. This becomes increasingly important in the case in which prewetting of the warp sheet is done. Carryover of water from the prewet applicator to the size box will cause gradual dilution of the size solution. Additionally, evaporation occurring in the storage kettles as well as the introduction of a new mix in the middle of a set or a beam will cause changes in the concentration of the size solution and ultimately the size add-on.

The measurement of solids concentration in the sizing solution has typically been limited to off-line instruments such as hand-held or laboratory refractometers. Very often, real changes in concentration are detected long after they actually occur. The need for real-time monitoring of solids concentration is essential for measuring and controlling size add-on. Reliability and maintenance issues associated with in-line refractometers have limited their utilization.

To overcome the difficulty in measuring solids concentration of the size solution in its hostile environment, a non-contact, non-invasive sensor was developed. The first generation sensor used a microwave reflectance sensor to sense the water component of the size solution flowing through a non-metallic flow-through vessel inserted into the size line. The microwave energy was transmitted through the wall of the vessel into the size solution where it reacts with the water and is reflected back out to the sensor. Various installations of this sensor proved to be maintenance free and consistently sensitive to changes in solids concentration. However, due to effects of ambient temperature variations on critical mechanical dimensions of the sensor, long-term reproducibility was limited to approximately 0.5 percent solids concentration.

During the last several years, substantial research has been conducted to improve the accuracy of the microwave solids sensor.

Several new design configurations are being evaluated at present. Each of these designs addresses environmental limitations of the existing sensor.

Some of the development efforts related to the microwave solids sensor have already been incorporated into the current version of the non-contact microwave moisture sensor. The most recent microwave electronics technology provides higher accuracy and measurement stability even in the case of very low density warp sheets.

The accuracy and repeatability to which solids concentration can be controlled is critical for optimum size add-on. The lower size add-on target realizable with prewetting greatly increases the importance of accurate solids concentration measurements, as the margins for error become tighter. The economic effects related to consumption of sizing materials and weaving performance make this a key parameter for optimization.

The benefit of prewetting the warp sheet prior to the application of size materials has been well discussed. The effect of prewetting on actual size add-on values is significant as moisture levels in the warp sheet entering the size box affect the wet pickup from the size box as well as providing a source of size dilution. The level of moisture in the warp sheet entering the size box also affects the absorption and penetration of the size material into each yarn end and consequently the quality of sizing. Therefore, measurement of wet pickup between the prewet applicator and the size box is important. In many prewetting configurations, mechanical space and environmental issues preclude the use of a microwave moisture sensor.

A new sensor has been developed which utilizes full-span rolls installed at the exit of the prewet applicator in contact with the warp sheet to measure wet pickup or moisture. The sensor uses an electrical conductivity signal to measure moisture in the wet

ranges. The sensor is available in full-span measurement and three segment profiles versions.

Installations of this monitoring system on prewetting applications have produced significant benefits. Measurement values from the sensor provide essential information in setting the squeezing forces applied during stop, slow and run speeds. Significant changes in wet pickup values have been observed in stop, slow and run speed conditions in certain installations. Correction of these conditions enabled the reliable use of the prewetting box and solved corresponding warp quality problems. The sensor has also proven to be responsive to incremental changes in squeeze roll pressures during run speed providing the possibility to maintain consistent moisture in the warp sheet after prewetting using either manual or automatic control.

The design of this contact sensor has been significantly improved over the last two years. A new Teflon coating process is used to apply conductive Teflon coating to the measuring segments of the sensing rolls. Insulating segments are coated with traditional, non-conductive Teflon. This allows the contact sensing rolls to be installed at the size box exit to provide on-line profile measurement of size add-on. These rolls are motor-driven in the reverse direction to minimize the build up of size material. An added benefit of this feature is the tendency to lay down the fibers in each spun yarn end, which decreases yarn hairiness. This sensing arrangement has also proven to be applicable on filament sizing machines. Measurement values may be used for automatic control of squeeze roll pressures and alarm generation.

Recent developments have also occurred in the sensing of residual moisture. A new sensor has been developed which has significant sensitivity in low moisture applications down to zero percent. The high moisture range has been extended above 20 percent moisture regain. There is also greatly improved performance in the presence

of high static electricity. These attributes produce greatly improved moisture sensing in filament and glass yarn sizing applications. This includes applications in which the only significant moisture is actually only in the size film.

On-line instrumentation is applied to sizing machines according to the realistic needs and economics of each installation. Sensors are typically mounted in fixed measurement positions that are selected according to the relative importance of the measurement. Very often, it is not economically or mechanically feasible to place on-line sensors in every location ranging from major to minor importance. The use of portable, hand-held measuring devices allows periodic survey of many process parameters and machine conditions for which on-line measurement is not feasible.

The Spectrum 4 Portable Process Multimeter provides a convenient set of interchangeable sensors used with a common hand-held instrument for use in sizing and other processes. The Spectrum 4 automatically detects the identity of the attached sensor and loads the appropriate measurement algorithm into its main memory. Measurement values are displayed in big figures on an LCD display which allows data storage and recall of minimum and maximum values. Up to 100 data points may be stored for later printout or transfer to PC.

Many critical sizing parameters can be measured using the Spectrum 4 and its sensing probes. Beginning with residual moisture, a conventional hand roll attachment allows moisture measurement in the loom beam and at the drying zone exit. Simply walking the sensor across the warp sheet provides excellent information regarding the moisture profile including the presence of wet streaks resulting from squeeze roll imperfections and other influences. The new residual moisture sensing technology described previously for on-line instruments is also available for the portable instrument. Other probe attachments for residual

moisture include a yarn needle probe for insertion measurements of yarn packages and loom beams, a surface probe for open stock and other loose materials, and bale probes for insertion measurements of baled stock, before and after shipment from the gin.

High moisture measurements are also possible using the same sensing technology previously described for on-line instrumentation. A high moisture interface is available for use with contact type probe attachments, such as the hand roll and edge probe. The edge probe consists of two parallel sensing rods with an adjustable Teflon stop that fixes the sensing contact length with the warp sheet. The edge probe is used on both sides of the warp sheet at the size box and prewet applicator exits to measure wet pickup and side-to-side profile. Using the hand roll attachment, measurement of warp sheet moisture values through the drying zones can be made. These measurements can detect uneven drying gradients in the separate warp sheets that can cause ends to stick together when the sheets are brought together in the final drying section.

One of the most popular sensors developed for use with the Spectrum 4 is a speed and stretch sensor. Similar to conventional stretch sensors, this portable version uses two contact wheels which drive a high-precision rotary encoder to measure surface speeds at successive points through the lengthwise direction of the process. As these measurements are made successively and not simultaneously as done with conventional stretch monitors, line speed changes due to moisture control and other reasons must be prevented. Measurements may be made in either direction on the machine. Stretch measurements may be calculated in reference to the initial measurement point, such as at the loom beam or at the creel, or may be calculated in successive manner in reference to the previous measurement point. The former mode provides stretch

measurements at each point common to initial measurement point and the latter mode provide interval or zone measurements.

The wheels of the hand-held speed sensor ride in contact with the warp sheet, which allows self-aligning of the sensor with the direction of warp travel. This allows stretch measurement accuracy within 0.1 percent. Beginning in the creel, the stretch sensor is applied to one of the section beams. After an adjustable time interval, typically 3 to 4 seconds, a measurement value update occurs. This value is stored by keyboard command as the reference value for subsequent stretch measurements. Measurement is then made on the warp sheet entering the size box. Upon keyboard storage of the new measurement value, the first calculated stretch value is displayed. This value is the percent stretch from the creel to the size box. The next measurement is made on the warp sheet in contact with the first most convenient drying cylinder after the size box. This calculated value indicates the wet zone stretch. On machines with multiple size boxes, these measurements are repeated. Additional stretch measurements between drying cylinders can be made to ensure correct speed synchronization. Measurement is then made at the exit of the drying zone that indicates the overall stretch through drying or the stretch within the drying section itself. A final measurement is made at delivery to calculate overall stretch or stretch in the leasing zone. Depending on machine configuration and warp sheet threading, additional measurements would be made as necessary.

Another important sensor that is providing new information about sizing is a squeeze roll pressure sensor. This sensor utilizes a force-sensitive thin film that is 25 centimeters long and 1.5 centimeters wide for insertion between the squeeze rolls. The film, when placed between the squeeze rolls, produces a signal output that is equivalent to the total loading force applied by the nip. This value is related to the squeezing effect of the rolls on the warp sheet. According to roll width, the displayed value can be

scaled in units of pounds per lineal inch or kilograms per centimeter. This sensor is very useful in checking the uniformity of squeeze pressure across the roll width, as well as to make comparisons from size box to size box.

Other sensors available for use with the Spectrum 4 include yarn and beam hardness probe, and contact and non-contact temperature sensors.

The use of the Spectrum 4 allows operators and maintenance technicians the opportunity to quickly survey the sizing process. Storage of measurement values in a PC provides the opportunity to develop trend information on parameters related to machine maintenance as well as product quality issues. Very often, the quick and simple information provided by the Spectrum 4 can prevent off-quality loom beams from entering the weave room.

Finally, upgrade of the conventional portable moisture meter has been made. The analog meter has been replaced with a digital one. Digital calibration settings for the various fibers and blends are easily dialed in so that the digital display shows actual moisture regain values. This meter also includes the new residual moisture sensing technology providing better accuracy, sensitivity, expanded measuring range and suppression of static electricity. An added bonus is that all sensing probes used by the analog moisture meter are compatible with the new digital moisture meter.

Information provided by on-line and portable instrumentation keeps us informed about our sizing processes. Decisions affecting quality, efficiency, and profits are better served as a result of being better informed.