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IBB RHEOLOGY PROBE

1. Introduction

A concrete producer need to have feedback as fast as possible from newly made concrete. At the moment, some sensor in the batching plant mixer (usually a Watt-meter measuring the electric power consumption to operate the mixer) can help to estimate the slump providing that the produced concrete quantity is constant from batch to batch. This is not always the case and do not give any information on concrete temperature.

To get more precise feedback, many suppliers sample and measure, on a regular or as required basis, the fresh properties after batching. This takes time and effort, creates waste and takes away concrete from their clients.

IBB has developed a Rheological probe that can help to measure the concrete fresh properties in continuous and automatic way and in respect of the environment by not creating any waste material.

This document has been produced to describe how to use the IBB probe. It contains three sections:

1- Historical background
2- Description of probe system
3- Basic Operation

This document is complemented by four other documents explain some specific aspect of the probe. They are:

- The Installation Manual that explains how to install the device on the truck.
- The Configuration Manual that explains how to communicate with the probe and receiver. This also explains how to retrieve data from the receiver.
- The Slump Calibration Manual that explains how to calibrate the slump for a particular mixture.
- The Volume Calibration Manual that explains how to calibrate a particular installation in order to read the volume of concrete inside the drum.

All of these documents are continuously updated and the latest version is available on IBB Rheology website at www.ibbrheology.com.

2. Historical Background

Historically concrete workability has been measured using different tests among which the slump test is still the most popular. More recently, rheometer have been used to measures more fundamental properties such as yield stress and viscosity.

In short, viscosity is a properties of fresh concrete that affect the speed at which the concrete will flow under certain stress, this is particularly important for pumping operation. The yield stress is like some internal friction that must be overcome before the concrete starts to flow, it will affect directly the slump in an inverse manner: the lower the yield, the higher the slump. The viscosity is not related to the slump. For more details on rheology, please look into our web site (ibbrheology.com).

Rheological properties have been measured on concrete for at least 35 years but the lack of standard method and the cost, availability and size of rheometer have keep the industry from using these properties to describe the fresh concrete behavior. Up to now, rheology has been a science used in laboratory with little use in the field.

IBB rheology, a company that was making the IBB rheometer, has recently completed the development of a probe that can be mounted inside the drum of a ready-mix truck and therefore do not require any sampling. The device called, rheological probe, measures much more than the

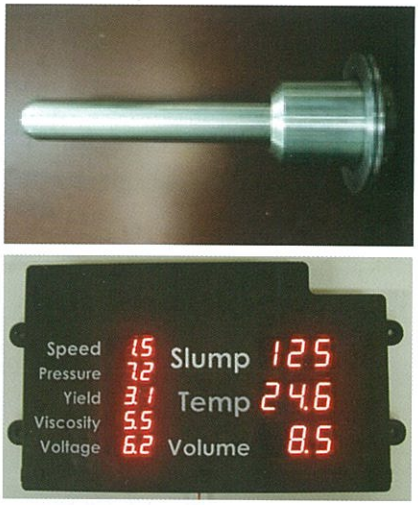
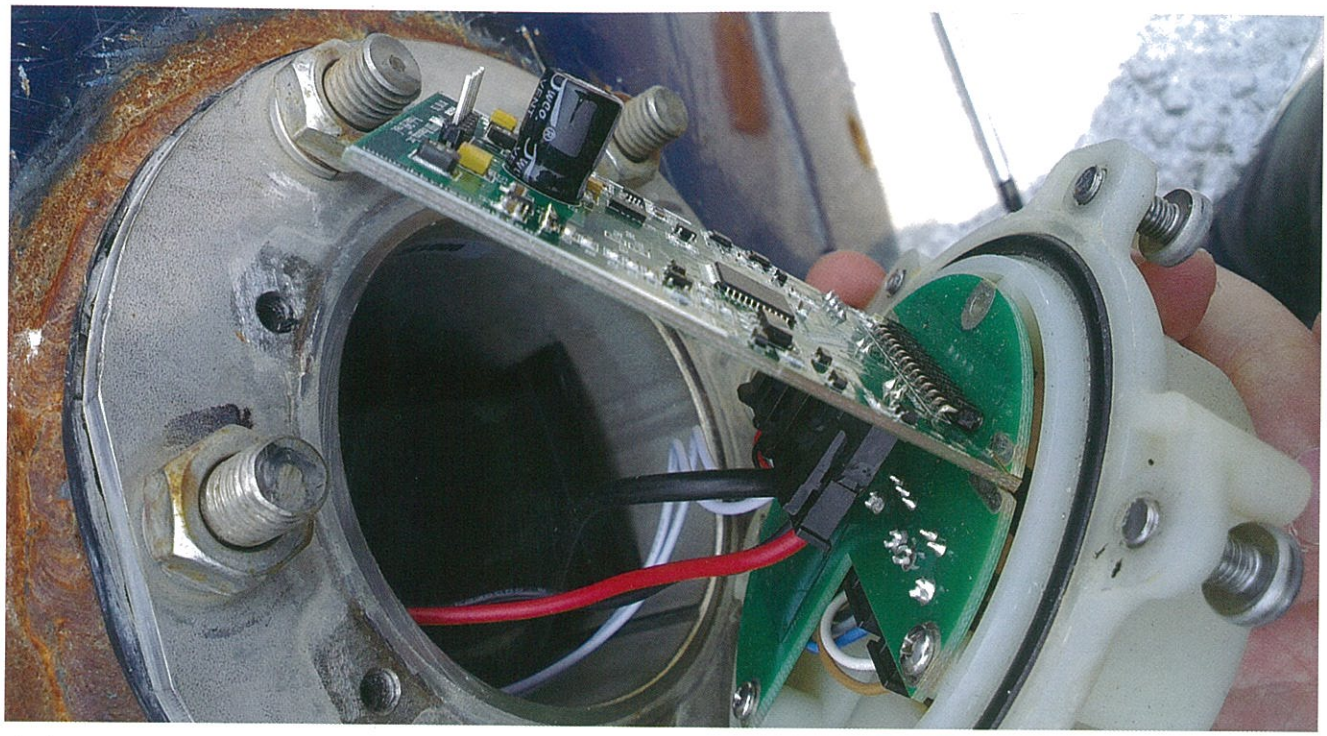


Figure 1: IBB Rheological Probe and Receiver



rheological properties as it gives, all the following parameters:

- Slump
- Viscosity
- Yield stress
- Temperature
- Speed & direction of drum

- Volume of concrete inside the drum

These parameters are displayed and stored on a receiver without wasting any concrete. This is one reason the rheological probe can be seen as a green technology and has helped a producer in the Middle East to get a Silver certification for sustainability by the NRMCA.

3. System description

The IBB Probe system has two main components with two main options:
1- A Stainless steel probe; installed inside the drum of the ready-mix truck (See installation manual for details),
2- A Receiver that is fixed on the truck,
3- A Solar Panel (optional but strongly recommended); fixed outside the drum and connected to the probe,
4- A System Manager, that enable two way communication and data transfer between the plant operator and the probe to improve the system performance.

The Probes works using a variety of sensor (accelerometer, thermistor and load cell) and electronic component that are powered by rechargeable batteries. Collected data from many sensors are processed, stored and send to a Receiver using radio signal to be displayed, stored and further made available for an alternate communication system, such as GPS (not provided by IBB Rheology), for real time monitoring. Figure 1 show a picture of the IBB Rheological Probe.

The Receiver displays the information shown in Figure 1. It has memory to store data for up to approximately 2 days of normal utilization. The Receiver can be connected to a computer, on temporary basis, to collect the stored information. The Receiver can also be connected to a GPS communication system (not provided by IBB) to transfer that data on real time basis or for further processing. The receiver is powered by the truck main batteries. The receiver has also a cable that can be used to recharged the batteries when the truck is not working.

The Solar Panel is normally connected to the probe to keep the battery pack charged. The power of 4 Watts is sufficient to power the probe even in cloudy condition.

The System Manager is a two way communication system between the plant operator and the probe to transfer useful information that improve the plant performance and ease the recovery of data for the previous delivery.

4. Basic Operation

The probe constantly monitor the position (angle with vertical from 0-360 degree) by calculating the change in angle, one can get the angular speed (in rpm) or in tangential speed in m/s if the circumference of the drum is known. The probe also makes several measurements of temperature and pressure and can detect at which position it enters and exits the concrete.
The angle, speed, temperature and pressure are further analyzed and compared to some calibration table to estimates the slump and volume and, if a proper sequence of drum speed was performed, the probe also calculates the rheological properties. These data are sent every 10 seconds to the receiver for storage and display.

When no motion is detected for more than 5 minutes, the probe goes to sleep and stop sending data the display on the receiver also changed reduce electric consumption. As soon as the drum will start to turnv-again, the probe will wake up and restart to make automatic measurements.

The speed of the drum is always calculated and updated every 10 seconds. The slumps will be displayed is the drum speed is between 1 and 3 Rpm in the loading direction (or positive speed on the display).

To get the rheological properties, the truck operator will have to turn the drum at a speed between 4 and 6 rpm (referred to as medium speed) for at latest three turn, when the speed and load will acquired, the speed can be reduced between 1 and 3 rpm (referred to as low speed) for at least three turns. The measurement at low speed must be taken within 5 minute from the last measurement at medium speed. When this is completed, the probe will calculate the viscosity and the yield.

Because the viscosity do not change much with time (unless some modification is done to the mixture composition) the calculated viscosity will be kept ''alive'' for 30 minutes. As long as the speed will remain in the low range speed of mixing direction, the yield will be updated every turn.

If Concrete Can Speak

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Some of you will remember this well-known 1965 song and film title, "What's New Pussycat". It was sung by Tom Jones for the film starring Peter Sellers, Peter O'Toole, Romy Schneider, Capucine, Paula Prentiss and Ursula Andress. Now what is new for me, concrete?

The recently held 37th Conference on Our World in Concrete and Structures, was specially dedicated to Mr. Willie Kay, a long time supporter of this continuous series of conferences in Singapore first held in 1976. Singapore Concrete Institute and ACI Singapore Chapter became sponsors of OWICS in 1984 besides the founder sponsor, RMCAS. During this Conference I discover "What's New" in developments for concrete, me. I shall only touch on three of them in this issue of Concretus, more are available in the conference proceedings (1).

Many are aware that my big carbon footprint comes from the clinker component of Portland cement that binds me with my aggregate partners together to perform the many tasks during my service life. Although good efforts have been made to reduce my carbon footprints in the product process of cement, it remains the highest contribution to my footprint as concrete. Two new developments were presented at the recent OWICS in August, 2012. Both involve the development of a new binder for me to partner with conventional aggregates to perform just like my partnership with Portland cement. The first is a new type of proprietary geopolymer (activated fly ash) which can develop strength at similar rate as conventional Portland cement at normal ambient temperatures (2). Hence, I can be cast on site besides in precast plants where heat curing is available. The second is another binder which consists of 95% ggbs with a special proprietary activator as an alternate to Portland cement. It is very close to my cousin, CEM III/C who has 5% clinker as activator (3). The absence of Portland cement makes its carbon footprint very much reduced. These are truly green cementitious binders and turn me enviously in to a GREEN concrete. Without the presence of tricalcium aluminate (heat of hydration, 910 J/g) tetracalcium aluminoferrite (heat of hydration, 420 J/g) and other hydration products are likely to be mainly ß-dicalcium silicate hydrates (heat of hydration, 260 J/g) compared to tricalcium silicate hydrates (heat of hydration, 526 J/g). Such binders can be expected to be very low in heat of hydration. Hence, I can be produced with a much higher cement content to achieve very high compressive strength without getting too hot in thick sections, and without the need for special internal cooling systems or cooling my constituent components to lower placing temperature (and hence lower peak temperature) at a high cost.

Thirdly, I have a new monitoring friend, a rheological Probe, who can tell my consistence, e.g. slump or slump flow diameter, my temperature and even my bulk (volume) when I am still inside the truck mixer (4). This will save time at delivery to carry out these measurements before placing me into the forms. The continuous monitoring also provide feedback on rate of slump loss and temperature rise due to travel time between plant and site, thus enabling minor adjustment, when necessary, to the concrete design during the course of supply.

All the above developments are "What's New" for me. They will make me GREEN if you adopt them and turn others green with envy of the NEW ME.

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