NIR Analysers: Farm to Factory

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Introduction:

NIR analysers are now available for use in all aspects of food production, from Farm to Factory. Next Instruments is an Australian company that specializes in designing and manufacturing NIR analysers for use by farmers, grain traders, grain processors and food manufacturers. The challenge has been to design instrumentation that is powerful yet simple to operate and maintain. Farmers often have science and engineering degrees, but their primary job is to grow and reap their crops. As such the tools that they use to assist them in this process need to be easy to use, rugged and reliable. Grain buyers and grain processing companies, typically have a laboratory or at least an office to operate instruments, but still the instruments have to perform the tasks quickly and simply and the information generated must be easily accessible in this digital age. Food manufacturers want to use information to improve their product quality and their operational productivity. NIR analysers can play a useful role in the process of taking grains and oil seeds from the farm to the supermarket shelves.

Description

Next Instruments broad range of NIR analysers is based on a simple diode array spectrometer that has a small footprint, has no moving parts, is relatively low cost to manufacture and is rugged and reliable. Figure 1, shows a schematic of this diode array spectrometer. Light from a tungsten halogen lamp shines through a sample of grains, powder, slurry or liquid. The light energy is absorbed by the protein, moisture, oil and sugars present in the sample. The transmitted light is focused into the spectrometer where the light gets separated into its component wavelengths. The separated light, called the NIR spectrum, figure 2, is projected onto a silicon photodiode array detector that are also used in photocopiers and flatbed scanners. The detectors in the array measure the intensity of the light that hits each detector. Protein absorbs at a specific wavelength, 1020nm, water at 970nm, oil at 905nm and sugars at 820nm. By measuring the amount of light that hits each detector elements, then the amount of light absorbed at each wavelength can be calculated. This allows the instrument to measure the concentration of each component. The more light that is absorbed, the higher the concentration.

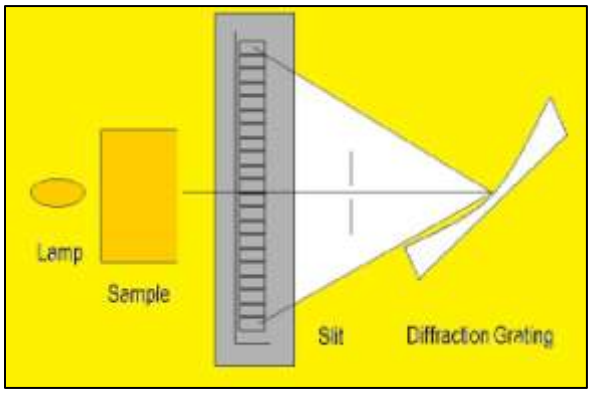

Figure 1. Schematic of Diode Array Spectrometer

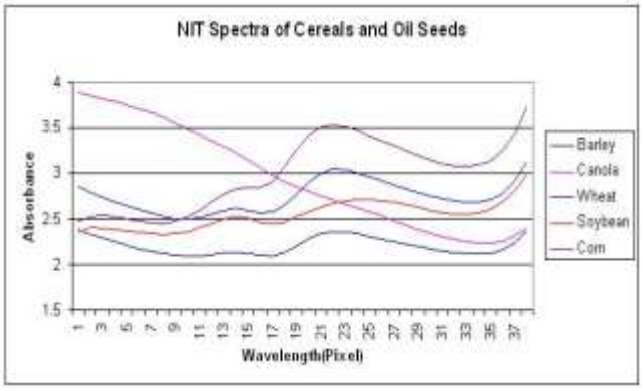

Figure 2. NIT Spectra of Grains and Oilseeds

Typically this simple diode array spectrometer weighs 7kg and is the size of a lunch box. The spectrometer can be fitted to an instrument chassis with the appropriate sampling mechanism to make a NIR analyser for many different applications.

On Farm NIR Analysers:

The CropScan range of On Farm NIR Analyser includes the CropScan 1000 and 3000 configurations. The CropScan 1000G, figure 3, is a portable whole grain analyser designed to provide farmers with the ability to measure their grains before the truck leaves the farm gate. The 1000G can be run from a car adapter and suits operation in a utility vehicle, a tractor or a combine. Grain can be analysed in less than 60 seconds for protein, moisture and oil. The farmer can use the information to segregate the crop by protein and oil in order to capture higher grade premiums. The superior accuracy of the NIR for measuring moisture provides farmers with the ability to know when to strip and when to dry their grains.

Figure 3. CropScan 1000G On Farm Analyser

Figure 4. CropScan 3000H On Combine Analyser Components

The CropScan 3000H On Combine Analyser is the only proven whole grain analyser to operate on virtually any combine harvester. The 3000H consist of three parts, 1) Remote Sampling Head, 2)NIR Spectrometer and 3) Touch Screen PC Controller, figure 4. Grain travelling up the clean grain elevator on the side of the combine falls into the Remote Sampling Head where it trapped for several seconds while the NIR spectrum is collected. The light that passes through the sample is transmitted back to the NIR Spectrometer located inside the combine's cabin. The NIR Spectrometer is described above. The Touch Screen PC Controller generates the NIR Spectrum and applies the calibration models stored in the PC's memory. The protein and moisture, for wheat and barley and protein, moisture and oil for canola, are displayed on the PC screen. The PC controls the Remote Sampling Head whereby the flaps are opened and the grain drops out and returns to the downside of the clean grain elevator. The flap closes, the Sample Head fills up and another NIR Spectrum is collected. The system collects data at approximately 12 second intervals. Each reading is tagged with the GPS coordinates so that Real-Time Protein Paddock Maps can be displayed on the PC screen, figure 5.

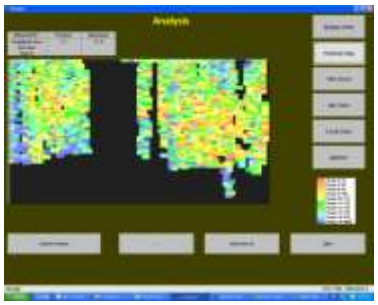

Figure 5. Protein Paddock Maps

Figure 6. CropNet Software

The CropScan 3000H can send the data to the internet where it can be remotely monitored from a Smart Phone, Tablet or office PC. The CropNet Grain Data Management Software suite provides all the tools necessary to store the data in the Cloud and then access it from anywhere in the world. Figure 6 shows an example of the CropNet software.

NIR Analysers for Grain Traders

NIR is used throughout the world for determining the protein, moisture, oil, fiber and starch in grains and oil seeds. In the 1970 to 1990 period, NIR analysers worked in reflectance and measured ground or powdered materials. From the mid 1990's whole grain analysers working in transmission have virtually superceded the reflectance analysers for buying and selling grain. Whole grain NIR analysers are faster, easier to operate, less dust, no sample preparation and measure a lot more grain to provide a more accurate result for protein, moisture and oil.

Figure 7. CropScan Whole Grain Analysers

The CropScan 1000B and 3000B, figure 7, are popular whole grain analysers used around the world. The 1000B includes a built in Test Weight Module and comes with adapters to measure seeds from canola and linseed to cereals such as wheat, barley and oats to large seeds such as faba beans and corn. The 3000B is a more sophisticated system with a built in Touch Screen PC. The 3000B software allows the operator to enter a number of data fields that are important for grain traders, ie, variety, farmer ID, Tonnage, Test Weight, Screenings and Retention, along with the protein, oil and moisture. The big difference between the 1000B and 3000B lies in that the 3000B does no require adapters to handle small to large seeds. The pathlength of the sample cell is adjusted automatically for each seed type.

Both the CropScan 1000B and 3000B can be interfaced to the CropNet Grain Data Management Software. CropNet can read a weighbridge monitor, the CropScan analyser, a Falling Number analyser , a GAC moisture analyser and a SeedCount Image analyser so that all data related to the grain's quality, source, tonnage, storage location and grade can be stored in a single spreadsheet. The data is automatically sent to the Cloud and can be accessed remotely from anywhere in the world through the CropNet web site.

NIR Analysers for Grain Processors and Food Manufacturers.

Companies that process grain into animal feed, flour, meals etc, use NIR in the laboratory as well as in line analysers in the factory. Likewise food manufactures use NIR for discrete testing of raw materials, goods in process and finished products. Food manufacturers not only measure grain and grain based products but also dairy and meat products as well as ingredients.

The major benefits offered by NIR analysis are speed and simultaneous multiple component measurements. However NIR is only a secondary technique and must be used in conjunction with laboratory or wet chemistry methods. As a guide, if a manufacturer or processor requires 5 tests per day, then wet chemistry methods should be used. However if the number of tests increase to 20 or 50 per day then a NIR analyser can be an economical and fast way to measure 90% of the samples but still use the wet chemistry methods for the other 10%. This ensures that the NIR method is monitored and if necessary, to be updated as new samples become available. The counter side to this argument is that if there are no wet chemistry methods available to monitor the NIR method then the accuracy and precision of the testing will be unknown.

Next Instruments offers a number of NIR analysers for grain processors and food manufacturers, figure 8. The MultiScan Series 2000 Near Infrared Transmission Analyser provides the ability to measure grains, powders, pellets, liquids and slurries. The MultiScan Series 4000 FTNIR Spectrometer is designed to measure powdered materials such as animal feeds, flour, milk and whey powder, chemicals, soybean products, corn starch, corn flour, rice and rice flour, powdered egg, sugars and starches. The MultiScan Series 5000 In Line Analyser provides continuous measurement of multiple components in a flowing or moving stream. These systems have software included to collect, store, plot and send the data to the internet or intranet.

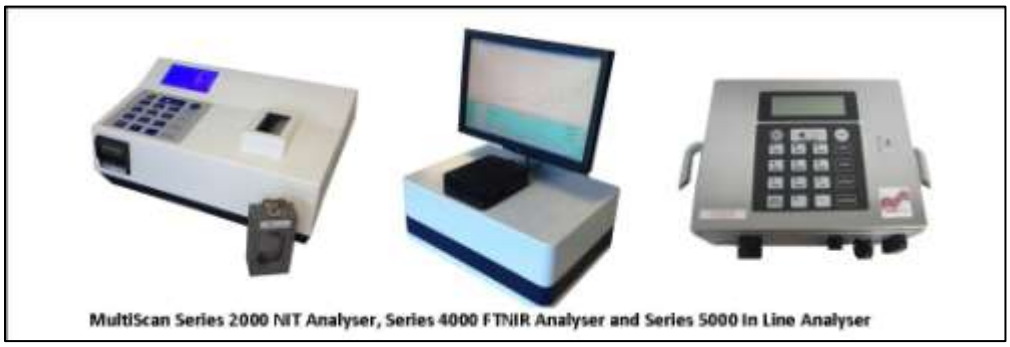

Figure 8. MultiScan Analysers

Conclusion:

NIR analysis is possibly the most diverse technique available in analytical chemistry. No other technology can measure five to six components simultaneously without any sample preparation. No other technology can be used to measure such a wide range of samples and forms of samples, ie, grains, powders, pellets, slurries, liquids and solids. NIR analysis is not a panacea for all analytical problems. It is generally not suitable for trace component analysis. The limit of testing is generally 1% for any single compound. NIR analysis is a secondary method and must be supported by primary analysis techniques. But overall, NIR analysis is the only technology that can be used from Farm to Factory.