MONITORING YOUR YIELD MONITOR

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Yield monitors have become very common on combines in the last decade. The primary goal of these devices is to help the producer monitor variability occurring in his or her fields. Utilizing GPS, this data can be saved spatially and downloaded to the producer's computer to build an almanac that may be used to better understand how field inputs and growing conditions over a number of years (e.g., wet years, dry years) affect yield variability. Producers have also used this technology to conduct on-farm trials assessing economic return of various hybrids or management inputs.

The combine automates yield monitoring by aggregating data from various sensors, including speed, position, header height and width, mass-flow and moisture. Each of these sensors contributes an essential piece of data necessary to the production of an accurate yield map.

The first piece of information needed is the area harvested. Various machines solve this problem differently, but generally the yield monitor knows that the harvest has commenced by first verifying the separator is on and then if the header height is in the harvest position. This brings us to the first important adjustment. Different operators and varying harvest conditions require positioning the header higher or lower. The operator must inform the yield monitoring system when the header is at the harvesting height so it can determine if the machine is harvesting or making another maneuver (e.g., headland turn). The header position assigned to harvesting works in conjunction with the activated separator, like an on/off switch for the yield monitor. The value is usually set through the monitor itself and can be represented as a percent of height or angle measured between the header attachment point and the ground.

Now that the yield monitor knows that the operator is serious about harvesting (separator on, header down) the monitor must know the width being gathered into the combine. Surprisingly, most machines have not automated this process. Therefore, the operator must enter the number of rows being harvested or, in the case of a cutting platform, width of the header used (e.g., feet).

Harvest width combined with forward travel speed allows the combine to calculate area harvested per unit time, usually represented as acres per hour. For example, a 6-row (15 ft) corn head, fully utilized, traveling at 5 miles/hour would result in an area productivity of about 9 acres/hour (5 MPH multiplied by 15ft and divided by 8.25 to convert the units). For those using GPS there is no need for speed calibration; however, those using a wheel speed pickup or a ground-speed radar system need to calibrate their speed sensor. Once again, the

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procedure varies by machine, but in general it requires traveling a known, measured distance under field conditions (proper header attached, half-tank of grain). This distance is used in conjunction with the sensor's output to correct its calibration.

With area harvested precisely known, we just need to measure the amount of grain harvested for that area. This might be done by simply weighing the grain, but engineers have had difficulty coming up with cost-effective and accurate on-board weighing systems. So this task is accomplished indirectly with a grain mass-flow sensor. This type of sensor measures the mass per time (lb/sec) of grain that is carried by the clean grain elevator to the grain tank. Various mass-flow sensors have been used in the past, but today, two types are being utilized. The first type measures the height of the grain on each paddle of the clean grain elevator as the paddle passes by (Fig. 1, left). Using this height, the volume of grain on the paddle is estimated and, by multiplying by the grain density (mass of grain per volume), the weight of the grain on the paddle is estimated. The grain density is calculated by adding up the individual paddle volumes during a calibration load and dividing by the scale ticket weight for the load.

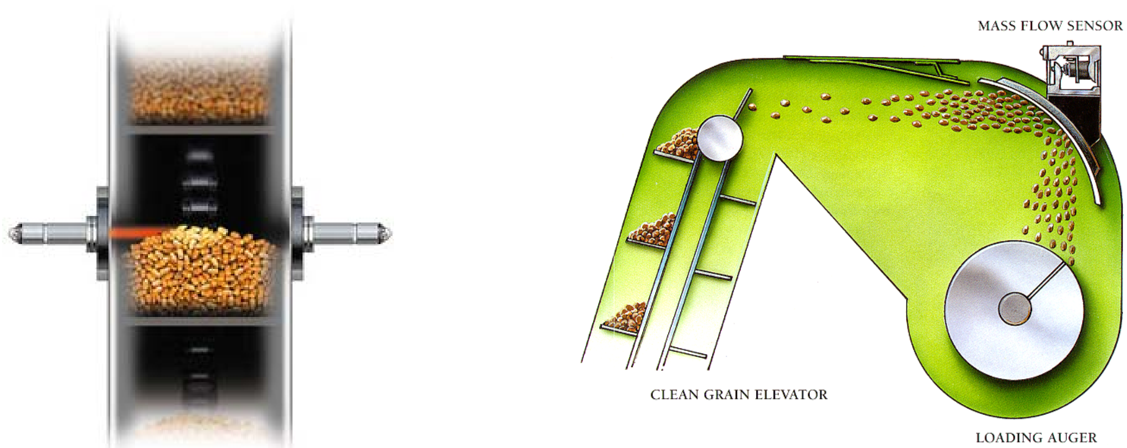

Figure 1: Volumetric (left) and impact plate (right) mass flow sensors [3].

This approach can be accurate if the relationship between weight and volume is constant, but unfortunately, as in most biological products, nothing stays the same for too long. Changes in grain variety, moisture content and individual kernel density can lead to measurement error. It is recommended that a calibration load be run every 2-3 weeks, or more often, if there are noticeable changes in crop condition.

Another more common type of mass-flow sensor measures the force that the grain being ejected from the top of the clean grain elevator applies to an impact plate as it moves towards the bubble-up auger (Fig. 1, right). The estimated mass flow rate of the grain is

[3] Image sources: Deere & Company and Claas of America. Mentions of trade names in this paper are made solely to provide specific information and do not imply endorsement of the product or service by the Univ. of Wisconsin-Madison or the authors.

computed from this force and the speed of the elevator. The idea is to add up the estimated mass flow rate over time to determine the accumulated weight. This, too, is an indirect measurement of weight requiring calibration to ensure good accuracy. Before considering calibration, it is prudent to inspect not only the sensor for wear but also the clean grain elevator paddles. Bent or broken paddles could result in grain falling before being thrown against the impact plate. Also, worn paddles may not cause the grain to follow the top of the conveyer to the impact plate, resulting in low readings. Some machines allow for an adjustment of paddle height at the top of the clean grain elevator. The manufacturer's instructions should be followed carefully as this adjustment affects how the grain hits the impact plate and can have a significant influence on sensor consistency. It is also a good idea to inspect the clean grain elevator speed sensor.

With impact-plate sensors, the relationship between sensor output and grain mass flow rate is usually non-linear. This means that the sensor output isn't quite proportional to grain flow rate (Fig. 2). For example if this relationship were linear, then an output of 1 volt (V) might be produced by 10 lb of grain per second, 3V by 20 lb/s, 5V by 30 lb/s, etc. However, due to friction and not all of the grain hitting the impact plate at high flow-rates, the relationship is non-linear. So, in our previous example, 1V might be produced by 10 lb/s, 3V by 20 lb/s, and 4.25V by 30 lb/s. What this means for the operator is that if the sensor is calibrated at just one flow rate, it will be less accurate at flow rates that are significantly different.

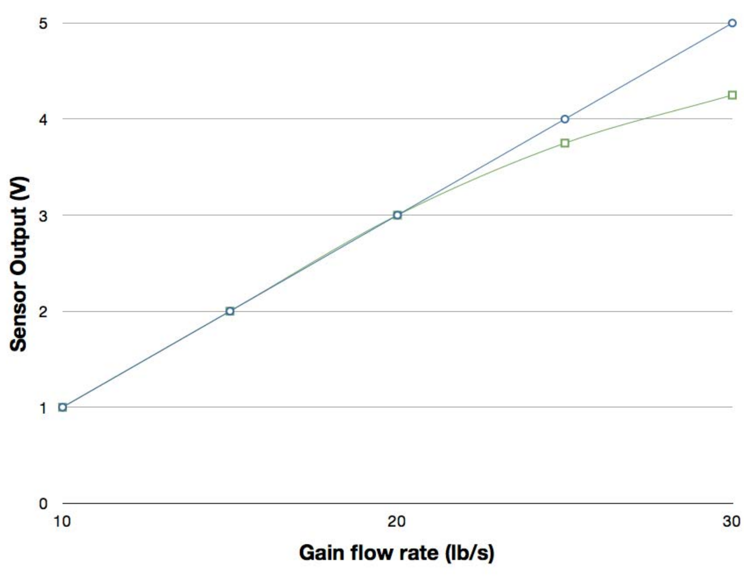

Figure 2: Simulated sensor linear (circles) vs. non-linear (squares) response to grain at various harvest (flow) rates.

Calibration load recommendations vary depending on manufacturer. Some may have the operator find a level, consistently yielding area of the field and harvest at an average rate while others have the operator harvest at varying rates throughout the calibration load. Several manufacturers offer the capability to perform multiple calibration loads at different flow rates to correct for nonlinear effects (described above). These systems typically require the operator to harvest more than one calibration load, with each load harvested at a different rate (speed). Most operators' manuals provide step-by-step instructions. It is important to follow the instructions specified by your operator's manual. This process may seem involved, but most machines allow the operator to continue harvesting until the calibration load weigh ticket returns so harvesting is not impeded by a calibration update.

Most yield mapping software allows you to enter actual load weights after the harvest is complete in order to fine-tune the maps. Even if you already weigh all of the loads from the field and plan to do this post-harvest correction, it is still recommended that you calibrate the mass-flow sensor in the field in order to correct for the nonlinear effects described above. This is especially important when there are large yield or speed variations in the field.

The final piece of the yield data is moisture. Grain yields must be corrected for moisture, otherwise wetter, heavier grain will skew the yields higher while drier, lighter grain will appear to decrease yield. Current technology moisture sensors need periodic adjustment as conditions change. This process usually includes taking a few representative samples from the grain tank to the elevator for analysis; the moisture readings from the elevator are then used to update the moisture sensor calibration on the combine.

Although time investment may seem significant, calibrating your monitor is necessary to ensure accurate yield maps and subsequent management decisions. For more grain production-related information please visit the Univ. of Wisconsin–Extension Team Grain website at: http://www.uwex.edu/ces/ag/teams/grains/.