Grain Moisture Meter and Moisture Detector for Flowing Grain

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Grain moisture meter in Japan

Moisture meter is an instrument to speedily measure the moisture content by simplifying the measurement method standardized by such measure as the air-oven method. The instrument should be so devised that indicated value thereof must conform with the established value under the standard measurement method.

However, attention must be focused to the fact that the standard measurement method differs by country and organization, and in case the measurement is carried out under a respective different method some different value may be indicated.

The standard measurement method as provided for in the official grain inspection regulation of Japan is a method whereby about 5 g of grain are ground, then put into a designated dish and dried for 5 hours in air-oven at 105°C. In the case of a high moisture content the so-called two-stages drying method is recommended.

Although such methods as the drying of whole grain for 18 to 24 hours in air-oven under 135°C or ground grain dried for one hour under 135°C are employed by research institutions, all scales of moisture meters made and used in Japan are graduated to comply with the specification of the official standard measurement method.

Three kinds of moisture meter usually used in Japan are: the infrared heating electric resistance and electric capacitance types.

Although a small number of imported meters are used, most of the meters used are domestic makes which will be described hereunder.

Infrared heating type moisture meter

The meter is devised to rapidly dry under radiant heat produced by infrared bulb instead of drying by air-oven. As shown in Fig. 1,

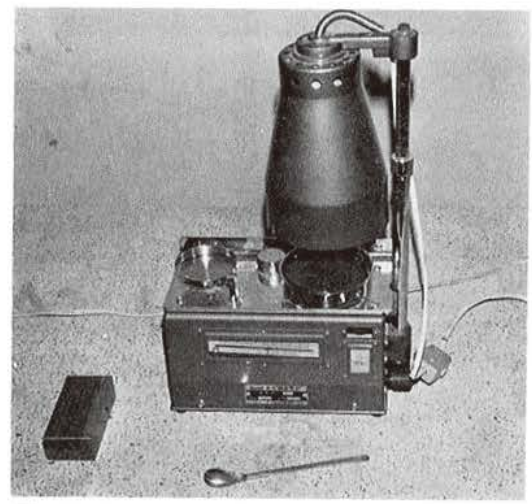
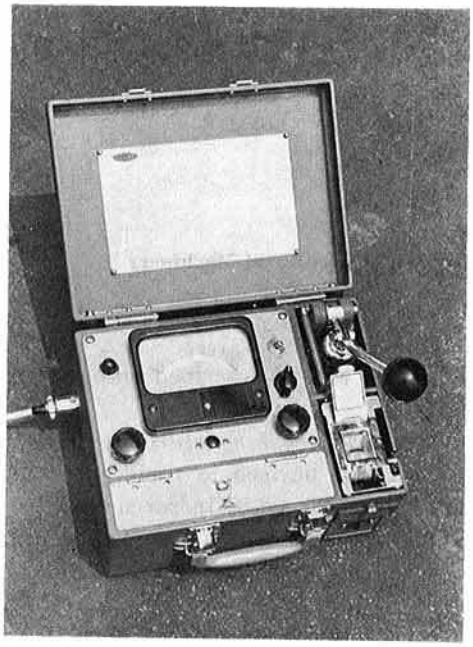


Fig. 1. An infrared heating type moisture meter

the grain is dried on a dish of the balance and the moisture content can be read by measuring directly-removed-moisture weight.

The meter can be widely used in the measurement of moisture content of hay and soil, etc. besides grain. And if the drying period (usually 20 to 30 minutes) and the distance from the dish to the infrared bulb are decided in accordance with established method, it is possible to obtain the same value as under the standard measurement method and the deviation in measured value is small. In Japan



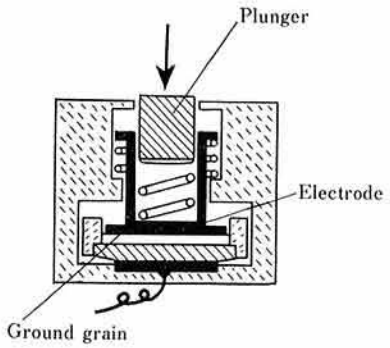


Fig. 2. An example of an electric resistance type moisture meter

the meter is used not only in research institutions but at rural elevators.

Electric resistance type moisture meter

The grain is put in between two plates of the electrode, and the moisture content is measured by utilizing the fact that there is a correlation between the electric resistance thereof and the grain moisture content. The meter is widely used in the operation of grain dryer and in grain inspection. Among those used in Japan one is a method of utilizing electric resistance of grain under low frequency (50 or 60 Hz) as shown hereunder.

Ground grain ground by the grinder equipped to the moisture meter is put in between two plates of the electrode and electric resistance is measured by adding a certain pressure. As a simpler type there is such an instrument as shown in Fig. 3 which used direct current and of which grinding part serves as an electrode, too, and electric resistance is measured by grinding the grain.

The instrument is somewhat inferior in accuracy than that of Fig. 2 but the price is cheaper and it is widely used in grain inspection, in large-scale processing facilities and in the operation of dryer on farm. In both cases the volume of a measured grain at one time is only about 1 g, and then if there is an unevenness of moisture distribution (for instance, the mixture of immature grain) there is a risk of enlarging the error.

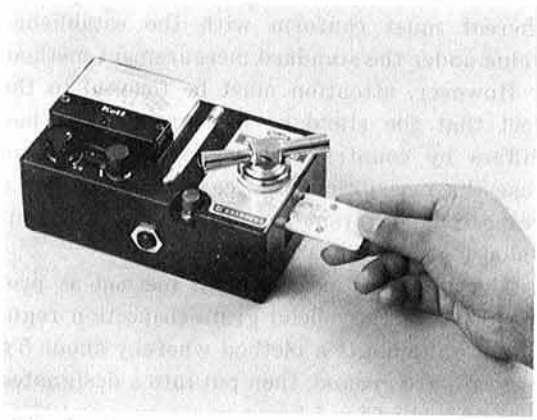


Fig. 3. An example of an electric resistance type moisture meter

Electric capacitance type moisture meter

Grain is put in between two plates of the electrode or on the part located two plates, then moisture content is determined by utilizing the fact that when the electric capacitance between the plates increases along with the increase of grain moisture content.

This type is convenient in that the measurement can be made without grinding the grain

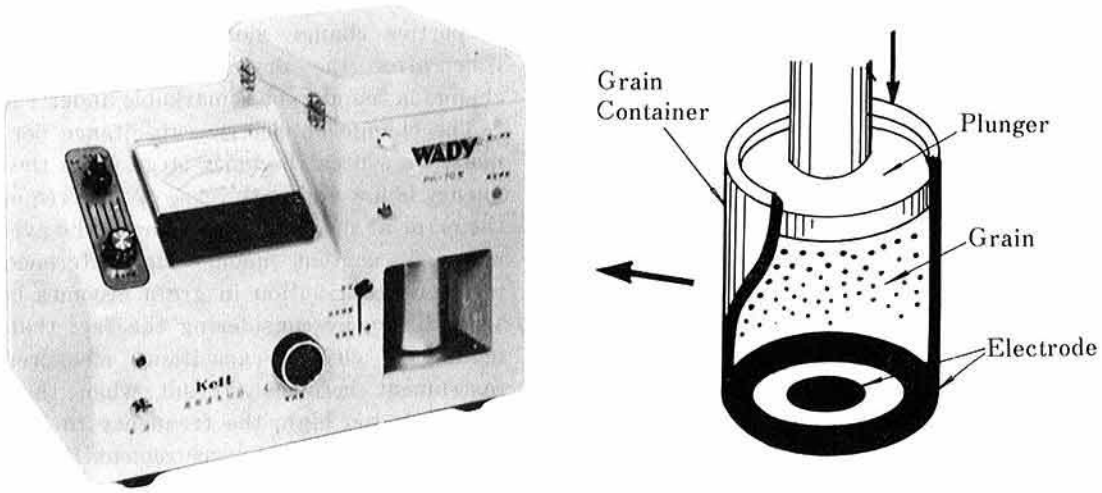


Fig. 4. An example of an electric capacitance type moisture meter

but indicated value changes even in identical moisture contents by the apparent density of grain between the plates so it is necessary to minimize this influence. And usually, the amount of the grain which should be put into the electrode must be fixed by measurement. To eliminate this labor and to minimize this influence of apparent density there is an instrument as shown in Fig. 4.

A nearly fixed amount of grain is put into the cylindrical grain container of this instrument and then compressed under the fixed pressure for the determination of its moisture content. It has been so devised that apparent density of the portion of grain through which the electric line of force of electrode passes through becomes practically fixed.

That which is indicated in Fig. 5 is, in the case of rough rice, exactly 31 g which must be put into the cylindrical grain container equipped with electrode, and the bottom and cover of this grain container are electrodes and apparent density is approached to fixed condition by screwing the cover to increase the accuracy.

The appearance of the electric capacitance type moisture meter in Japan is new compared with the electric resistance type moisture meter and the extended number is small at present but it is used in the measurement of moisture content of grain transported from the farmer to the drying installation and in

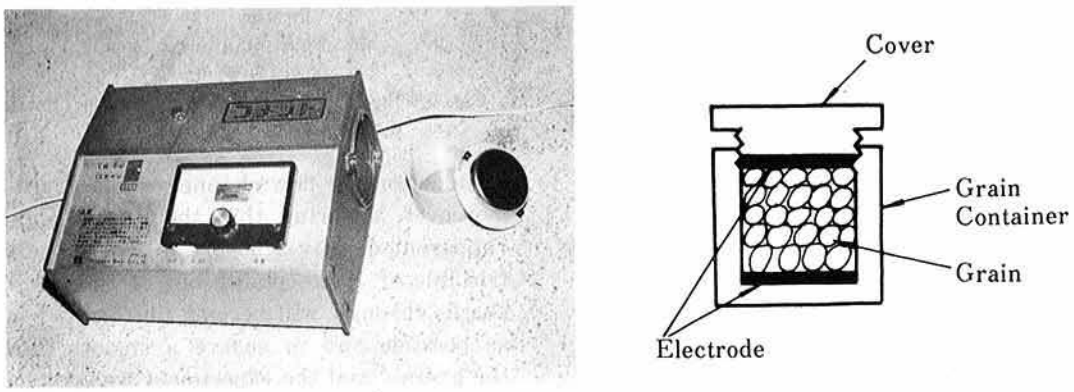


Fig. 5. An example of an electric capacitance type moisture meter

the operation of the dryer.

Grain moisture detector for continuous flow of grain

For the automation of dryer and grain inspecting instrument as well as of processing facility, it is necessary to construct a sensor for the use of detecting the grain moisture content during the grain flow thereby making it possible to know continuously the moisture content of the grain passing through this sensor. Research concerning it has been carried out at the Institute of Agricultural Machinery since 1967 and a portion of the research is introduced hereunder.

Because the non-destructive measurement of grain moisture content is easy, the principle of measuring moisture content under the electric capacitance type has been adopted and rough rice was used as the detection-test grain.

First, even in the case of rough rice which have been stored for long hours or immediately after the drying in order to obtain the correct average moisture content value, investigation has been carried out as to what kind of change occurs in the electric properties of rough rice, which have been stored without drying and moistening with the lapse of time after the drying.

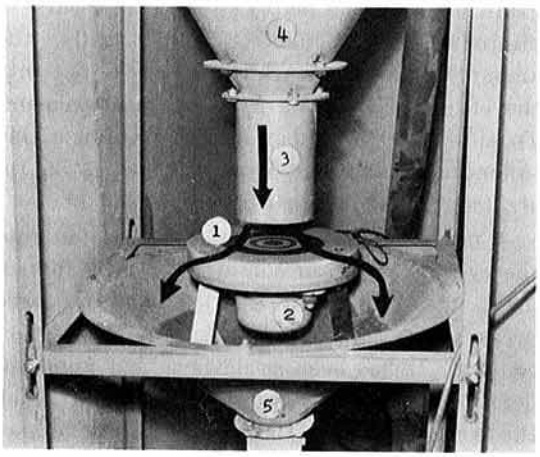
That is, even if the average moisture content of the grain kernel is the same to what extent the electric properties changes according to the difference in moisture distribution in that grain has been investigated. The electrode used was a cylindrical type electrode and the device is such that grain can be put in between a cylinder and a coaxial column. The height of the cylinder and a coaxial column was 150 mm respectively, and the inside diameter of the cylinder was 75 mm and outside diameter of column was 25 mm.

The electric capacitance between the two and Q-value has been measured by Q-meter and real permitivity (dielectric constant) and less tangent of dielectric have been computed. The frequency used was from 100 KHz to 10 MHz.

As the result it has been found that electric properties change along with the lapse of time after the drying. Particularly, this change is found to be remarkable under 1 MHz.

The change of electric capacitance per 1% moisture content becomes large when the frequency is low and in the case of low frequency, the error at the time of measuring the average moisture content under the difference of moisture distribution in grain becomes large. In addition, by considering the fact that the making of electric capacitance measurement instrument becomes difficult when the frequency is too high, the frequency to be used at the time of such measurement by us has been set 10 MHz since this time.

Then a sensor was manufactured on a trial basis so as to make possible the attachment of the vibrator as shown in Fig. 6 which can be



1 : Plane type electrode
2 : Vibrator
3 : Pipe for guide of grain flow
4, 5 : Grain hopper

Fig. 6. Sensor part of the prototype moisture detecter

installed on the flow channel of the grain and moreover, ensuring that the grain condition (apparent density) in portion where the electric line of force coming out of the electrode passes through will become uniform as much as possible and to ensure a smooth flow of the grain. And the experiment was conducted accordingly[2].

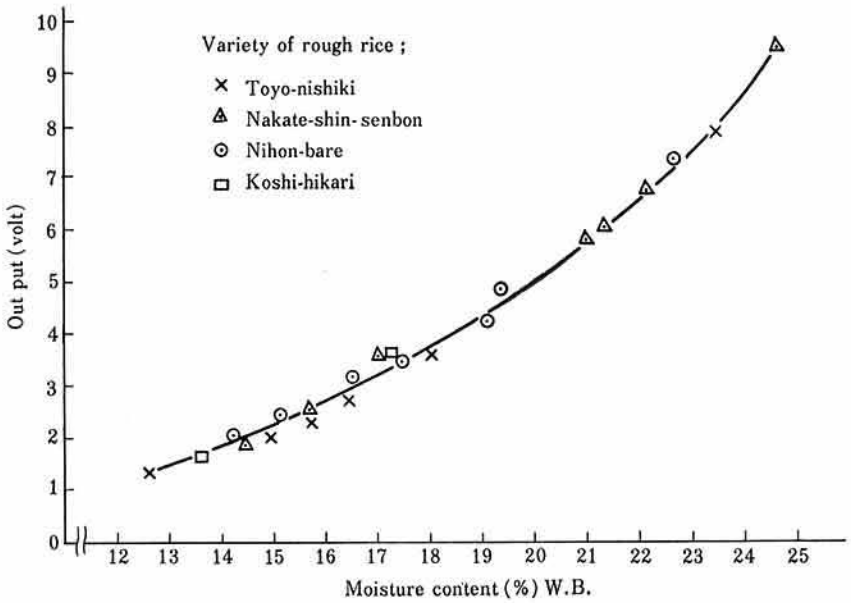


Fig. 7. Relation between moisture content and output (voltage)
Note: Grain temperature 20°C
Apparent density 0.585 to 0.621 g/cm³
(measurement in the static condition)

An electrode used herein has been named as the plane type electrode. The method of detecting the electric capacitance was that the change in moisture content has been taken as electric capacitance between plates of the electrode fixed on a circular plastic plate then converted the same to oscillating frequency within the limit of 10 MHz ±0.125 MHz, then, further the change of this frequency is converted into voltage and observation has been made under the recording meter.

Electric circuit to convert electric capacitance to frequency was installed in the plane with the vibrator board on which the electrode has been attached so that stabilized measurement can be obtained even if a lead wire becomes long from the sensor up to the part where the converting instrument to convert this frequency to voltage and recording meter are located. Rough rice of various varieties with different moisture content and temperature have been fed into this device and the relation between the output of voltage and moisture content has been studied.

As example of the results is shown in Fig. 7. In this case it has been found that indicated value is practically not influenced by the flow rate of rough rice as long as rough rice is flowing.

Furthermore, several experiments have been undertaken, such as on rough rice differing in separating condition, on sensor with different shapes of electrode and the investigation of accuracy by attaching this detection device to the practical dryer.

However, as a problem, although the influence of apparent density can be made smaller to a certain extent by using the vibrator, as for grain with a large mixture of foreign matter and those whose apparent density differs to a large extent it is feared that the error becomes large. Moreover, problems to improve the accuracy by the correction of apparent density, etc. still remain.

References

1) Ban, T. et al.: Studies on the detection of moisture content in artificial drying. Institute of Agricultural Machinery 1967 Annual Report, 109–130 (1968). [In Japanese]

2) Ban, T. & Suzuki M.: Studies on electrical detection of grain moisture content for flowing grain. Institute of Agricultural Machinery 1971 Annual Report, 31–59 (1972). [In Japanese]