Reduce Costs and Process Variation with Microwave Instrumentation

By Frank Cunnane, Product Specialist, Cristini NA.

INTRODUCTION:

Since the introduction of planar microwave technology, new applications continue to be found for this investigative tool. Starting first in the forming section, it replaced older gamma gauge tools which require federal licensing, extensive record keeping, and the need for a Radiation Officer on site. This technology went forward into the press section, initially to measure felt moisture, then later to measure felt and sheet moisture, and now to measurement of the sheet consistency itself in open draw configurations.
In the past year these tools have been expanded to help control sheet properties as well as a new application for the TAD segment of the tissue industry, the fastest growing segment in the paper industry. Data is shown that allows predictable sheet consistency in the heart of the process. Work is ongoing to predict sheet consistency in Unorun sections. The results from that application will be published soon.

A. Principles of Operation

Older technology relied upon nuclear radiation from so-called “back-scatter” gauges. There were numerous issues with nuclear technology, not the least of which were inherent radiation risk, governmental regulation, having a separate radiation officer, and disposal of the radioactive source material after its useful life. A new generation of instruments has been developed using microwave technology. These units use less radiation than a cell phone and is safe to the touch.

(Figure 1 opposite) demonstrates that a fabric or a fabric/sheet passing over the head will cause a change in the flux of the microwave field set up between the incoming source (antenna) and the receiver. The fact that microwaves cause resonance in water molecules above the sensor, means that all the sensor perceives is the water itself, not the fiber, the fabric, or the surrounding machinery.

B.The Instruments Themselves

In the forming section the FiberScanOnLine can be mounted anywhere that the roughly 10 X 12 cm head can fit. Since the instrument does not see the machine framing in its measurements, tight fitting spaces can be accommodated between table elements.

Forming Section Microwave Moisture-measuring

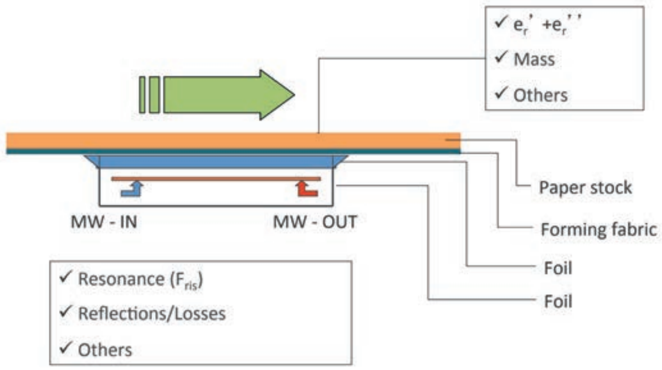
In tissue manufacturing, most forming sections allow little or no access for measurement of water content, so we will focus on applications in the press section and in TAD manufacturing.

Press Section Moisture Measurement

In the press section, there are two instruments that can be used. The first, the PresScan (Figure 2 opposite), is used to measure felt moisture, and felt/sheet moisture combined. Standard applications involve determining the efficiency of uhle boxes and doing water balances to determine the relative contribution of each dewatering element. The most common application is in reducing vacuum consumption for uhle boxes and suction rolls.

These instruments are also available with traversing scanning capability. These units measure felt moisture, permeability and temperature. These EasyScan units are equipped with sophisticated 3D felt mapping capability and can be interfaced with the machine’s DCS. A portable version of this felt scanning unit called the PermFlow DUO is used for manual felt traversing.

Figure 1: New planar sensor operates without a resonance chamber



Real-time permeability profiles present opportunities for cost savings and process control heretofore not possible.

The Fixed Head for Measuring Felt and Felt/Sheet Moisture

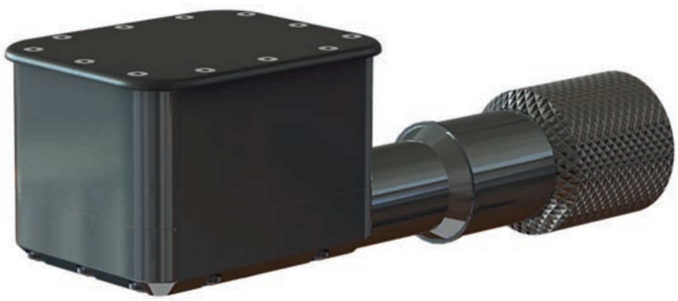


Figure 2: The microwave field generated by this sensor measures a high range of moisture-containing media.

Sheet Consistency Measuring Sensor

For applications that need to measure sheet consistency with high accuracy in open draws or on fabrics such as TAD or Transfer fabrics, there is a third instrument, the SmartScan. This instrument, shown in (Figure 3 overleaf) measures lower moisture values with extreme accuracy. The unit will provide +/- 1 gsm resolution, so that even lightweight sheet consistencies can be measured accurately.

In the past, only heavy weight sheets could be measured in open draws because the sensor head had to be in contact with the sheet, and only special cases could tolerate this without the risk of sheet breaks. Our "new generation" technology now allows the sheet to be as far as 10 millimeters away from the sensor head and still provide +/- 1 gsm resolution, so that even lightweight sheet consistencies can be measured accurately.

In the past, only heavy weight sheets could be measured in open draws because the sensor head had to be in contact with the sheet, and only special cases could tolerate this without the risk of sheet breaks. Our "new generation" technology now allows the sheet to be as far as several millimeters away from the sensor head, and still obtain a high accuracy and precision (+/- 1gsm water content).

This unit is being evaluated for the "holy grail" of tissue manufacture, ie, measuring Post Pressure Roll Consistency (PPRC) on the Yankee dryer itself. As work progresses, additional papers will be made public

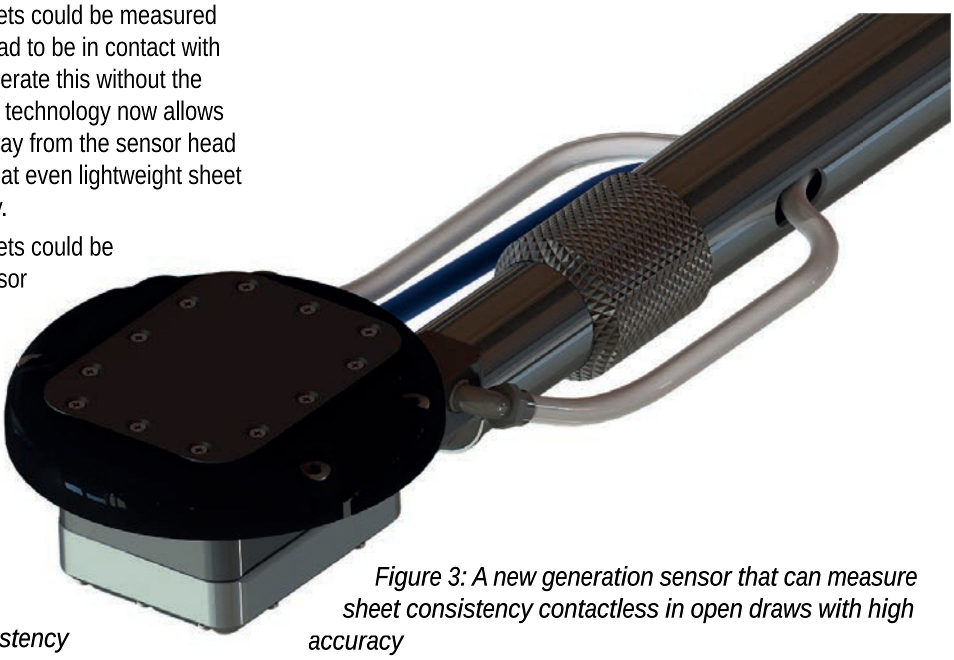


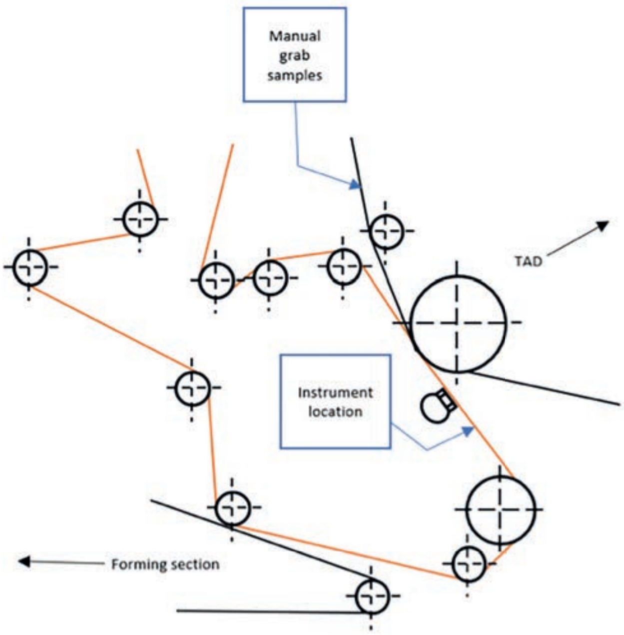
Figure 3: A new generation sensor that can measure sheet consistency contactless in open draws with high accuracy

CASE STUDY ONE

For The last 15+ years, the greatest expansion in the paper industry has been the TAD segment. The complexity of these machines frequently present challenges to the installation of instrumentation, but recent work with paper companies has shown that microwave moisture measurement is possible and provides accurate sheet moisture levels without the need for grab samples. Obtaining grab samples can be a safety risk, and the lab-measured consistency is often called into question.

(Figure 4) is a simplified drawing of where the instrument was located vs. where the grab samples were obtained. The vacuum box shown on the drawing was not in use for the purpose of these trials.

Figure 4: shows location of the instrument, and the location of where lab samples were obtained.

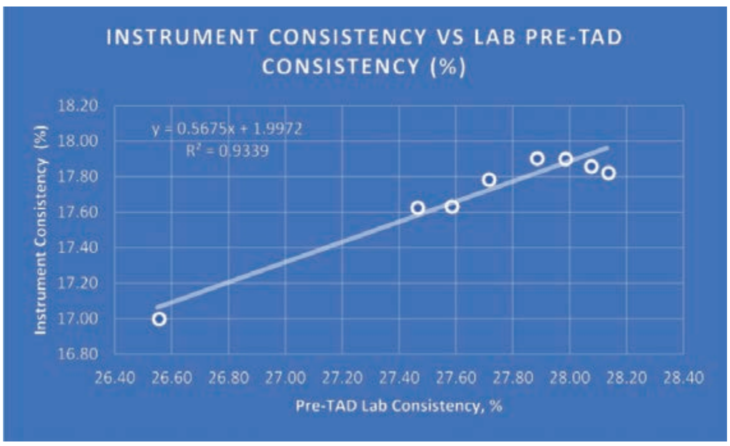


In our first round of trials data was gathered that compared the microwave instrument readings to grab sample lab readings while various process variables were changed, designed in improve and/or reduce water removal performance. These results are shown in Figure 5.

The R squared value indicates how well the data conforms to a linear regression. The 0.93 level shows that the data has a good correlation to a straight line, but as obvious on the graph, the absolute values don't agree.

The microwave transducer produces a field that is several cm wide and several cm high. The exact location of wherein the field that the fabric and sheet matrix pass through the field, needed to be corrected. When this adjustment was made, subsequent measurements across numerous grade changes showed excellent correlation comparing sheet water content to total water content in the sheet and fabric (Figure 5). It is a straightforward conversion from water content in the sheet to consistency by removing the water content of the fabric.

Figure 5: shows a good level of R-squared (coefficient of determination).



Correlating Sheet Moisture to Total Moisture in the Fabric/Sheet Matrix

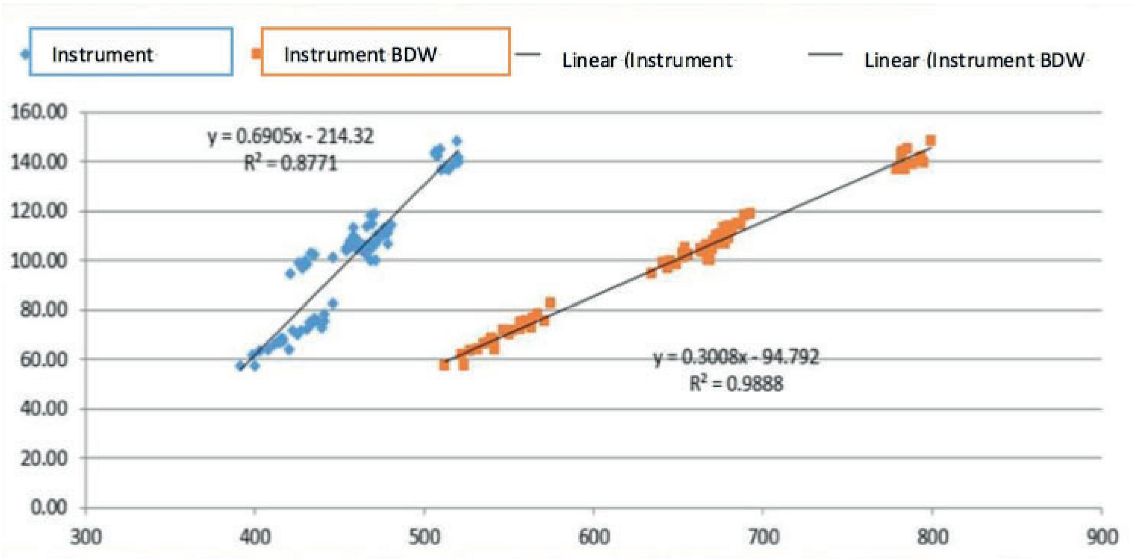
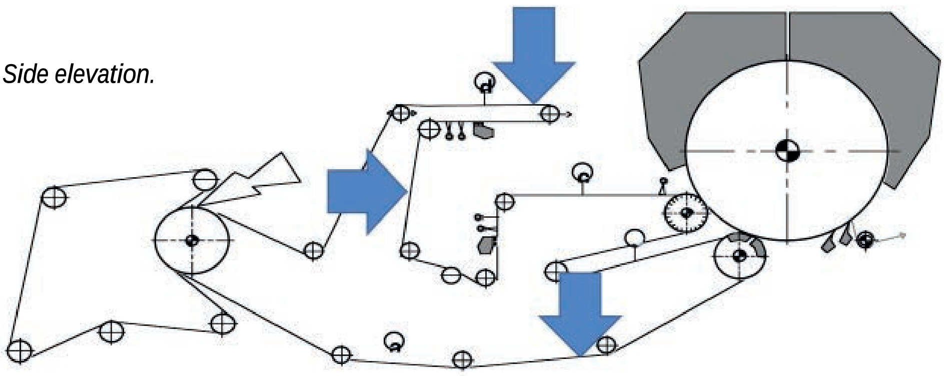


Figure 6: Above shows various sheet weight trials and comparing total water mass, x-axis, to sheet water weight. Note the high level of the coefficients of determination.

Machine configuration showing position of sensors

Figure 7: Side elevation.



CASE STUDY TWO: Elimination of Vacuum Pump and Reducing Overall Vacuum Levels

Studies have established that there is a fairly wide range of felt moistures that will not affect sheet moisture, whereas, above a certain limit, it will. In daily mill operation, the "more is better" theory often applies to vacuum application at uhle boxes, frequently resulting in excess vacuum, higher press section drive loads, and premature felt wear. At this crescent former mill, we installed 3 fixed moisture measuring heads (before the uhle boxes, between the 2 uhle boxes, and after the uhle boxes). See (Figure. 8.) There was a liquid ring pump supplying the pick-up roll and the 2nd uhle box, while a blower system supplied all other vacuum to the machine.

Water Content and Energy Consumption Over Time

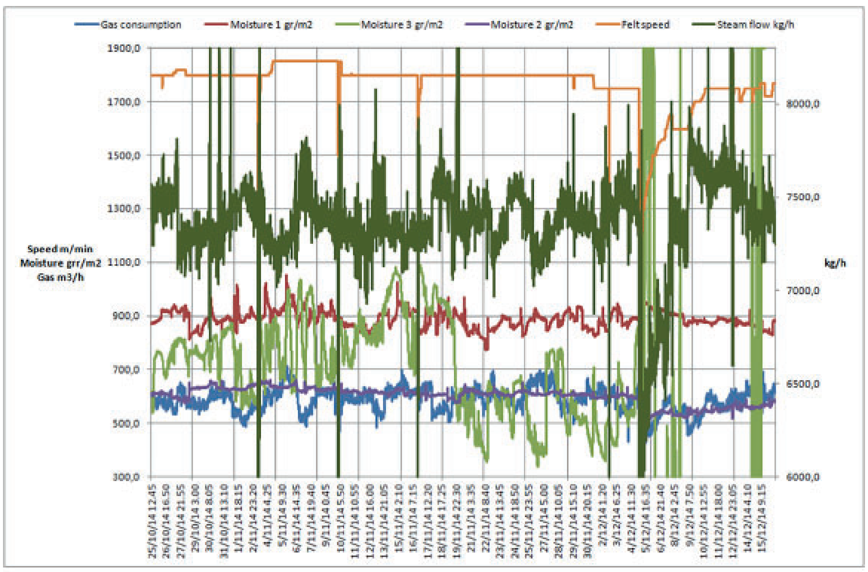


Figure 8: Plot of energy and moisture vs. time showing erratic measurements during felt start up.

Change in Moisture Content (Before Nip – After Uhle Box vs. Energy)

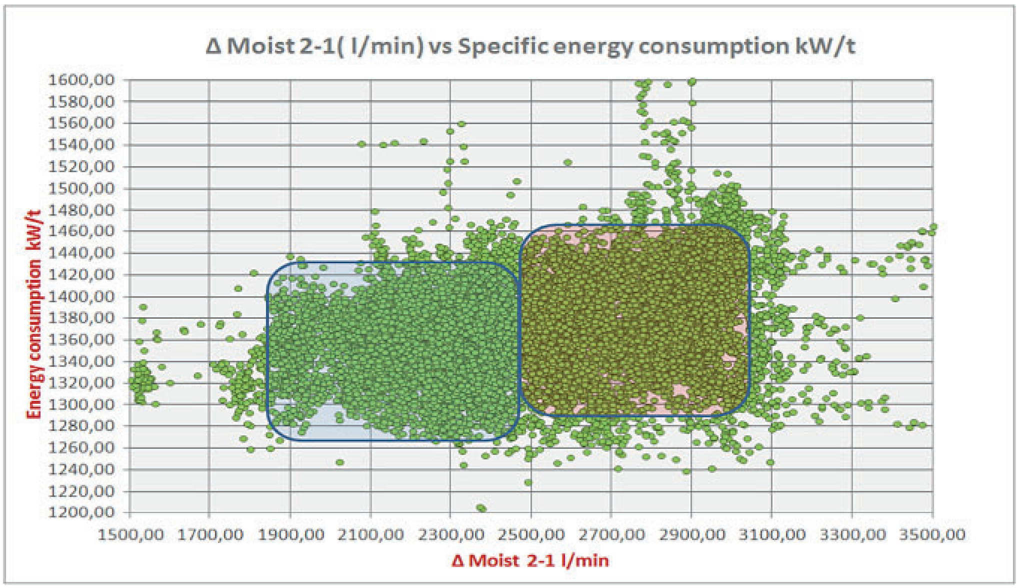


Figure 9: Energy Savings Possible by Controlling Felt Moisture.

In a series of stepwise reductions, vacuum was reduced until sheet dryness was affected. It also became obvious from our measurements, that the 2nd uhle box was ineffective. Through these trials, we were able to redirect vacuum from the blower to the pick-up roll, and totally eliminate the liquid ring pump and the 2nd uhle box.

Summary of Savings

- 2% of 2260 kWh blower reduction: 45 kWh
- 1 Liq. Ring Pump shut down: 190 kWh
- Total: 1900 MWh/year

CASE STUDY THREE: Energy Savings and Process Control Enhancement

FFT Analysis of Energy Data Shows a Peak at 8 Hrs.

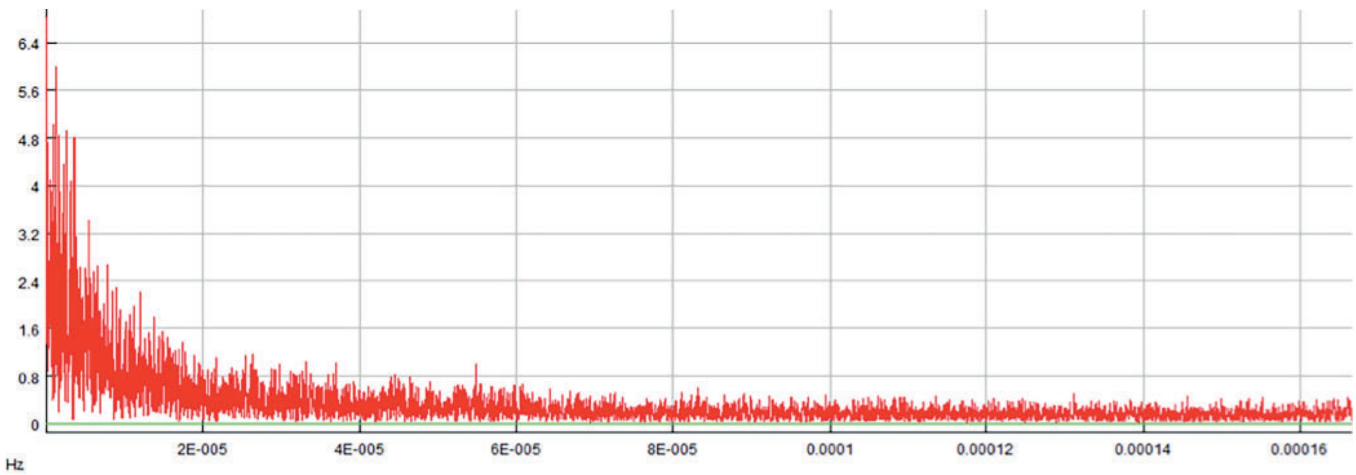


Figure 10: The frequency graph of the data shows discrete periodicity at 8 hrs.

In this study continuous measurements were taken with the 3 heads and compared to energy consumption on the machine. A chart of these measurements is shown in (Figure.10.above) The moisture content from the heads were plotted continuously along with the energy being used to dry the sheet. By correlating the amount of water removed (felt water content with sheet on, minus felt moisture after the uhle boxes, to the amount of energy consumed during the felt start-up phase, we established a bi-modal distribution (Fig. 11 opposite). By comparing the population of felts with high moisture removal after the uhle boxes (≥ 2500 l/min. vs those lower than 2500 l/min.), it can be shown that the population with the lower total water eliminated though the interaction among flooding showers, high pressure cleaning showers, and vacuum dewatering, also consumed 2.2% less energy.

Data Plot During the "up" Phase

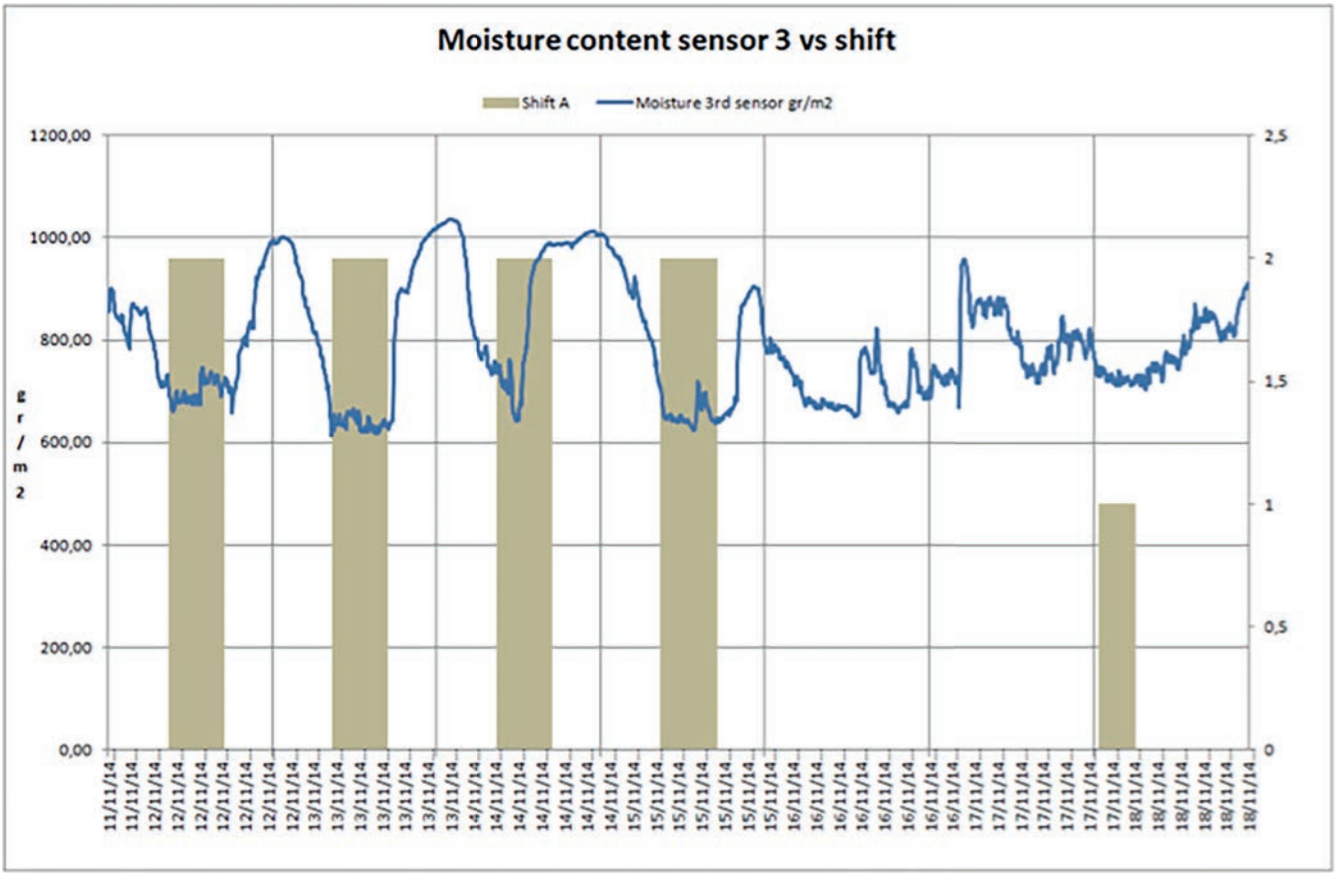


Figure 11: Moisture data from sensor shows that each shift has their own conditioning strategy

Furthermore, when the FFT software was applied to the sensor data, it became obvious where the differences were coming from (Figure.10). The peak amplitude from the data plotted on a time domain, was at 8 hours, which coincides with shift changes. The crews had been given the freedom, in lieu of having hard data, to manipulate the showers and uhle box vacuums as they saw fit during the start-up phase of the felt's life. With hard data available from the moisture sensors, felt moisture can be controlled to the levels that will minimize energy levels and thereby maximize production. This periodicity can be seen in (Figure. 11.)

CONCLUSIONS

- New moisture measuring instrumentation is available for the forming and press sections that can be either traversing or fixed, providing flexibility to the user.
- These instruments can monitor and control consistency in the forming section for precise incoming or outgoing moisture levels.
- Onboard software in these instruments can perform vibration and pulsation analysis for predictive maintenance and process control.
- Significant energy savings and improved process control can result in short ROI.