THE USE OF A DIELECTRIC MOISTURE METER IN THE SUGAR INDUSTRY

Introduction.

The introduction of bulk storage and shipment of raw sugars posed new problems for the sugar technologist. One is the evaluation of the keeping qualities of the different sugars, coming from different factories, just before unloading in the bulk store. The risk of sugar deterioration on storage is very much minimized if sugars with high Dilution Indicators are not mixed with others of better keeping qualities.

The calculation of the Dilution Indicator, or any other safety factor for that matter, could not be done on the spot before. The main reason was the absence of a quick reliable method for determination of moisture in sugars.

This paper deals with calibration and evaluation of the "Kappa" dielectric moisture meter as a rapid and reliable instrument for the determination of moisture in raw sugar. It also suggests a quick graphical method for the determination of the Dilution Indicator of a sugar on the spot.

Moisture in Sugars.

The moisture in sugar is mainly incorporated in the molasses film surrounding the crystals. This film is composed of a solution of sucrose, reducing sugars and some salts.

The keeping quality of a sugar is primarily a function of its moisture content. Hence all the factors suggested to indicate the keeping quality of a sugar are based on the percentage moisture in the sugar related to some other factor e.g. its solid non-sucrose content or the relative humidity of the atmosphere.

The three factors which are used in the sugar industry are:-

(a) The Safety Factor.

This has been introduced by the Colonial Sugar Refining Company of Australia. It measures the relationship between moisture and the non-sucrose content of the sugar i.e.

$$\frac{\text{Percent Water}}{100 - \text{Polarization}} = \text{Safety Factor.}$$

(b) The Dilution Indicator.

This is a modification of the Safety Factor. It measures the relationship between moisture and solids not sucrose. It is derived from the following equation:-

$$\text{Dilution Indicator} = \frac{100 \times \text{Percent Water}}{100 - \text{Pol} - \text{Percent Water}}$$

(c) The Equilibrium Relative Humidity.

This relates the moisture content of the sugar as sampled to the moisture content of the sugar when at equilibrium with an atmosphere of definite relative humidity. This relation gives the Equilibrium Relative Humidity of the sugar as termed by Powers. It is considered as a measure of the vapour pressure of the surface film and hence its osmotic pressure which has probably a major influence upon micro-organisms [1]. It has also been reported that when a number of different raw sugars at different Equilibrium Relative Humidities are mixed in the same store, they will interchange moisture in the effort to attain equilibrium. Hence with two extremes, one may well dry so much that the resulting crystallisation of sucrose in the molasses film will cause cementation, whilst the other may absorb water and become more vulnerable to microbiological attack [1].

All the above mentioned factors are ambitious attempts to define the density of the molasses film in which no micro-organisms can survive and hence lead to deterioration of the sugars. Control of cementation or concretion seems to depend on the uniformity of the sugar moisture content and the relative humidity of the atmosphere.

The accurate determination of the moisture in sugar frequently presents great difficulty, and the proper procedure has not yet been definitely established. This is because it has been reported that moist sugars resist drying with great obstinacy. Raw sugars were also found to be hygroscopic [2].

At atmospheric pressure, moisture can be removed only by prolonged heating at high temperature. But high temperatures frequently exert a destructive effect on the solid sugars. The destructive action of a temperature of 100°C is a particularly important consideration in the case of fructose and to a less extent in the case of glucose and sucrose. Consequently drying methods which combine mild temperature and high vacuum are adopted.

The other disadvantage of the drying methods is the lengthy procedure and the long time taken before the results can be found out.

Wise and Munro[3] of I.C.T.A. have already investigated the possibility of using the Kappa dielectric moisture meter to measure the moisture content of raw sugars. Their work produced promising results. Trott and Barrow[4] of Barbados substantiated and extended Wise's and Munro's work. From the results of these workers it can be concluded that the Kappa dielectric moisture meter is capable of producing rapid and reproducible results; an attempt to arrive at more accurate results by modification of the calibration technique for the Kappa meter is described in this paper.

The "Kappa" Moisture Meter.

This meter utilizes radio frequencies to measure the change in permittivity with moisture content.[5]

The advantages of the Kappa over other moisture meters are:-

(a) It measures capacitance instead of conductance and hence the range of moisture content to which it is sensitive is wider than conductance meters.

(b) Because it utilizes high frequencies (10 Mc/s), it is more sensitive to very low moisture contents than lower frequency meters.

(c) The high frequencies used help to reduce the erratic effects of the ohmic resistence produced by the electrolytes in the molasses film of raw sugar crystals.

(d) The meter is robustly built and easily manipulated. This makes it a suitable instrument for routine work in the factory or the bulk store.

(e) The determination of moisture in the sugar sample takes only a few minutes by the Kappa meter, once it has been properly calibrated.

Calibration of the Meter for Raw Sugars.

The meter measures the permittivity of the whole sample, and not that of its moisture content only. Thus the measurement of permittivity can be made to serve as a measure of moisture content only if the relationship between permittivity measurement and moisture content is known. Since this relationship follows no known law, it has to be determined experimentally and a calibration curve should be drawn for the material in hand. This is rendered easy by the fact that a small change of moisture content induces a measurable change of permittivity, on the meter dial. The accuracy of the results obtained depend mainly on reproducibility of the samples used. The factors affecting the meter reading are as follows:-

(a) Uniformity and size of the grains

(b) The packing degree of the sample

(c) The ash content of the sample

(d) The temperature of the sample.

To obtain maximum reproducibility of the results, a standard procedure was adopted.

The introduction of the sample to the meter cell followed a definite pattern. A sample of 200 grams was poured into the cell; it was shaken, then compressed with a well-fitting plunger. This step was taken to minimize the packing error as well as to standardise the bulk density of the material.

To annul the error that may be produced because of temperature changes, an air conditioned room was used.

The sugar samples used, were collected from five different factories in the out-of-crop season. More samples were bought from different groceries. The samples included different types of sugars, e.g. export greys, washed greys, local yellows and some refined sugars.

The errors which arise due to lack of uniformity of grain size were not corrected for; they are reported as small [4].

To reduce the errors produced by large variation in ash content, sugars falling within different ranges of one degree pol e.g. 96-97° were plotted on separate curves.

In order to draw the calibration curve of the sugar moisture content against the sugar Kappa reading, Percent moisture of the sugar has to be determined accurately. A vacuum oven operated at 50 mm. Hg. and 70°C was used. A triplicate of five gram samples placed in open ground cover bottles were left in the oven overnight. The mean percent moisture of the three samples was taken as the average percent moisture in the sugar.

Polarization of the sugar was accurately determined, following the details recommended by I.C.U.M.S.A. [6]. Temperature corrections were applied using Brown's formula [7].

The experimental data given by those sugar samples acquired from factories and groceries, was not enough to give the full shape of the Calibration Curves. Very dry sugars and very wet sugars were needed.