NIR in Feed Mills

Introduction

NIR analysis has been utilised within both laboratory and production environments for decades.

Laboratory based systems are traditionally calibrated by scanning a large number of ground and homogenised samples, performing wet chemistry reference analysis on them and using sophisticated software to derive NIR models to describe the relationship between the NIR spectrum and the wet chemistry analysis. Samples being tested routinely have their analysis derived from prediction using a relatively small number of these "global" calibrations. Typically, in the feed industry, there may be one calibration set for each species of finished feed and raw material type.

These types of global calibration have also been used for in-line predictions in some production environments although the trend has never really caught on. This may be (in part) because of the expense in placing an in-line system onto each production line within a plant.

In more recent years, with advances in computer processing ability, it is now possible to perform "on the fly" calibrations by capturing a spectrum of the sample being analysed, picking the closest spectral neighbours from a vast database of spectra/reference values, and forming a calibration specifically for that one sample before discarding the calibration in preparation for the scan on the next sample. This approach offers the greatest potential for precision and accuracy with NIR. When placed in a "cloud" environment, it also offers a network of NIR instruments access to the latest calibration developments and avoids the need to circulate new global calibrations after each review.

This following is concerned with the potential options for looking into a "halfway" approach to providing NIR predictions on samples within a feed plant whether the samples be taken at intake or from production.

Basic Considerations

Where a production plant is considering the possibility of placing an NIR on site, that instrument must be used for testing both raw material at intake and finished product during process and/or dispatch. This means that the instrument needs to be located in a central and easily accessible location, ideally in a clean and environmentally controlled room.

If utilising non-laboratory-based people to operate an NIR instrument, the equipment needs to be:

- Intuitive in its use
- Easy to operate
- Robust

An important question to ask is what would be the maximum time allowed to obtain the analytical data on the sample. If the analysis is required immediately after capturing the sample spectrum, then this may rule out an approach where the spectrum is measured against a large database to produce a local calibration. We would therefore favour a small number of global calibrations on the instrument. It may also be the case that the grinding of a sample cannot be adopted due to time or equipment considerations and so the calibrations would need to be formed on "whole samples" rather than "ground and homogenised" samples.

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It is worth noting that generally speaking, global calibrations formed on whole samples demonstrate poorer precision compared to local calibrations formed on ground samples. For trend analysis, that may not be an issue as the mean values produced during a production run over many scans on many samples should be the same for both approaches. It merely means that there may be more variation (the lowest and highest values predicted) for individual samples during the production run. Care needs to be adopted in using the global calibrations on unground samples for the intake of raw materials and it may be that a larger number of samples from the material need to be taken to achieve an accurate mean value.

Consideration needs to be made as to whether the data produced by the equipment is to be captured in a data system. This is something where we have experience and partners able to offer an integrated solution where all data captured by an NIR instrument can be directed back to a central database.

A further consideration is whether a database of samples within the Business already exists. It may be that further calibration development can be developed by using this as a starting point. However, it is worth noting that starting from an existing foundation is not always the best approach from an economic perspective.

Financial Considerations

Recent developments have seen a number of different NIR Instruments coming into the Marketplace. In particular, handheld devices not only provide flexibility as samples can be scanned throughout a production plant but can be purchased at a much more cost-effective price point compared to a benchtop NIR instrument.

If a single NIR machine is being placed into a single production environment, choosing between a benchtop and handheld device may not generate a significant cost differential for the project once the cost of calibration development is also factored in. Once we start to look at 10+ instruments, then the situation can be somewhat different. Handheld devices can start at the £5k price point up to (say) £25k whilst benchtop instruments can cost in excess of £50k. Hence, choosing between the cheapest handheld and the most expensive desktop can change the economics of the overall project by nearly £500k across 10 instruments! It is therefore important to choose the most cost-effective instrument that is “fit for the purpose” at the outset.

Starting Point

A feasibility study is the way in which an assessment of the most appropriate instrumentation can be made. This project need not be too complicated or last too long. For example, it may be that one Feed type (e.g. Pig Feed) and one Raw Material type (e.g. Wheat) are chosen for the feasibility study. Scans of ground and unground material can be captured on a small number of instruments for 100 samples of each type and the wet chemistry reference values obtained (choosing key nutrients such as Moisture, Oil-A, Protein, Starch and Crude Fibre for example). Calibrations can be developed, and the instruments/calibration approach evaluated. An ideal scenario would be where an assessment of the transferability of calibrations to a second instrument of the same model also takes place, this being an important consideration for a Network of instruments.

We would expect that given the fact that 10+ instruments may be purchased, instrument manufacturers would be accommodating with the loan of 1-2 machines for 1 month to help progress this study. We would be happy to assist in drawing up a shortlist of suppliers/models.

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Project Implementation

Once a feasibility study has been completed and an instrument chosen, the process of calibration development is relatively simple. We have extensive experience of calibration development in-house which covers the requirement needed to satisfy UKAS accreditation on NIR analysis.

Collection of samples from all production locations would need to take place in order to fully represent the population of samples that the networked system would encounter. Whilst calibration development is underway, it would be possible to determine how many global calibrations would be required and also whether there are any geographical differences that require us to provide specific models based on geographical areas.

The key aspect with NIR work is that the foundations need to be maintained. In this case, that being the database of spectra and wet chemistry reference values and the representation of changes with time at each opportunity.

Ongoing Maintenance

With the NIR instruments being monitored over a Network, it would be simple to ensure that daily checks were in place in order to verify the instrument before scanning takes place. Depending on the model of instrument chosen, it should be possible to supply sealed “reference samples” for the daily checks and these could be updated (say) annually.

In order to assess the operation of the instrument at each site, some form of Performance Testing Scheme would need to be introduced to further check operator and instrument performance, the net effect being that training and instrument maintenance can be identified at the earliest point in time. This is specifically required if the Network were to seek any form of formal accreditation for the analysis being produced by the instruments. Of course, it is also important in helping to ensure that the mean values reported by an instrument continue to be accurate.

There also needs to be some form of validation/development programme where the Master instrument used for calibration development is presented with fresh samples/reference data to validate the system and further develop the calibrations. This is an area where many projects ultimately fail in time as calibrations are not updated to reflect changes in raw material use, manufacture process or changes in the instruments themselves.

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