

Laser Based, Non-Contact Speed Sensor Reduces Breaks on High Speed Unwind

By precise matching of speeds between parent reel and expiring reel, mill is able to better control tension and reduce breaks during splicing operation. — By PETER NAWFEL

With high speed unwinds continually pushing higher speeds, speed matching of the parent reel to the expiring reel has become more critical. However, at these high speeds, typical methods of calculating speed may not suffice.

Measuring initial reel diameter at slow speeds in conjunction with RPM at high speed may not provide the reliability and repeatability required to meet process efficiency goals. Diameter expansion of the parent reel due to centrifugal force during acceleration and potential errors in the initial diameter measurement with traditional sensors can result in surface speed calculation errors large enough to create wide variations in tension, causing a break during splicing.

Laser Based Velocimeter

Experiencing a break a day with its existing unwind system, causing a significant loss of production efficiency, a U.S. based paper mill recently installed a laser based, non-contact speed and length sensor in conjunction with a new high speed (5,200-fpm) unwind supplied by Metso Paper. The mill believed that a high percentage of the breaks were due to mismatched speeds between the parent reel and the expiring reel.

Since it was installed in February 2002, online data from the Polytec LSV5000 laser velocimeter have supported the mill's analyses. A significant reduction in sheet breaks has clearly illustrated that precise matching of speeds during the unwind operation becomes progressively critical as paper machine speeds increase. Controlling tension during splicing has proved to be a key factor in attaining higher efficiency at the unwind station.

Laser velocimeters directly measure the velocity of a surface without contact by utilizing the proven technique of Doppler frequency shift. Laser light of a known frequency will shift in frequency as it scatters off the surface of a moving material. The velocity is determined by

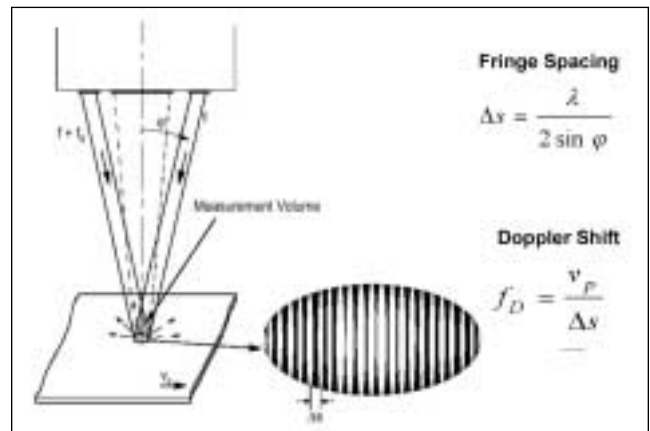


Figure 1. LSV Laser Surface Velocimeter for Noncontact Speed and Length Measurements

measuring this frequency shift, which is directly proportional to the velocity of the material. By integrating high-speed velocity data over time, the system can also calculate precision length measurements in real time.

These systems offer a variety of outputs, such as RS232/RS422, -10V to +10V, Quadrature Encoder pulse count, for easy interface of velocity and length data to process control systems. Also, 24V logic I/O is available to set up interlocks, such as laser on/off, open/close of external shutters, start/stop of the internal length measurement, and other logic functions. Figure 1 illustrates the operating principals of laser based velocimeter systems.

Laser Velocimeters can measure speed of all types of materials and, in addition to paper, have been used in a variety of industries including steel and metals, plastics, high-grade films, glass, textile, and rubber. The sensors are typically used when contact devices such as encoder wheels, tachometers, etc., do not provide an accurate measurement of product speed or length due to slippage, bad contact, thermal expansion/contraction, or when a contact device marks, scratches, or deforms the product to be measured.

Control Loop Integration

The mill's existing control loop was based on measuring the diameter of the parent reel at very slow speeds with an ultrasonic sensor. Final surface speed, at the time of splicing, was calculated based on this initial diameter measurement and the RPM of the reel at speed.

However, in practice, the mill found that at higher speeds the actual diameter of the parent reel increased with increasing speed due to centrifugal force. The result was an error in calculated surface speed at the time of splicing. Due to the increasing diameter, the true surface speed was greater than the calculated speed.

The LSV5000 verified that errors in calculated speed were indeed occurring and were as great as 20-30 fpm. Although the mill attempted online measurements of diameter at speed with various sensors, including ultrasound and lasers, they found that the readings were too unstable for controlling the drives.

Initially, the LSV5000 noncontact speed sensor was installed as a monitoring device to measure the true surface speed of the parent reel, with the quadrature encoder output integrated into the control system for future use as a possible feedback device. Review of the data after one week of operation showed a noticeable difference between the calculated speed and the true surface speed, demonstrating the correlation between surface speed and the variation in tension during splicing. Resulting data enabled the mill to predict when a break would occur due to mismatched speeds.

With this information, the mill immediately integrated the sensor into the control loop as a trim device to fine-tune the final speed of the parent reel before splicing. It has utilized this outer feedback loop ever since.

The new control loop measures the parent reel diameter at slow speeds and uses this value as the initial input for ramping the drive system roughly to the specified speed. However, once in range, the measurement from the LSV5000 is used to precisely match the parent reel with the expiring reel just before splicing.

By integrating the surface speed signal into the control loop, the mill now consistently matches parent reel speeds to within 5 fpm at about 5,000 fpm (0.1%). The control could be tighter, but this is sufficient for the particular process. The result was a significant reduction in tension variation during the splice, which eliminated breaks due to mismatched speeds.

Project Justification

In general, a missed splice can cost a mill from \$500 to \$8,500 for various operations, processes, downtime, and equipment. This is based on the cost of the discarded chemicals, lost paper product, possible slowdown of the paper machine, rescheduling of sets at the winders, and other issues. In addition to process and production losses,

matching of the reel speeds also minimizes mechanical shock and stress to the machinery resulting from the splicing event, which might reduce maintenance costs in the long run.



Laser Velocimeters measure true speeds of the paper web, directly and without contact, thus eliminating errors due to slippage, bad contact, or changing diameter.

By analyzing the total cost per missed splice and the number of missed splices related to mismatched speeds or tension, a mill can determine if a justification exists for such an upgrade. Installation at the mill discussed in this article achieved ROI in less than one year.

Conclusions

Laser Velocimeters are typically used when traditional contact devices do not provide appropriate measurement accuracy. Since they measure the true speed of the paper, directly, without contact, rather than a turning drum, wheel or motor, they eliminate errors due to slippage, bad contact, or changing diameter. They also eliminate quality issues due to scratching or marking of the surface.

In regard to the parent reel on a flying splice, due to centrifugal force the diameter will increase with increasing speed. A variation in diameter results in a variation of surface speed. Therefore, if the assumed diameter is incorrect, the calculated speed will be in error. This error could be great enough to cause a mismatch in speeds resulting in significant variations in tension causing a break during splicing.

The LSV5000 measures surface speed directly, thus providing an accurate, repeatable, and reliable method of determining the true speed of the parent reel.

Other possible laser velocimeter applications include:

- Precision length verification at the paper machine and winders
- Differential sheet speed for stretch or draw calculations
- CD speed variations
- FFT analysis of velocity variations on sheet, felts, drums, etc, for PPM applications

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