Drainage and FFT pulsation analysis using high speed microwave meters

FiberScan™ has set new standards in the PMC industry **By Giovanni Cristini and Luca Canali**

Over three years ago, Cristini Group introduced to the market FiberScan™, the world's first microwave consistency meter (pictured below).

For the first time, critical ionising radiation equipment was replaced forever with a harmless, easy to handle and transport microwave instrument.

The instrument is the fruit of research, which took over five years with microwave engineering to read water density and over 10 years of microwave technology development. The research involved Cristini Group laboratories, universities, excellent research centres and many engineers using the instrument daily.

This new and innovative application of the microwave has changed forever the technology and principles of the drainage instrument, setting what is became a standard in the PMC industry.

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Fig. 1: FiberScan™, the world's first microwave consistency meter

DEVELOPMENT TARGETS

When developing the instrument, one of the main targets was not only to replace instruments emitting ionizing radiation, but also to boost the use of the equipment, improving its performance and the possibility to collect data on positions where the traditional gauges where limited by their technologies.

An advantage of the instrument microwave technology is that it reads purely the amount of water on top of its measuring head. Therefore, the synthetic forming fabrics are totally transparent to the measurement, and the water carried by the fabric itself can be easily and precisely measured by a separate measurement. With the traditional gamma backscattering gauges, the fabric mass is often a guess, not knowing exactly the fabric wear, etc; this parameter impacts on the precision of the dryness out of the couch roll calculations.

But the unique and most innovative part is the patent pending, measuring process: a unique algorithm, a dedicated processor and hardware virtually erase all the influences coming from the change of the water electric charge consequent to impurities, chemicals or temperature. The last feature added was the sampling speed. The sampling rate has been pushed to the limit to be able to see the eventual periodical problems occurring in the machine direction with a good resolution. The sampling speed is sufficiently high to evaluate turbulence on the foil elements, or to find other problems, such as fan pump fluctuations.

The high amounts of sample values are then processed by a mathematical algorithm (Fast Fourier Transform, or FFT) to plot an 'amplitude-frequency-histogram'. Through this method it is possible to find out the periodical variations (pulsations) in the forming section and to make pulsation studies in a fast and simple way.

READING HIGH WATER THICKNESS

The first difficulty of the instrument design was to be able to read high water thickness. Microwaves can be easily employed to read water thickness. Another story is to ready considerably high water thickness (in excess of 45mm), with one single measuring head, with the same high accuracy from the head-box to the couch roll, in the wide range of water characteristics.

This feature actually enables the new instrument to read with higher repeatability than traditional drainage meters of up to 48.000 gr/m2 of water thickness. This allows measurements to be taken over a wider range of machines from pulp to fine paper.

The example in Fig.2 shows the comparison between FiberScan™ microwave meter and the standard gamma backscattering meter. The first reading is over 46.000 gr/m2 of water.

REACHING NEW MEASURING POSITIONS

The microwave field emitted by the measuring head mainly follows and is contained by the stock thickness to be measured. This makes the instrument ideal to reach new positions (i.e. gap formers), where the readings taken with the previous instruments were affected by the vicinity of machine parts.

The example in Fig.3 shows the measurement taken on a high speed gap former, before and after the drainage shoe, with FiberScan™ and with a traditional instrument. The reading taken with the instrument has a correct trend, while the traditional gamma backscattering meter is clearly affected by the presence of the dewatering box, with a reading 1.200 gr/m2 higher than the real.

In our experience this new feature allows us to reach two to three new positions on gap or hybrid formers, compared to the traditional consistency meters.

DATA RELIABILITY AND REPEATABILITY

The high sampling rate, the microwave technology employed and the special sensor case design made the readings very reliable and with high repeatability. Fig.4 shows the comparison test performed on the same machine by the same operator, in the same conditions. The lower standard deviation (CV) of FiberScan™ is very clear compared to traditional consistency meters. This becomes more important closer to the couch roll, where a higher reading variation can heavily affect the precision of the consistency calculations.

HIGH SPEED FFT PULSATION STUDY

Paper machines are complicated mechanical systems which are susceptible to a larger number of problems or variations, some of them can affect the quality of the paper produced.

From this point of view, a paper machine can be seen as a gigantic multi channel tape recorder. The effects of mechanical vibrations, pulsations, control loop faults, non-uniform consistency of the pulp, together with a number of types of smaller scale random variation, all get written into the paper web. If not kept within limits, they can affect the efficiency of the manufacturing process as well as the paper quality.

The FiberScan™ measuring values generate a drainage curve in the same way as done with traditional drainage meters, therefore a drainage analysis.

In addition, the instruments have an additional setting option which permits to determine the amount of

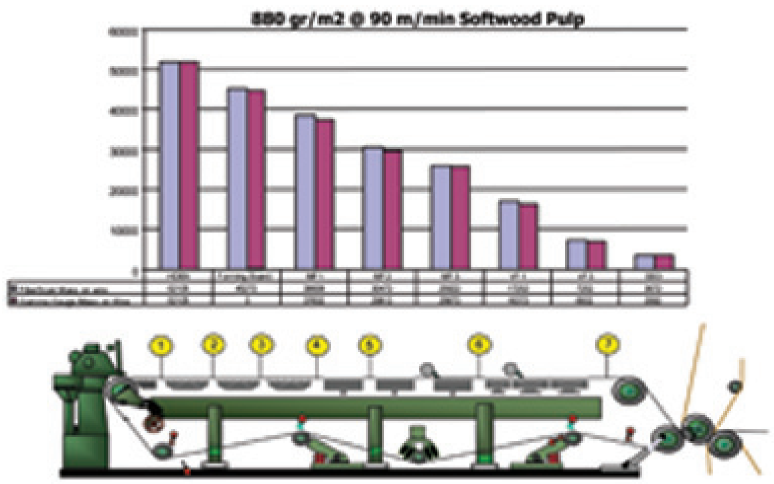

Fig 2 *Capability of reading high water thickness*

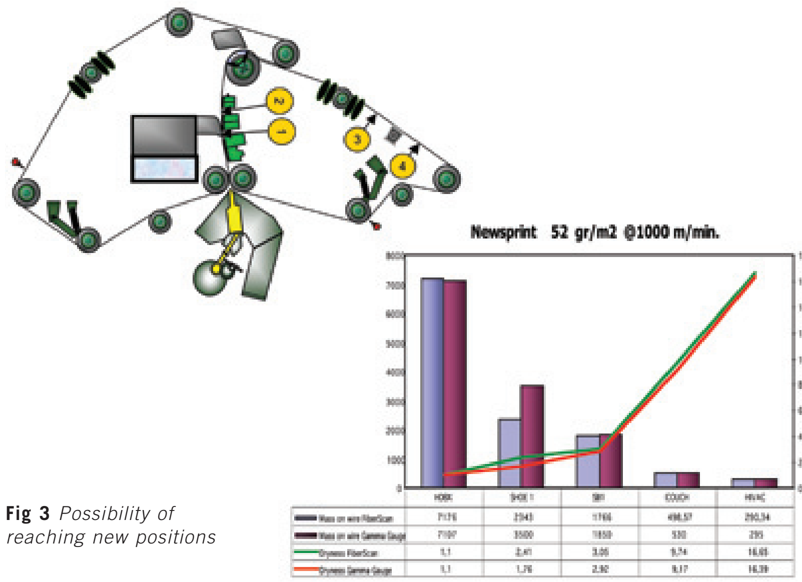

Fig 3 *Possibility of reaching new positions*

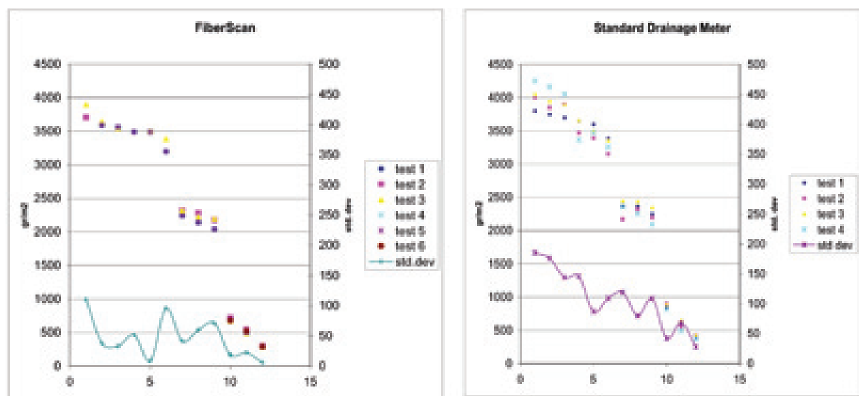

Fig 4 *Repeatibility of the readings: CV analysis*

water for a longer period, continuously with a high sampling rate.

These high amounts of sample values are then processed by a mathematical algorithm (Fast Fourier Transform, or FFT) to plot an 'amplitude-frequency-histogram'. Through this method it is possible to find out the periodical variations (pulsations) in the forming section and to make pulsation studies in a fast and simple way.

SUMMARY

A new tool for the paper machine drainage evaluation is now available. Its new and innovative features will permit to get on target and solve new paper production problems, using for the first time harmless microwave technology.

In the past to find out pulsation frequencies, a larger number of diagnostic and measurement tools were needed. This type of analysis was expensive and required considerable amount of time.

FiberScan™ now allows fast and simple pulsation studies in the forming section. It gives an accurate frequency analysis (FFT) which lets the diagnostic service engineers to find the origin of pulsation and turbulence problems.

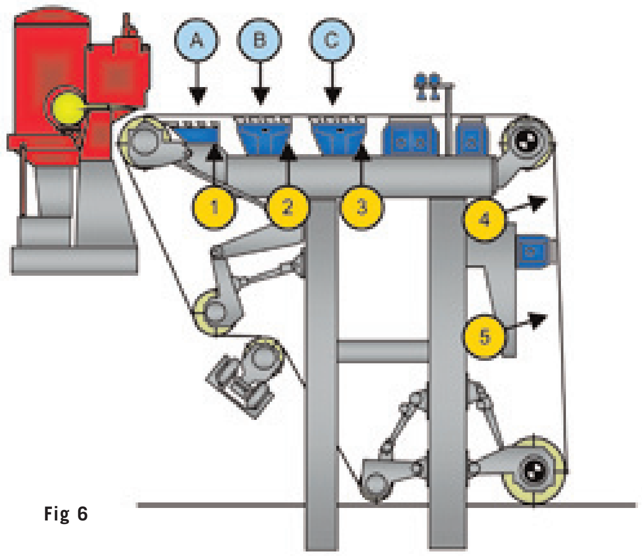

Fig 6

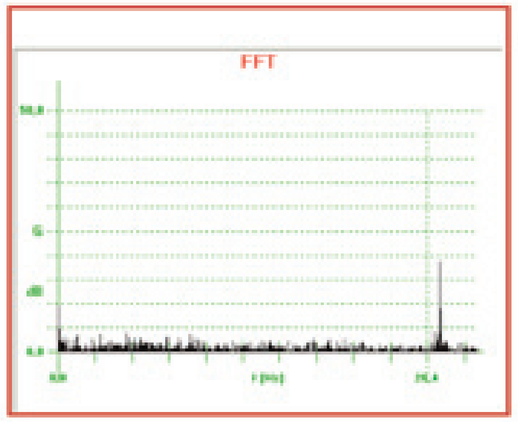

Fig. 7 *FFT spectrum @ point 1*

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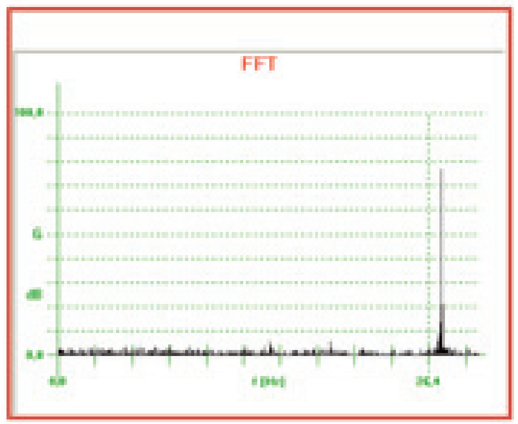

Fig. 8 *FFT spectrum @ point 2*

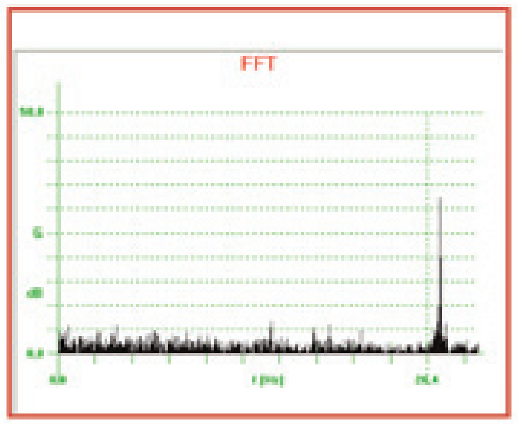

Fig. 9 *FFT spectrum @ point 3*

Practical case study

An Austrian folding box board machine was facing a sudden and uncontrollable production problem. This problem led to un-sellable paper quality, paper breaks and production losses.

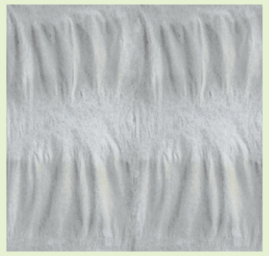

Fig. 5 (left) shows the paper surface; the phenomenon was described as paper mass variation, moisture and caliper streaks. These streaks were fluctuations of the basis weight in machine direction, completely parallel, always the same distance over the paper width. The darker streaks were clearly related to higher basis weight. This leads to different paper characteristics in relation to the target basis weight, thickness and moisture.

The paper weight and thickness variations where apparently pulsations; this could involve several types of operating equipment (e.g., mixing pumps: flapping of blades of the traversing wheels, vertical sorter, rotor frequency), random turbulence, mechanical oscillations, air in the stock system, foil set up and vacuum system.

Several investigations and trials were conducted to solve the problem. These involved the control of the air at the head-box flow system and in the de-foamer, bypassing the cleaner, checking the vertical sorter rotation, the diffuser in the headbox and the jet angle adjustments. After all these tests it was still unclear if the problem originated in the head-box approach flow system or in the forming section by means of the foil design/ layout or the vacuum pumps.

One last doubt was if the paper streaks where intensified by the vacuum system effect.

FiberScan™ was calibrated and adjusted in a way that immediately after the pulsation measurement (FFT) was then started a standard drainage mass measurement. In this way the conditions during the measurements were identified for the pulsation study. Thus, conclusions of the drainage behaviour and their influence on the FFT analysis can be taken into consideration.

As shown in Fig.6 it was possible to measure the points 1-5. In order to be as accurate as possible, white-water consistency samples were taken from every possible element A-B-C, then analysed in the lab. As already mentioned, the FFT and the water mass measurements were taken together.

Results:

Already at the first measuring point – immediately after the forming board – a dominant frequency of 26,47 Hz. with high-amplitude was evident (Fig. 7). This reinforced itself with the work of the Varioline boxes up to amplitude of more than 150dB (Fig. 8). After the divert roll the frequency is substantially weaker but still clearly obvious (Figs. 9 - 10).

With the FiberScan™ measurements and its FFT analysis it was possible to define the frequencies and to focus on the area where the problem started.

Based on our measurements and the frequency of 26,27 Hz, it can be clearly stated that the reason for the unstable streaks were to be investigated in the approach flow system, particularly in the fan pump.

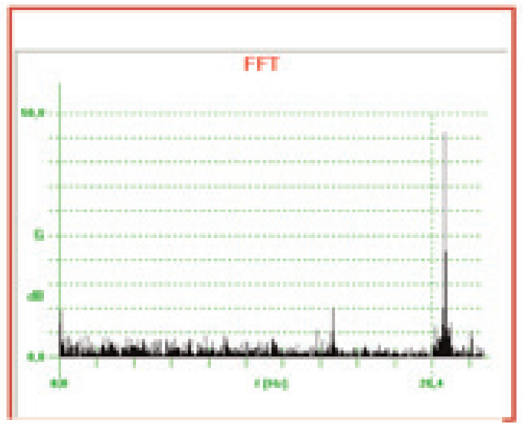

Fig. 10 *FFT spectrum @ point 4*

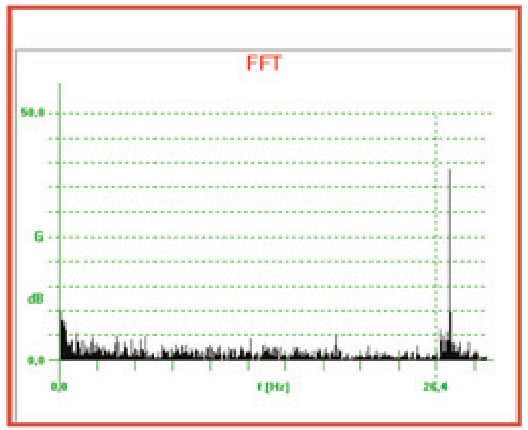

Fig. 11 *FFT spectrum @ point 5*