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Review on Grain Moisture Content Determination Techniques

Supriya

ME (Electrical Engineering) NITTTR, Chandigarh (INDIA)
E-mail: supriyasingh.er@gmail.com

Abstract—*Agriculture plays a vital role in stabilizing the economy of the country as it is the third largest sector of India's economy. Moisture content is the most important characteristics of cereal grains affecting their suitability for harvesting, storage, transport, and processing. The rapid, non-destructive, reliable sensing of moisture content in cereal grains and other agricultural crops is essential in modern agriculture for prevention of losses and improvements in efficiency of production. A variety of techniques have been used for the measurement of moisture in grains and better results have been achieved with the use of new techniques. Spectroscopic moisture analysis methods are of considerable interest as they are non-destructive, efficient and accurate techniques. A variety of techniques have been developed over time and provided improved results.*

Keywords: *moisture determination, electrical methods, spectroscopy.*

1. INTRODUCTION

The term moisture refers to the presence of water, often in trace amounts in matter. Moisture content is usually measured from weight loss after drying the feed. Moisture content in grain is related to the relative humidity and the temperature of the surrounding air. Equilibrium moisture content point is the point when grain no longer losing or gaining water when contacting with drying air. The final moisture content of the grain is up to the amount of moisture in the drying air, which is the relative humidity. The low relative humidity means air is dry and it has a large potential of picking up water. The lower the relative humidity is, the drier the air is. In general, one-half reduce in relative humidity is caused by 20° degree increase in air temperature.

Moisture content is critical from harvest, through storage, to final sale of cereals and oilseeds. If moisture is too high, there is a risk of quality reduction, or even crop loss in store. On the other hand, excessive drying is wasteful and can lead to reduced returns. Balancing these opposing risks is not easy due to the variable nature of grains within a bulk and the inherent difficulties of measuring grain moisture accurately.

Cereals and oilseeds which are too moist in storage can be subject to:

- Mould growth and mycotoxin production
- Mite infestations, especially in rapeseed
- Heating due to moulds and mites
- Sprouting.

Grain which is over-dried before, or during, storage can result in:

- Splitting and cracking
- Impaired quality, particularly in rapeseed
- Wasteful energy use.

Grain contracts specify moisture content which, if not met, will result in penalties [1-5].

2. MOISTURE DETERMINATION TECHNIQUES

Moisture content measurement techniques of grain can be classified into-
i. Primary method

ii. Secondary method

Primary method of moisture measurement is based on weight measurements. Oven method and infrared moisture balance methods are the standard methods used to measure amount of water by removing it from the sample and then measuring it. Primary methods are often used as reference methods. Laboratory type electronic weighing balance is used to weigh the sample before and after drying it. The moisture can be determined based on the difference in weight of sample.

Secondary method measures moisture using an electronic instrument that uses electrical characteristics of the grains. Capacitive moisture content meter and Resistance moisture content meter are most popular and extensively used secondary methods.

2.1 Oven Method

Oven method works on the principle of evaporation of water at high temperature. Moisture content is calculated from initial

weight and dry matter weight. This is most exact method of all and taken as reference in research. Oven method takes long process time and it requires expensive oven with temperature control [6].

2.2 IR Balance

Infrared moisture balance method measures moisture by detecting the weight loss by heating and drying. This method is more accurate than quick moisture meters and it covers full range (0-100% moisture content). It has automatic operation but it takes long process time around 10 to 30 minutes [7].

2.3 Capacitive Method

In capacitive moisture content meter, grain is filled in between two plates of a capacitor. Since, water contents affects dialectical properties, moisture can be measured. This is more accurate than resistance type meters and thus more expensive. It is portable but requires larger sized samples [8].

2.4 Resistive Method

Since water affects resistance, resistance type meter measures moisture on the basis of electrical resistance of crushed grains. It has advantages like it takes fast readings, very portable, affordable, rugged and it requires small sized samples. Its moisture content range is limited and its accuracy is low [9].

3. MOISTURE DETERMINATION USING INSTRUMENTS

A number of instruments are being used to measure the grain moisture. The different types of grain moisture meters are available in market. The standard equipments like spectroscopes are direct type instruments whereas indirect type instruments are based on capacitance and conductance. Direct instruments are of very high accuracy and precision. The output of these instruments has to be further processed for calculation of moisture content. Fig. 1 shows the probe type conductance based grain moisture meter. The moisture can be measured by inserting the two probes in grain sample and measuring the conductivity between the probes. These instruments are available with temperature compensation now-a- days.

Fig. 1: Probe Type Grain Moisture Meter

Fig. 2: Tray Type Grain Moisture Meter

Another type of instrument readily available in the market is cup type instruments. The grains and seeds sample has to be poured in to this from upper side. This instrument is again conductance based instrument and is available with temperature compensation. Fig. 2 and 3 show such type of grain moisture meters.

Capacitive type grain moisture meters are also available in the market. Fig. 4 shows capacitive type grain moisture meter. The meter also has in-built temperature compensation circuit for compensating temperature variation effects.

All these meters are portable and can measure the moisture non-destructively with an accuracy of 0.5% when used within range. However these meters are quite costly and error is introduced on account of density variations in grains. Meter shown in Fig. 4 has density compensation but the meter is very costly.

Fig. 3: Cup Type Grain Moisture Meter

Fig. 4: Capacitive Type Grain Moisture Meter

Spectroscopic methods use different types of spectroscopes depending on different methods. However these methods are very costly and are generally not used for moisture determination of grains, so these methods require calibration for different types of grains. Fig. 6, 7 and 8 shows different spectroscopes that can be used for moisture content determination [10].

4. SPECTROSCOPIC MOISTURE ANALYSIS METHODS

Spectroscopic techniques are non-destructive, efficient and accurate techniques which can be used for multi component analysis. These techniques can also be used for continuous online measurements. However these techniques are very expensive and require calibration for different samples.

Fig. 5: NMR Spectroscope

Fig. 6: NIR Spectroscope

Fig. 7. UV Spectroscope

4.1 Near infra-red (NIR) spectroscopy

NIR Spectroscopy uses near infra-red region of electromagnetic spectrum (from about 800nm to 2500 nm). The main advantage is that NIR can penetrate much farther into a sample than mid-infrared radiation. The moisture content can be determined by getting the reflectance and transmittance from the sample. This method can also be used for measuring other parameters like fatty acids, oils etc. of grain. However, the technique has not been standardized so far for the agro products and calibration has to be done for measuring the quantities using this technique [11].

4.2 Nuclear magnetic resonance (NMR)

NMR is another spectroscopic technique that can be used to measure the moisture of grains. This method is an expensive method and requires sophisticated instruments along with skilled operator to operate the machine. Furthermore, the magnetic material in the grains can harm the instrument. This method, though very accurate is rarely used for moisture measurement [12].

4.3 Microwave Spectroscopy

Microwave Spectroscopy can also be used to measure the moisture content of grains and seeds. The technique is extremely less time consuming and continuous measurements are also possible [13].

4.4 Fourier Transform Infrared (FTIR) Spectroscopy

FTIR Spectroscopy is a measurement technique that allows one to record infrared spectra. Infrared light is guided through an interferometer and then through the sample (or vice versa). A moving mirror inside the apparatus alters the distribution of infrared light that passes through the interferometer. The signal directly recorded as an interferogram which represents light output as a function of mirror position. A data-processing technique called Fourier transform turns this raw data into the desired result (the sample's spectrum): Light output as a function of infrared wavelength (or equivalently, wave-number). The sample's spectrum is always compared to a reference [14].

Fig. 8: FTIR Spectroscope

Fourier transform infrared spectroscopy is preferred over dispersive or filter methods of infrared spectral analysis for several reasons:

- It is a non-destructive technique
- It provides a precise measurement method which requires no external calibration
- It can increase speed, collecting a scan every second
- It can increase sensitivity – one second scans can be co-added together to ratio out random noise
- It has greater optical throughput
- It is mechanically simple with only one moving part.

5. CONCLUSION

Moisture measurement is an important parameter for quality assessment of grains. The harvesting, storage and processing of grains depend on their moisture contents. Techniques used till date are time consuming and destructive. Spectroscopy is faster and non destructive. FTIR spectroscopy is simple compared to other spectroscopy methods and it provides full range of resolution.

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