DEVELOPMENT OF SYSTEMS TO SPATIALLY QUANTIFY GRAIN FLOW FROM THE THRESHING AND SEPARATING SYSTEMS OF A COMBINE HARVESTER

By

ASHLEY K.M. STUBBE

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Abstract

Combine harvesters are used to harvest all types of grain crops such as: corn, wheat, soybeans, oats, rye, barley, etc. Therefore, there are a multitude of different crop conditions in which these machines need to adequately perform in, making product development and improvement inherently very costly. Not only do crop conditions change with the changing seasons and crops, but they also change regionally as well. If the material flow-rate from a threshing and separating standpoint could be better understood, current designs could be optimized leading to longer production lives.

This research focused on the development of systems to spatially quantify the mass-flow-rate of material exiting the concave and separation grate of a combine harvester during field harvesting. The initial attempt to collect this spatial flow-rate data was to use a vacuum system with funnel attachments mounted inside the combine to collect material samples at different locations within the combine during harvesting. The vacuum system samples were then separated into grain and material-other-than-grain (MOG) fractions, leading to both grain and MOG flow-rates over the test period. This system was tested in wheat, soybeans, and corn.

The vacuum system was able to collect material samples while harvesting in each of the crops and the samples were easily analyzed for grain and MOG content. The results showed a few consistent trends for each of the crops: (a) the grain and MOG mass-flow-rate progressively decreased from front to back in the combine, (b) the grain and MOG mass-flow-rate was greater on the right side of the concave than the left side, and (c) the location

of tailings entering the cylinder for re-threshing was easily determined by the high flow-rate on the right side of the concave in the middle position. The vacuum system was not able stop collection during start-up or shut-down transients and was a laborious and time-consuming test method. The system also would require major machine alterations to allow sampling from all locations of the concave and the grate.

Since the vacuum system had the above mentioned limitations and was not readily adaptable to different combine harvesters, a sensor system was developed as a less-invasive and more productive system. The sensor chosen was a John Deere grain loss sensor consisting of a piezoelectric material behind a flat impact plate. This sensor would output a voltage proportional to a strike on the impact plate. The signal was then centered over zero, rectified, and integrated using the trapezoid rule. This system was used when harvesting soybeans and corn.

The sensor data showed similar trends as the vacuum data for soybeans: (a) the sensor signal progressively decreased from front to back, (b) the sensor output was greater on the right side of the concave than the left side, and (c) the sensor was able to determine the location of the tailings entering the cylinder. When directly related to the vacuum data, the sensor data showed a good correlation (R = 70%) in soybeans, however, this was due to two anchor points.

In corn, the sensor data did not mimic the vacuum data as well: (a) the sensor output did progressively decrease from front to back, (b) the sensor output was not greater on the right side of the concave but rather was larger on the left side, and (c) the sensor was not able to determine the location of the tailings entering the cylinder. Also, when directly related to the vacuum data, the sensor data for corn showed a poor correlation (R = 49%). Some of the data points suggest that when the mass-flow-rate doubled the sensor signal halved.

Overall, the vacuum system is able to collect spatial flow-rate data; however, it is a time consuming and difficult process. Although, it is possible to separate the material samples into grain and MOG fractions. The sensor system was a high efficiency system; allowing for many test replicates in a short amount of time. Unfortunately, the sensor output did not react as the vacuum data predicted.