Proposal No. 2014_TC_008

The Andersons Research Grant Program
Team Competition

Project Title: Determining Time, Aeration, and Loading Cycle Effects on Grain Packing

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Period of Proposed Project Dates:

Beginning: 01/01/2015 Ending: 12/31/2016

Amount Requested (maximum $75,000 per year for two years):

Year 1: 75,000 Year 2: 75,000

Problem Identification and Related Research

When stored in a bin, grain undergoes compression from the weight exerted from the overlying material within the bin. The extent of compression depends on crop type, test weight, moisture content, bin wall material, and bin size. The compression, or packing, results in an increase in bulk density. Therefore, accurate pack factors (also called packing factors or compaction factors) that account for the increase in bulk density are required for determining the exact amount of grain in a bin. Furthermore, pack factors are needed by grain elevator managers and farmers for proper inventory control, and by government agencies for auditing. The pack factors that are currently being used for grain were developed empirically by federal and state auditing agencies several decades ago. With the changes and developments in grain varieties, bin construction, and bin size, there is immediate need for updating pack factors for grain.

The USDA Risk Management Agency (RMA), the USDA Farm Service Agency County Offices (FSA-C), and the USDA Farm Service Agency Warehouse Licensing and Examination Division (FSA-W) measure grain volume in bins for insurance, loan, and auditing purposes. At present, RMA and FSA-C use the same procedure and share an empirical pack factor table referred to as the current RMA loss adjustment handbook and manual (USDA-RMA, 2012a and 2012b). These handbooks contain pack factors for wheat, corn, soybeans, rice, sorghum, barley, and oats. This current method adjusts the pack factor based on test weight and cross-sectional area of the bin. For grain mass calculation, the adjusted pack factor is applied along with the initial test weight to the measured volume of grain in the bin using the following relationship (Boac et al., 2014a):

$$M = D_0 \cdot P \cdot V \quad OR \quad M = R \cdot V \tag{1}$$

where grain packing and test weight (initial density) are combined in the second equality with the term $R = D_0 \times P$, and M is the mass of grain in the bin, t (lb or mass bu), D_0 is the initial test weight (TW) of the grain from the Winchester Bushel Test, kg/m^3 (lb/bu), P is the average grain packing, and V is the measured volume of grain in the bin, m^3 (volumetric bu).

Commercial grain elevators are required to register with an appropriate government agency if they store grain owned by others. These commercial elevators, or warehouses, can be registered under the FSA-W or under similar agencies administered by state governments. The FSA-W pack factor table (USDA warehouse examiner's handbook, no date) and calculation procedures are different than the RMA method. As mentioned above, both the RMA and FSA-W take into account test weight during grain compaction calculation. However, neither of these methods takes into account the moisture content, grain height, dockage, time, and vibration that could influence compaction.

There are a few studies reported in the literature on grain compaction and its relation to crop type, crop quality (moisture, test weight), bin type, and bin dimensions based on a particle compression mechanics model, widely known as Janssen's model (Janssen, 1895).

$$P_j = \frac{D_o R_h}{\mu k} [\, 1 - exp - \left(\frac{\mu k y}{R_h}\right)] \tag{2}$$

where, P_j is the unit vertical pressure at depth y, D_o is the uncompressed bulk density of the granular material, R_h is the hydraulic radius, μ is the coefficient of friction between stored material and bin wall, k is the ratio of lateral to vertical pressure at any point, and y is the depth of grain measured from the top of the bin to the grain section under consideration.

The solution by Janssen (1895) assumed μ, k, and D_o to be constant. Because of this assumption, the above model is not accurate in large grain storage bins where the density of the stored material changes with changes in grain depth. An example of predicted vertical pressures for 30, 60, and 90 ft diameter bins is shown in Figure 1, which illustrates the relative effect of both grain depth and bin diameter on increasing grain packing. The plotted pressures were predicted using a modified version of Janssen's equation with both density and pressure varying with changing depth. This model better reflects the true physics of the packed grain particles than previous models that assumed the bulk density and the material and interaction properties were all constant.

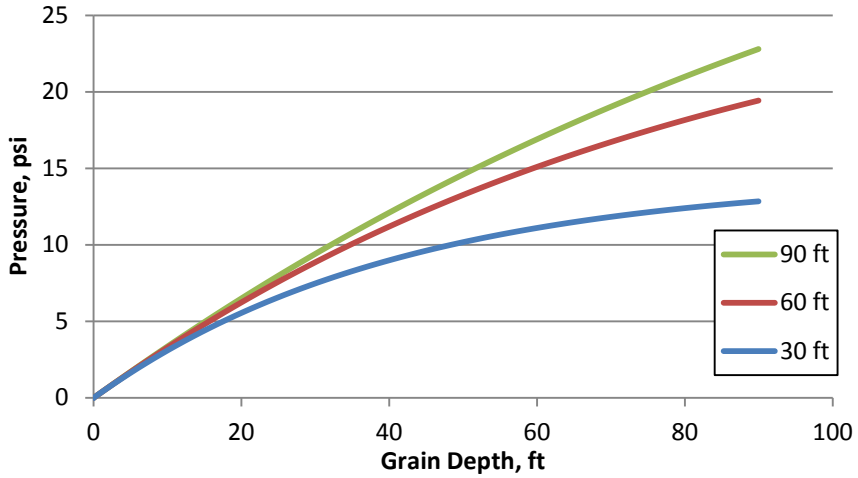

Figure 1. Internal grain pressure for 30, 60, and 90 ft diameter bins at varying grain depths.

Literature Review on Grain Pack Factor

The major drawbacks of the Janssen's equation (equation 2) are the assumptions that bulk density remains constant at the initial value, D_o, and that k is also constant. Clower et al. (1973) found a parabolic relationship between bulk density and vertical pressure for corn meal. Furthermore, Loewer et al. (1977) found a parabolic relationship between bulk density and moisture content (8 to 24%, wb) of shelled corn and a linear relationship with pressure. These studies indicated that bulk density is not uniform across the bin depth. Thompson et al. (1987, 1990) developed a model, WPACKING, to predict pack factor and total mass for any size and shape of bin, average moisture content of the grain in the bin, initial average test weight of the grain in the bin, type of bin, grain height, and grain profile (cone up, cone down, or flat) with known values of μ and k. This model was later adopted as the ASABE standard (2010) for pack factor prediction. Recently, the WPACKING program was updated and validated and calibrated by the proposing team for six major U.S. crops (wheat, corn, soybean, barley, oats, and sorghum) with laboratory tests and field measurements on grain bins.

One of the earliest studies of pack factor of grain was by Malm and Backer (1985), who attempted on-site measurement of pack factors for six crops (oats, barley, two types of sunflower, and two classes of wheat). Pack factors were estimated by measuring the total settlement of the stored material in bins 7 to 14 days after filling and again at 23 to 40 days after filling. A statistical model was tested to correlate selected physical properties such as moisture content, percent dockage, test weight, crop depth, and the bin dimension to the pack factor. They found that only barley and oil sunflower yielded significant terms in the model development.

They attributed the difficulties in developing predictive models to disturbances to the grain in the commercial setting. Although the results were inconclusive, they measured a maximum settling of 2.5% in the grain volume in measurements up to 40 days after filling. *To date, there have been no reported studies on the effect of long- or short-term storage or of the combined effects of time and aeration on grain pack factor, other than the study by Malm and Backer (1985).*

Laboratory studies have evaluated the effects of vibration on grain compaction (Wassgren et al., 2002; Ge et al., 2000). Ge et al. (2000) observed settlement of a grain pile with vibrations of 48 Hz, but indicated this frequency is too high to be from railway traffic near silos. Overall, it is clear that the effect of time and aeration on grain packing has never been the focus for previous research efforts, even though previous studies strongly suggested that storage time and aeration influence grain compaction.

Molenda et al. (1996) looked at loading and unloading cycles with soft red winter wheat in a pilot scale smooth walled steel bin (2.44 m diameter and 7.3 m eave height) and found that μ (coefficient of friction) and k (lateral to vertical pressure ratio) can change with every loading cycle, where one loading cycle includes both filling and emptying the bin. The values of 'μ·k' in equation 2 decreased from 0.16 for the first loading cycle to 0.06 for the 23rd loading cycle. This change was due to the combined effects of decrease in the coefficient of wall friction and increase in k value. It has been shown that each time there is loading and unloading of grain in a steel bin, wear-in reduces the coefficient of friction (Thompson et al., 1988). The k values are correlated to angle of internal friction (ϕ) (Equation 3). Thus, decrease in internal friction (ϕ was 25° for the first loading cycle and 22° for 23rd loading cycle) will result in increase in k values. The relationship between k and internal friction (ϕ) is given as:

$$k = \frac{1-sin\phi}{1+\sin\phi} \qquad (3)$$

Furthermore, the vertical wall load-to-total grain load ratio decreased from 52.7% (after the first loading cycle) to 28.3% (after the 10th loading cycle). Though this study by Molenda et al. (1996) developed an understanding on the grain properties during loading and unloading cycle, *there have been no studies reported in the literature looking at loading cycle effect on grain pack factors.* Thompson et al. (1998) investigated the change in wall and floor loads due to side discharge flumes (side-draws) in bins. Because the wall and floor loads changed during unloading due to the side discharge, it would be expected that the overburden pressure on the grain would also change. Due to the change in pressure the amount of packing would likely change. The effect of side-draw on the change in pressure and grain pack factor is also unknown.

At present, the use of WPACKING to calculate the grain mass is based on assumptions that storage time, aeration, and loading cycle does not affect grain packing factor. With many reported studies indicating the effect of these external factors on different grain physical properties, there is a need for updating the grain packing factor predictions.

Problem Statement – Rationale and Significance

The proposing team recently validated the pack factor prediction model, WPACKING, mentioned above, under a collaborative agreement between USDA-RMA and USDA-ARS. The study calibrated the model using field measurements from several hundred grain bins in the U.S. immediately after loading. The resulting model predicts pack factors based on the normally available, directly measurable attributes of the grain and the storage bin such as the grain type,

test weight, and moisture content; the bin wall material; and the grain volume based on bin dimensions and grain height. The additional factors such as storage time, aeration, etc, were not within the scope of that work and thus not included in the model. Previous research with limited crops indicated that *storage time* (Malm and Backer, 1985) and *grain loading cycles* (Molenda et al, 1996) have a significant effect on grain compaction. Long term storage and partial unloading and then refilling of grain bins are common scenario in grain elevators. Inclusion of these parameters in WPACKING will allow much-needed improvement in the prediction of grain mass based on packing in bin at common storage conditions.

The recently concluded study (Bhadra et al., 2014) showed that there is an effect of varieties (within a crop type) on grain pack factors in addition to moisture and test weight effects. Currently, the WPACKING model accurately predicts the grain packing based on moisture, test weight, and crop type. However, *secondary quality factors* like dockage in wheat, BCFM in corn, and GMO vs. non-GMO varietal effects are addressed by WPACKING. We hypothesize that storage time, aeration, grain loading cycles, and secondary quality factors like dockage, BCFM, and grain variety will have a significant effect on grain compaction. Hence, it is important to study the impact of these effects on grain packing to permit accurate predictions in these common grain industry situations.

Objectives

There is very limited information in the literature on the effect of storage time and aeration and the effect of partial unloading/loading cycles and side discharge on grain compaction in bins. These are frequent occurrences during grain storage and could result in significant deviations in packing during storage. In addition, secondary grain quality parameters such as high dockage, high BCFM, and GMO varieties have not been studied in relation to grain compaction. To address these issues, the objectives of this study are to:

1. Determine the effect of storage time, up to 12 months, with and without aeration on pack factors of wheat, corn, and barley during storage using field studies, laboratory compressibility tests, and computer modeling.
2. Determine the effect of bin loading and unloading procedures on packing including partial unloading and refilling and side discharges using field- and laboratory-scale bins.
3. Evaluate the effects of secondary crop quality parameters such as high dockage (for wheat), high BCFM (for corn), and GMO vs. non-GMO varieties on grain packing and evaluate using DEM modeling to characterize the fundamental compressibility measurements in the laboratory.

Experimental Methods

Approach

These large-scale grain compaction effects require field tests to confirm laboratory and modeling results. A well-established approach to address complex physical processes like grain packing due to overbearing pressure is to measure fundamental properties (grain compressibility) in the laboratory and incorporate that in a computer model that is then validated in the field (Thompson et al. 1991, Boac et al., 2014a). This approach will generally be followed to achieve the three objectives.

For objective 1, effect of storage time and aeration, we will determine the effect of time under compression on grain in laboratory compressibility experiments and incorporate this fundamental compressibility data into WPACKING. New laboratory compressibility boxes will be constructed to allow for airflow with controlled temperature and humidity to simulate grain aeration for the laboratory measurements. The modifications to WPACKING will be validated with field measurements of grain packing during long-term storage.

For objective 2, effect of partial unloading cycles, a 2.44 m diameter laboratory bin supported on load cells to monitor forces will, after initial loading, be partially unloaded and then re-loaded with grain for five cycles. The effect of these loading cycles will be incorporated into WPACKING and field measurements of similar loading-unloading cycles will be used to validate the results.

For objective 3, effect of secondary quality parameters, the basic effect of each new parameter will be measured in the laboratory compressibility boxes and the results will be compared with DEM modeling predictions and, again, these will be incorporated into WPACKING before validating the results with field measurements.

Objective 1 – Effect of Storage Time **and Aeration**

Laboratory Scale Compressibility Tests (University of Kentucky)

We will determine the effect of time under compression on grain in laboratory compressibility experiments. These effects will be incorporated into the WPACKING model and the resulting predictions validated with field measurements. Our hypothesis is that changes in grain packing during long-term aeration are due to moisture changes and the resulting change in particle size and stress within the grain mass. To evaluate changes in packing due to aeration, 12 inch diameter cylinders will be constructed and pressure applied to the cylinder with all thread rods (Figure 2). Perforated steel blocks will be used at the end of the cylinder to allow for conditioned air to flow through the cylinder. Air will be provided by an environmental chamber to create conditions that result in either rewetting or drying for each test. Based on this data the change in grain packing can be evaluated.

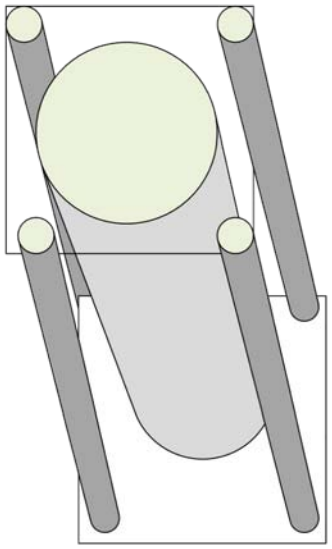

Figure 2. Proposed cylinder with all thread rod to compress grain samples for long term storage.

Field Data Collection and Calibration of WPACKING (Kansas State University, USDA-ARS, and University of Georgia)

Several test bins are available at the USDA-ARS Center for Grain and Animal Health Research (CGAHR). Validation data will be gathered from CGAHR, commercial, and on-farm bins. This will give a comparative study with field data for time and aeration on changing grain pack factors. Commercial facilities commonly store malting barley undisturbed for six months or longer, so we have identified collaborators storing barley for long-term measurements. Pilot scale steel bins (up to 5,000 bu) and larger concrete bins (up to 85 ft tall and 11,500 bu) are available at CGAHR for additional long-term measurements with wheat and corn. Approximately 16,000 to 20,000 bu of grain will be available at any given time to use for tests in the CGAHR bins. Pilot scale steel bins will be monitored monthly, and the change in grain heights will be measured. The concrete bins will be tracked on a daily basis for the first week, to see the initial effect of storage on grain height settlement and then weekly for at least 3 months. Collaborators will also be sought with larger bins of wheat and corn; these crops are stored for several months on-farm and collaborators will be sought who store for at least three months and preferably over six months. Similarly, collaborators for sorghum and soybean will be sought who store grain for 3 months or longer. Packing values will be measured immediately after loading and at monthly intervals in all tests with additional early measurements of the tall concrete bins at CGAHR as mentioned above.

For the initial measurement we will collect data on the standard bin and grain variables: bin diameter, eave height, hopper bottom angle, grain and cone height, average test weight (with dockage and BCFM), method of filling, average moisture content, and mass of grain in the bin (from scale measurements). In addition, we will collect other important variables: time of storage, aeration hours, aeration airflow rates, and loading cycles.

Preliminary Field Data on the Effect of Storage Time

Preliminary field data collected in 2012 and 2013 showed a significant decrease (95% confidence level) in grain height for commercial grain bins with respect to storage time. Four barley bins in Idaho were tracked for a period of 12 months (November 2012 to November 2013) and are shown in Figure 3, the bin nomenclature is that used at the facility. All four bins measured 88.5 ft (26.97 m) in diameter and 66.0 ft (20.11 m) in eave height. The average test weight was 57.5 lb/bu (740.02 kg/m^3) and the average moisture content was 9.5% (wb). A measureable decrease in grain height was measured in Bins 1 and 2 after 7 months of storage and in Bin 5 after six months of storage. However, it is clear that from 7 months onwards there was a slight decrease in grain height. A final decrease in grain height of 1.42% (on Nov 2013, i.e., the last data point) was observed with much of this occurring between the 7 and 12 months of storage. These bins were not aerated, but aeration usually changes the moisture content of the grain and, thus, aerated bins are expected to exhibit different grain packing trends than bins without aeration.

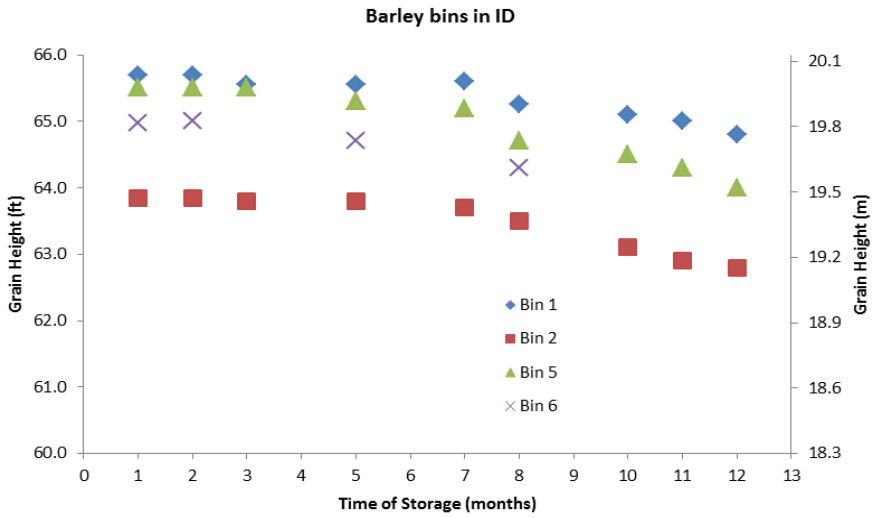

Figure 3. Plot of grain height (ft) vs. time of storage in months for barley stored in corrugated steel bins in Idaho. Storage was from Nov 2012 to Nov 2013.

Objective 2 – Effect of Partial Unloading Cycles

Laboratory Scale Bin Tests (University of Kentucky)

The effect of 1 to 5 loading cycles on basic grain compressibility will be evaluated in laboratory experiments. Previous work indicated the pressure distribution within the bin changed due to partial unloading, which would be expected to influence grain packing. A 2.44 m diameter bin supported on load cells at the University of Kentucky Granular Mechanics Laboratory will be fully loaded initially then partially unloaded and the percent packing quantified, with the unloading cycle repeated up to five times. Accurate grain volume measurements using a laser distance meter (Leica Disto D8, Leica Geosystems AG, St. Gallen, Switzerland) will allow for accurate determination of grain packing during the repeated loading and unloading cycles. Soft red winter wheat will used in these tests and results incorporated into the WPACKING model.

Field Data Collection and Calibration of WPACKING (Kansas State University, USDA-ARS, and University of Georgia)

The resulting predictions from WPACKING will be validated under field conditions. Commercial bins will have grain height and cone height measured with every loading cycle in the bin (i.e., filling, partial unloading, and refilling). Overall grain volume changes with loading cycle will be computed and the model will be calibrated with this field data as needed.

Commercial grain bins, both farm scale and commercial scale (i.e., diameter ranging from 15 ft for farm scale to 105 ft for large commercial bins) will be tracked and monitored for a number of loading cycles. Commercial bins will be filled, partially unloaded and refilled, thus, completing one loading cycle. For each loading cycle, change in grain and cone heights will be measured, and subsequently, this information will be fed in the current WPACKING program. During every loading cycle, the exact amount of grain unloaded and the amount of grain loaded back in will be tracked and reported from our cooperators. Change in grain and cone heights with time, aeration, and loading cycles will change the prediction results of the existing WPACKING

program. Differences (%) between actual mass of grain (sum total of truck loads in the bin) and WPACKING program predicted mass will be calculated for each bin type and shape and crop type. Differences in an ideal case should be zero. However, we hypothesize that time, aeration, and loading cycles will significantly change the compressibility behavior of the WPACKING model, and thus, the differences is expected to show either under-prediction, over-prediction, or random distribution. Such trends in difference will be carefully studied based on bin type, bin shape, H/D ratio, and crop types. Results of these differences will ultimately be used to validate and calibrate the WPACKING program for time and loading cycle's scenarios. Results from the laboratory compressibility studies (University of Kentucky) and field data collection (Kansas State University) will be compiled and refined models to predict pack factors of crops based on time, aeration, and loading cycles will be incorporated in the WPACKING program. Calibration of WPACKING will involve new models from laboratory tests for time, aeration, and loading cycle factors, and fine tuning of μ and k values, if necessary.

Objective 3 - Effect of Secondary Quality Parameters

The effect of high dockage (for wheat) and high Broken Corn and Foreign Material (BCFM, for corn) will be measured in laboratory compressibility experiments. Effect of GMO, non-GMO, and mixed variety of GMO and non-GMO at a ratio of 1:1 for corn and soybeans will be studied using laboratory scale compressibility set-up.

Laboratory Scale Compressibility Tests (University of Kentucky)

The University of Kentucky granular mechanics laboratory designed an automated compressibility tester (Figure 4). To predict grain packing using the modified Janssen's equation, the relationship between packing and pressure needs to be defined for the specific type and condition of grain in the bin. Packing can then be calculated throughout the bin and the average packing for the whole bin can be determined. To obtain the required relationships between packing and pressure, uniaxial compression tests were performed for various whole grains using established methods and equipment. Numerous uniaxial laboratory compression tests were performed on the grains using a steel box equipped with a flexible rubber diaphragm. The box constrained the grain in a chamber 12×12-inches in cross-section and 4-inches tall. The flexible rubber diaphragm in the base of the box was used to produce an equivalent overbearing pressure using compressed air matching conditions found in grain storage bins.

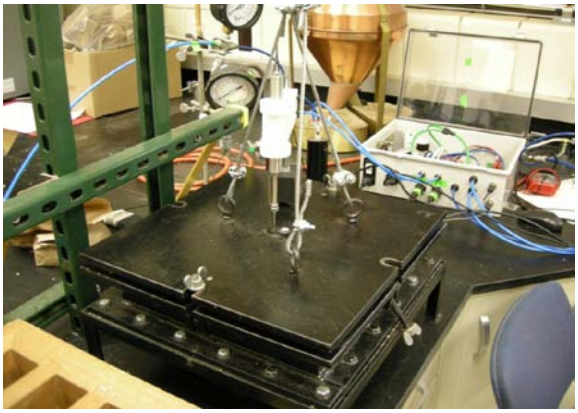

Figure 4. Compressibility measurement apparatus at University of Kentucky to measure grain compaction

Samples of grain with the desired characteristics will be obtained. A minimum of three GMO and three non-GMO samples of corn and soybeans will be obtained. These samples will have the same genetic background with only the GMO traits differing. Physical properties of the kernels (density, size, shape, etc.) will be determined along with the compressibility of the samples using the laboratory compression device. Targeted field sites will be identified where the effects could be validated.

Corn and wheat samples will be mixed in the laboratory to provide high BCFM and dockage samples. Levels that would be appropriate for sample grade corn and wheat will be used to set the desired quantity of secondary crop parameters. The samples will be well mixed and analyzed with the laboratory equipment. Field scale bins will be found with sample grade wheat and corn and the results from the laboratory compared to field data.

Application of DEM to Grain Compaction (Kansas State University and USDA-ARS)

The Discrete Element Method (DEM) is a proven numerical technique that models dynamic motions and interactions (particle-particle and particle-surface) of individual particles such as grain kernels. The DEM governing equations follow Newton's second law of motion, which provides the relationship between the motion of the particle and the surrounding contact forces (Theuerkauf et al., 2007). The soft sphere approach, which represents the deformation of particles upon contact as overlap, is commonly used for agricultural granular materials (Boac et al., 2014b). The force-displacement law for particle-particle contact applied to grains is based on Hertzian non-linear contact model (Mindlin, 1949; Tsuji et al., 1992).

DEM simulations for agricultural granular materials greatly depend on material (e.g., kernel shape, size, density, Poisson's ratio, shear modulus) and interaction (e.g., coefficients of restitution and friction) properties of grains, which can widely vary depending on the crop type. Both material and interaction properties are input parameters for EDEM, a DEM software package (ver. 2.6, DEM Solutions, Ltd, Edinburgh, UK). The list of those values for major crops in the United States are given by Boac et al. (2010), which was applied to study grain commingling in an elevator boot (Boac et al., 2012). These input values will be used to simulate grain compression in the laboratory compressibility box (Figure 4).

The standard measured factors that affect grain packing such as change in bulk density and moisture content will be represented by the material and interaction properties in the model. The secondary factors in this objective, such as high dockage and BCFM will additionally be represented by particle shape, size, and size distribution. The GMO variety differences may be represented by the material and interaction properties if property measurements indicate that is appropriate. All of these factors will be studied by simulating grain packing inside the laboratory compressibility box. Using DEM, forces acting on the grain at the particle level can be determined and analyzed in comparison to the laboratory results. Future work, beyond the scope of this study, is expected to apply the resulting validated model to a full grain bin.

Data Analysis and Interpretation

All laboratory compressibility tests will be done under controlled room temperature condition with four replications. Detailed statistical analysis will be performed using SAS software (SAS Institute, Inc., Cary, NC) with tools like non-linear regression modeling (PROC NLIN), mean, standard deviation, standard errors, Analysis of Variance (ANOVA) and Least Significant Difference (LSD) test. Detailed field data collection will be entered in AUTOCAD

and MS Excel to draw the grain bin profile and cone angle for each measured bin. Change in estimated pack factors and measured grain height after each month will be calculated. The existing WPACKING program will be used to estimate the percentage difference (or error) due to time, aeration, and loading cycles. Calibration of WPACKING will involve including new regression packing models in the database and then changing coefficient of friction (μ) and/or ratio of lateral pressure to vertical pressure (k), wherever applicable.

Technology Transfer

Results of this project will be incorporated in the existing WPACKING program that will be used by USDA-RMA, the agency that administers Federal Crop Insurance Corporation (FCIC) programs. The updated version of WPACKING, after incorporating effects of time, aeration and loading cycles will be available through Kansas State University's extension website and USDA-ARS, Manhattan, KS website along with program manual so that interested parties can access it. Results of the project will be published through appropriate channels of USDA-ARS, Kansas State University, and the University of Kentucky in peer-reviewed scientific journals and technical magazines for readers from both academia and the grain industry. Additionally, the results will be shared in ASABE international conferences, GEAPS Exchange, NC-213 meetings, and also through personal contacts with the stakeholders. We also propose that results of the project along with the updated WPACKING program will be delivered as part of lectures at Kansas State Universities International Grains Program (IGP) instructional courses "Bulk Solids and Grain Handling" and "Grain Marketing."

Anticipated Results, Products, and Impacts

The existing WPACKING model does not account for the effect of storage time, aeration effects, and loading cycles for grain volume calculations. This research will estimate these effects on grain pack factor to calibrate and modify the WPACKING model to give accurate results in these cases. In addition, the effect of high dockage and high foreign material (BCFM) for wheat and corn, respectively on the pack factor will be estimated. The study will also estimate the difference in compaction behavior of GMO, non-GMO and mixed variety of corn and soybeans. The proposed DEM model will be an effective tool for expanding the grain compaction studies to other cereal grains and for simulating extreme conditions of storage and compaction.

The major deliverables are:

1. An updated and accurate WPACKING model for grain inventory purposes specific to variables like time of storage, aeration, and loading cycles.
2. A DEM model for future expansion of WPACKING model to other cereal grains

The results of this project will be incorporated in the existing WPACKING program. Effects of time and aeration in the WPACKING program will be an important addition to improve its accuracy of prediction and grain volume calculations. The comprehensive WPACKING program in an extremely user–friendly software and will be an effective tool for crop insurance agencies, licensing agencies, and stored grain managers for accurate grain inventory information.

Leveraging Resources

This research can be expanded to predict pack factors of other major cereal grains and will aid in the development of a larger grant. The updated WPACKING model will be useful for government agencies, insurance agencies, and farmers for accurate inventory of grains. The results will also provide a basis grant proposals targeting other challenges in grain inventory assessment. While USDA-RMA is preparing to use updated pack factors from this work, the warehouse auditing groups, USDA-FSA-W and the state agencies, have not yet taken steps to move on from the old empirical pack factors that don't take into account any of these new issues, and don't even account for all of the fundamental measured grain and bin parameters that affect pack factors. With this additional work we hope to address the needs of the warehouse auditors and be able to provide more accurate pack factors needed for their auditing activities.

Timetable

The timeline for this project is illustrated in the Gantt chart below. Collection of crop samples (corn, wheat, barley, and soybean) for time and aeration effects and GMO and non-varieties (corn, soybean, and wheat), will be done during the first three months. Laboratory compressibility tests to see the effect of time and aeration on pack factors will continue for a year, from March of 2015 to March of 2016. Simultaneously, tests of multiple loading cycles laboratory bins and the field data will be conducted. Laboratory tests with secondary quality parameters begin in June of 2015 and continue June of 2016.

Gantt Chart – Schedule of Tasks

	Task	Dates	Location	Q1 '15			Q2 '15			Q3 '15			Q4 '15			Q1 '16			Q2 '16			Q3 '16			Q4 '16		
				1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1	Collect corn, wheat, barley, and soybean samples from academic and industry sources.	1/15/2015 to 3/15/2015	Kansas State Univ. & Univ. of Kentucky																								
2	Laboratory compressibility tests for time & aeration effects & loading cycles. Storage up to 1 year.	3/15/2015 to 3/15/2016	Univ. of Kentucky																								
3	Collect GMO and non-GMO samples of corn and soybeans, & conducting compressibility tests.	6/1/2015 to 6/30/2016	Univ. of Kentucky																								
4	Field measurements in grain bins across the U.S. Grain volume to be tracked for 3 to12 months.	3/15/2015 to 9/30/2016	Kansas State Univ. & USDA-ARS																								
5	Field measurements in commercial grain bins during loading-unloading cycles.	7/1/2015 to 6/30/2016	Kansas State Univ. & USDA-ARS																								
6	Annual Report	12/1/2015 to 12/23/2015	ALL																								
7	Non-linear modeling of pack factors; incorporation into and calibration of WPACKING.	5/1/2016 to 11/30/2016	Kansas State Univ., USDA-ARS, & Univ. of Georgia																								
8	DEM simulation model development.	3/1/2015 to 11/30/2016	Kansas State Univ. & USDA-ARS																								
9	Final Report	11/1/2016 to 12/23/2016	ALL																								

Kansas State University will collect field data from farm and elevator bins for calibration of the updated WPACKING model with the new information for time, aeration, loading cycle and other effects. Field data collection will begin in March, 2015 and continue through September, 2016 and bins will be monitored for multiple loading cycle effects on grain pack factor, grain height, and overall error between the WPACKING-predicted and reported mass values for each month. Data compilation and calibrating the WPACKING model based on new non-linear compressibility equations from the University of Kentucky and field data collection from grain bins by Kansas State University and USDA-ARS will be completed from May, 2016 to November, 2016. During most of the project time frame (March, 2016 to November, 2016), Kansas State University and USDA-ARS will also develop the DEM simulation for predicting pack factors in crop samples in compressibility boxes.

Collaboration

Mark Casada will coordinate the project with Kingsly Ambrose coordinating the work at Kansas State University and Michael Montross coordinating the work at the University of Kentucky. The field measurements and data compilation will be largely conducted by Rumela Bhadra. Non-linear modeling and WPACKING calibration will be carried out at Kansas State University. Josephine Boac will conduct DEM simulation trials at USDA-ARS to perform compressibility tests using EDEM software. Michael Montross from the University of Kentucky will conduct all laboratory experimental trials with the help of an engineer. Sidney Thompson from the University of Georgia and Samuel McNeill from the University of Kentucky will lead the WPACKING calibration and will contribute to field data collection.

Literature Cited

ASABE Standards. 2010. EP413.2. Procedure for establishing volumetric capacities of cylindrical bins. St. Joseph, Mich.: ASABE.

Bhadra, R., J. M. Boac, R. G. Maghirang, M. E. Casada, M. D. Montross, S. G. McNeill, A. Turner, and S. A. Thompson. 2014. Developing new stored grain pack factors with known accuracy for the common grains in trade under a complete range of field conditions. Unpublished report to USDA-RMA. Available on request.

Boac, J. M., Kingsly, R. P. A., M. E. Casada, R. G. Maghirang, and D. E. Maier. 2014b. Applications of discrete element method in modeling of grain postharvest operations. *Food Engineering Reviews*: 1-22. DOI: http://dx.doi.org/10.1007/s12393-014-9090-y.

Boac, J. M., M. E. Casada, R. G. Maghirang, and J. P. Harner III. 2010. Material and interaction properties of selected grains and oilseeds for modeling discrete particles. *Transactions of the ASABE* 53(4): 1201-1216.

Boac, J. M., M. E. Casada, R. G. Maghirang, and J. P. Harner III. 2012. 3-D and quasi 2-D discrete element modeling of grain commingling in a bucket elevator boot system. *Transaction of ASABE* 55(2):659-672.

Boac, J. M., R. Bhadra, M. E. Casada, S. A. Thompson, M. D. Montross, S. G. McNeill, and R. G. Maghirang. 2014a.3. Stored grain compaction factors for wheat: comparison of methods. *Transactions of the ASABE*. (in review).

Clower, R. E., I. J. Ross, G. M. White. 1973. Properties of compressible granular materials as related to forces in bulk storage structures. *Transaction of the ASAE* 16(3): 478-481.

Chung, Y. C., J. Y. Ooi, and J. F. Favier. 2004. Measurement of mechanical properties of agricultural grains for DE models. In Proceedings of 17th ASCE Engineering Mechanics Conference, Newark, Delaware, American Society of Civil Engineers.

Ge, T., Q. Zhang, and M. G. Britton. 2000. Predicting grain consolidation caused by vertical vibration. *Transactions of ASAE* 43(6): 1747-1753.

Loewer, Jr. O. J., I. J. Ross, D. D. Kratzer, J. N. Walker. 1977. Properties of ground shelled corn as related to forces in bulk storage structures. *Transactions of the ASAE* 20(1): 155-156.

Malm, J. K., and L. F. Backer. 1985. Compaction factors for six crops. *Transactions of the ASAE* 28(5): 1634-1636.

Mindlin, R. 1949.Compliance of elastic bodies in contact. *Journal of Applied Mech.* 16(3): 259-268.

Molenda, M., J. Horabik, and I. J. Ross. 1996. Wear-in-effects on loads and flow in a smooth-wall bin. *Transactions of the ASABE* 39(1):225-231.

Theuerkauf, J., S. Dhodapkar, and K. Jacob. 2007. Modeling granular flow using discrete element method: From theory to practice. *Chemical Engineering* 114(4): 39-46.

Thompson, S. A., and I. J. Ross. 1983. Compressibility and frictional properties coefficients of wheat. *Transactions of the ASAE* 26(4): 1171-1176, 1180.

Thompson, S. A., R. A. Bucklin, C. D. Batich, and I. J. Ross. 1988. Variation in the apparent coefficient of friction of wheat on galvanized surfaces. *Transactions of the ASAE* 31(9):1928-1934.

Thompson, S. A., S. G. McNeill, I. J. Ross, and T. C. Bridges. 1987. Pack factors of whole grains in Storage Structures. *Applied Engineering in Agriculture* 3(2): 215-221.

Thompson, S. A., S. G. McNeill, I. J. Ross, and T. C. Bridges. 1990. Computer model for predicting the packing factors of whole grains in flat storage structures. *Applied Engineering in Agriculture* 6(4): 465-470.

Thompson, S.A., C.V. Schwab, and I.J. Ross. 1991. Calibration of a model for packing whole grains. *Applied Engineering in Agriculture* 7(4): 450-456.

Thompson, S.A., M. Molenda, I. J. Ross, and R. A. Bucklin. 1998. Loads caused by bottom unloading wall flumes in a model grain bin. *Transactions of the ASAE* 41(6): 1807-1815.

Tsuji, Y., T. Tanaka, and T. Ishida. 1992. Lagrangian numerical simulation of plug flow of cohesionless particles in a horizontal pipe. *Powder Technology* 71(3):239-250.

USDA Warehouse Examiner's Handbook Grain Pack Data WS-3. No date. Warehouse Examiner's Handbook. Washington, D.C.: USDA, Agricultural Stabilization and Conservation Services, Warehouse Division (Now USDA, Farm Service Agency, Commodity Services, Procurement and Warehouse Branch.

USDA-RMA. 2012a. Loss Adjustment Manual (LAM) Standard Handbook: Directive no. 25010-1H. Washington, D.C.: USDA Risk Management Agency. Online available at : http://www.rma.usda.gov/data/25000/2012.html

USDA-RMA. 2012b. Small Grains Loss Adjustment Standards Handbook: Directive no. 25430-1H. Washington, D.C.: USDA Risk Management Agency. Online available at : http://www.rma.usda.gov/data/25000/2012.html

Wassgren, C. R. 2002. Effects of vertical vibration on hopper flows of granular material. *Physics of Fluids* 14(10): 3439-3448.

MARK E. CASADA, Ph.D., P. E.
Research Agricultural Engineer
USDA–ARS, CGAHR, Engineering & Wind Erosion Research
Manhattan, Kansas 66502

EARNED DEGREES

Ph.D., Biological and Agricultural Engineering	North Carolina State Univ., Raleigh	1990
M.S., Agricultural Engineering	University of Kentucky, Lexington	1985
B.S., Mechanical Engineering	University of Kentucky, Lexington	1981

EMPLOYMENT HISTORY

1999–present **Research Agricultural Engineer.** USDA–ARS, Center for Grain and Animal Health Research, Manhattan, Kansas. Leads research on grain handling, drying, and storage.

1999–present **Adjunct Associate Professor.** Kansas State University, Biological and Agricultural Engineering Department. Member of graduate faculty.

1990–1999 **Associate/Assistant Professor.** University of Idaho, Biological and Agricultural Engineering Department. Taught and conducted research on grain drying and storage, food engineering, and potato transportation. Member of graduate faculty.

1989–1990 **Research Assistant**, Biological and Agricultural Engineering Department, North Carolina State University. Studied global methane emissions from livestock and poultry waste.

PROFESSIONAL ACTIVITIES

Major Committees:

American Society of Agricultural and Biological Engineers (ASABE):
- FPE-03, Standards Group. Chair, 2013 to present
- FPE-04, Publications Group. Chair, 2008 to 2010
- FPE-702, Crop and Feed Processing and Storage committee. Chair, 2003 to 2005
- FPE-704, Special Crops Processing. Chair, 1990 to 1991

American Society for Engineering Education (ASEE):
- Biological and Agricultural Engineering. Division, Chair, 1999 to 2000
- Biological and Agricultural Engineering. Division, Proceedings Editor, 1998 to 1999

IWQC-II, International Wheat Quality Conference:
- Advances in Processing Technology Technical Committee, Chair, 2000 to 2001

Other Professional:

Industry Advisory Board, Biological Systems Engineering Dept., Washington State Univ., 1998 to 1999

ASABE-FPEI Associate Editor (*Trans. ASABE*; *Applied Engr. in Agri.*). 1997 to present

NC-213, "Marketing and Delivery of Quality Cereals and Oilseeds," Chair, 2001, 2009

Theses Supervised:

University of Idaho – 2 M.S, 2 Ph.D.

Kansas State University – 2 M.S, 4 Ph.D. (1 in progress)

HONORS AND AWARDS

Sigma Xi, Alpha Epsilon (Agricultural Engr.), Pi Tau Sigma (Mechanical Engr.)
ASABE Paper Awards: 1995, 2006, and 2009
ASABE Outstanding Journal Reviewer Award, 2007.
Andersons Cereals and Oilseeds Award of Excellence (2013), Multistate Project NC-213.

RECENT PUBLICATIONS

1. *Boac, J.M.*, R.P. Kingsly Ambrose, **M.E. Casada**, R.G. Maghirang, and D.E. Maier. 2014 Applications of discrete element method in modeling of grain postharvest operations. Food Engineering Reviews: In Press.
2. Patwa, A., R.P. Kingsly Ambrose, H. Dogan, and **M.E. Casada**. 2014. Wheat mill stream properties for discrete element method modeling. *Transactions of the ASABE* 57(3): 891-899.
3. *Tilley, D.R.*, B. Subramanyam, **M.E. Casada**, and F.H. Arthur. 2014. Stored-grain insect population commingling densities in wheat and corn from pilot-scale bucket elevator boots. *Journal of Stored Product Research* 59: 1-8.
4. Armstrong, P.R., **M.E. Casada**, and J. Lawrence. 2012. Development of equilibrium moisture relationships for storage moisture monitoring of corn. *Trans. of the ASABE* In Press.
5. *Boac, J.M.*, **M.E. Casada**, R.G. Maghirang, and J.P. Harner III. 2012. 3-D and quasi-2-D DEM modeling of grain commingling in a bucket elevator boot system. *Transactions of the ASABE* 55(2): 659-672.
6. Jones, C., **M. Casada,** and O. Loewer. 2012. Drying, Handling and Storage of Raw Commodities. Book chapter 10 in *Stored Product Protection*.
7. Navarro, S., R.T. Noyes, **M.E. Casada**, and F.H. Arthur. 2012. Aeration of grain. Book chapter 11 in *Stored Product Protection*.
8. Lee, K.M., P.R. Armstrong, J.A. Thomasson, R. Sui, **M.E. Casada**, and T.J. Herrman, 2010. Application of binomial and multinomial probability statistics to the sampling design process of a global grain tracing and recall system. *Food Control* 22(7): 1085-1094
9. Lee, K.M., P.R. Armstrong, J.A. Thomasson, R. Sui, **M.E. Casada**, and T.J. Herrman, 2010. Development and characterization of food-grade tracers for the global grain tracing and recall system. *Journal of Agricultural and Food Chemistry* 58(20): 10945-10957.
10. *Boac, J.M.*, **M.E. Casada**, R.G. Maghirang, and J.P. Harner III. 2010. Material and interaction properties of selected grains and oilseeds for modeling discrete particles. *Transactions of the ASABE*. 53(4): 1201-1216.
11. Arthur, F.H, and **M.E. Casada**. 2010. Directional flow of summer aeration to manage insect pests in stored wheat. *Applied Engineering in Agriculture* 26(1): 115-122.
12. **Casada, M.E.**, and P.R. Armstrong. 2009. Wheat moisture measurement with a fringing field capacitive sensor. *Transactions of the ASABE* 52(5): 1785-1791.
13. *Boac, J.M.*, R.G. Maghirang, **M.E. Casada**, J. D. Wilson, and Y.S. Jung. 2009. Size distribution and rate of dust generated during grain elevator handling. *Applied Engineering in Agriculture*. 26(1): 533-541.
14. *Tilley, D.R.*, M.R. Langemeier, **M.E. Casada**, and F.H. Arthur. 2009. Cost and risk analysis of heat and chemical treatments. (In Italian). *Tecnica Molitoria* 60(11): 1234-1252.

R. P. KINGSLY AMBROSE
Assistant Professor
Department of Grain Science and Industry, Kansas State University
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URL: http://grains.ksu.edu/particle_technology/Home.html

EDUCATION

Ph.D., Agricultural and Biological Engineering 2010
Purdue University, West Lafayette, IN, USA.

M. S., Agricultural Processing 1998
Tamil Nadu Agricultural University, Coimbatore, India.

B. S., Agricultural Engineering 1996
Tamil Nadu Agricultural University, Coimbatore, India.

PROFESSIONAL POSITIONS

Assistant Professor 2012 January - Present
Department of Grain Sci. and Industry, Kansas State University, Manhattan, KS, USA.

Postdoctoral Research Assistant 2011 January – 2011 December
Department of Ag. and Biological Eng., Purdue University, West Lafayette, IN, USA.

Graduate Research Assistant 2007 - 2010
Department of Ag. and Biological Eng., Purdue University, West Lafayette, IN, USA.

Scientist 2001 - 2007
Central Institute of Post Harvest Engineering and Technology (CIPHET), Indian Council of Agricultural Research (ICAR), Abohar, Punjab, India.

Senior Research Fellow 1998 – 2001
Department of Bioenergy, Tamil Nadu Agricultural University, Coimbatore, India.

QUALIFICATIONS SUMMARY

Dr. Ambrose started developing a nationally and internationally recognized research group focusing on milling and grain processing. His research group focuses on three primary research areas namely: (1) milling of whole grains and specialty crops; (2) particulate flow and materials handling, (3) food process engineering, and (4) grain dust explosion prevention.

HONORS AND AWARDS

- NC-213 Andersons Cereals and Oilseeds – 2014 **Early-in-Career Award of Excellence**
- **Bilsland Dissertation Fellowship,** 2010. Purdue University, West Lafayette, IN, USA.
- **Purdue Agriculture TEAM Award,** 2009. The Integrated Corn Ethanol Co-Products Team. Purdue University, West Lafayette, IN, USA.
- **Norman E. Borlaug Fellowship,** 2006. USDA. To undergo training on "High Pressure Processing" at The Ohio State University, Columbus, OH, USA.
- **Best Scientist,** 2005. CIPHET, Ludhiana, India.
- **Certificate of Appreciation**, 2005. CIPHET, Ludhiana, India. For contribution towards the development of technology "Algorithm for maturity index calculation and development of color chart for mango".

External and Internal Research Awards: Since becoming a faculty member in Grain Science and Industry Department at Kansas State University in January 2012, as PI, Dr. Ambrose has obtained a total of $555,005 in new project funding and $157,637 in-kind gift. Funding sources include Multi-State funding (27.0%), federal sources (40.5%) and industry (32.5%) for research and extension programs. As a Co-PI he has received $705,559 grant funding.

SYNERGISTIC ACTIVITIES

- Member of American Society of Agricultural and Biological Engineers (ASABE)
- Member of American Association of Cereal Chemists (AACC International)
- Station Representative, Kansas State University, NC-213 Multi-state Project on 'Marketing and delivery of quality grains and bioprocess coproducts'.
- Co-Chair, Rheology Division, AACC International (2014-2015)
- Vice-Chair, Food Process Engineering Division of ASABE (2014-2015)
- Graduate Faculty Member, Food Science Institute, Kansas State University (2013 -Present)
- Adjunct Professor, Tamil Nadu Agricultural University, Coimbatore, India

TEACHING (AT KANSAS STATE UNIVERSITY)

- Materials Handling-GRSC 310; Particle Technology for Solids Handling and Processing-GRSC 786; Advanced Grain Processing-GRSC 840; Preventing Grain Dust Explosions-GEAPS 544.

PATENTS

- Jha, S.N., Chopra, S. and **Kingsly, A.R.P.** 2004. Method of determining maturity of intact mango on tree. India. 250880. Date of filling: 12/02/2004. Date of Issue: 02/10/2012.

PUBLICATIONS *(Recent Refereed Publications)*

1. Boac, J. M., **Ambrose, R. P. K.,** Casada, M. E., Maghirang, R. G. and Maier, D. E. 2014. Applications of discrete element method in modeling of grain postharvest operations. *Food Engineering Reviews*. DOI 10.1007/s12393-014-9090-y (*In Press)*.
2. Patwa, A., **Ambrose, R. P. K.,** Dogan, H. and Casada, M. E. 2014. Wheat mill stream properties for discrete element method modeling. *Transactions of the ASABE* 57(3): 891-899.
3. Patwa, A., Malcolm, B., Wilson, J. and **Ambrose, R .P.K.** 2014. Particle size analysis of two distinct classes of wheat flour by sieving. *Transactions of the ASABE* 57(1): 151-159.
4. Probst, K., **Ambrose, K .,** Pinto, R.L., Bali, R., Krishnakumar, P. and Ileleji, K.E. 2013. The effect of moisture content on the grinding performance of corn and corncobs by hammermilling. *Transactions of the ASABE* 56(3): 1025-2033.
5. Probst, K., Ileleji, K.E., **Kingsly, A.R.P.**, Clementson, C.L. and Garcia, A. 2013. Effect of condensed distillers solubles on the physical, chemical properties and moisture sorption isotherm of corn DDGS – Bench scale experiments. *Biosystems Engineering* 115: 221-229.
6. **Kingsly, A.R.P**, Ileleji, K.E. and Stroshine, R.L. 2013. Stress relaxation behavior of corn distillers dried grains with solubles (DDGS) in relation to caking. *Powder Technology* 235: 866-872.
7. **Kingsly, A.R.P.** and Ileleji, K.E. 2011. Glass transition behavior of corn distillers dried grains with solubles (DDGS). *Journal of Cereal Science* 54, 332-338.

Michael D. Montross, Ph.D., P. E.
Professor
Biosystems and Agricultural Engineering, University of Kentucky
Lexington, KY 40546

EARNED DEGREES

Ph.D., Biological and Agricultural Engineering	Purdue University	1999
M.S., Agricultural Engineering	Michigan State University	1995
B.S., Agricultural Engineering	Michigan State University	1994

EMPLOYMENT HISTORY

2012–present Professor, Biosystems and Agricultural Engineering Department, University of Kentucky, July 2012.

2005-2012 Associate Professor, Biosystems and Agricultural Engineering Department, University of Kentucky.

1999-2005 Assistant Professor, Biosystems and Agricultural Engineering Department, University of Kentucky, July 2012 - present.

PROFESSIONAL ACTIVITIES

Major Committees:

American Society of Agricultural and Biological Engineers (ASABE):
Finance Committee
FPE-702, Crop and Feed Processing and Storage committee, Chair, 2003 to 2005
ASAE, SE-202 Bulk Solids Storage Systems (2001 - present)

Theses Supervised:

Completed - 6 M.S, 2 Ph.D.
In progress – 4 M.S., 3 Ph.D.

HONORS AND AWARDS

Loys Mather Outstanding Teaching Award, College of Agriculture Student Council, 2007
Outstanding Teacher in Biosystems and Agricultural Engineering 2007, 2008, 2009, 2010

GRANTS IN LAST FIVE YEARS

PUBLICATIONS IN LAST FIVE YEARS

1. Crofcheck, C., Shea, A., Montross, M., Crocker, M., and Andrews, R. Influence of media composition and flue gas components on the growth rate of Chlorella vulgaris and Scenedesmus acutus utilized for carbon dioxide mitigation. Trans. ASABE. 56(6): 1421-1429.
2. Crofcheck, C., E. X., Shea, A., **Montross, M.**, Crocker, M., Andrews, R. 2013. Influence of media composition on the growth rate of *Chlorella vulgaris* and *Scenedesmus acutus* utilized for CO2 mitigation. J. Biochem. Tech. 4(2): 589-594.

3. **Montross, M.D.**, S. DeBolt, W.C. Adams. 2013. Interplay between yield, nitrogen application, and logistics on the potential energetic and greenhouse gas emissions from biomass crops. Global Change Biology Bioenergy. 5(6): 664-673.
4. Nascimento, J.W.B., Lopes, N.J.P., Montross, M.D. 2013. Horizontal pressures in cylindrical metal silos and comparison with different international standards. Engenharia Agricola. 33(4): 601-611.
5. Duguid*, K.B., **M.D. Montross**, C.W. Radtke, C.L. Crofcheck, L.M. Wendt, and S.A. Shearer. 2009. Effect of anatomical fractionation on the enzymatic hydrolysis of acid and alkaline pretreated corn stover. Biores. Tech. 100 (21): 5189-5195.
6. Debolt, S., Campbell, J.E., Smith, R., **Montross, M.**, Stork, and J. Jozsef, S. 2009. Life cycle assessment of native plants and marginal lands for bioenergy agriculture in Kentucky as a model for south-eastern USA. Global Change Biology. 1(4): 308-316.
7. Stork, J., **Montross, M.**, Smith, R., Schwer, L, Chen, W., Reynolds, M., Phillips, T., Coolong, T., Debolt, S. 2009. Regional examination shows potential for native feedstock options for cellulosic biofuel production. Global Change Biology 1(3): 230-239.
8. Molenda*, M., **M.D. Montross**, S.A. Thompson, and J. Horabik. 2009. Asymmetry of model bin wall loads and lateral pressure induced from two- and three-dimensional obstructions attached to the wall. Trans. ASABE. 52(1): 225-233.
9. Łukaszuk*, L., M. Molenda, J. Horabik, **M.D. Montross**. 2009. Variability of pressure drops in grain generated by kernel shape and bedding method. Journal of Stored Products Research 45(1): 112-118.
10. Fan, Z., K. Wagschal, W. Chen, **M.D. Montross**, C.C. Lee, and L. Yuan. 2009. Multimeric hemicellulases facilitate biomass conversion. Applied and Environmental Microbiology. 75(6): 1754-1757.

Rumela Bhadra, Ph.D.
Research Associate
Biological and Agricultural Department
129 Seaton Hall, Kansas State University
Manhattan, KS-66502

Education

Ph.D. & M.S. (integrated) in Agricultural & Biosystems Engineering - January, 2011
South Dakota State University, Brookings, SD

Bachelor of Technology (B. Tech) in Biotechnology July, 2006
Heritage Institute of Technology, Calcutta, West Bengal University, India

Professional Appointments

Research Associate – Kansas State University, KS, 2011-Present

- Involved in developing compaction factors for six major food grain crops in U.S. for USDA-RMA and USDA-ARS interagency agreement. Other collaborators are from University of Kentucky and University of Georgia.
- Involved in physical and bulk properties of modified (low-oil) DDGS, funded by Anderson Research Grant Program Team Competition in 2012.

Graduate Research Assistant – South Dakota State University, SD, 2006-2010

- Involved in developing co a comprehensive understanding of flowability issues in Distillers Dried Grain with soluble (DDGS) and established a suitable mathematical model (using advanced statistical and theoretical modeling tools) for flow problems and cohesiveness, in collaboration with USDA-ARS.

Awards

- **2014 New faces of Engineering** recognition at the National Engineers Week Feb 16-22, 2014 representing Agricultural and Biological Engineering professionals. Featured in DiscoverE website for outstanding contribution in engineering profession.
- **ASABE Young Member of the Year (age below 41), 2013.** ASABE Kansas Chapter (Co-sponsor).
- Order of Engineer, ASABE Louisville, KY, 2011.
- 1st place, Graduate Student Research Award competition, IFT sub-sectional meeting, Spring 2009.
- Graduate Travel award, South Dakota State University, Brookings, SD, Spring 2009.

Professional Memberships

- American Society of Agricultural and Biological Engineers (ASABE), Member
- Engineering Without Borders, KS Chapter, Member
- International Food Technologist (IFT), Member

- Sigma Xi Scientific Research Society, Member
- AABFIO (ASABE India Chapter), Vice Chair, Member

Publication list (recent five)

- **Bhadra, R.,** K. Muthukumarappan, and K. A. Rosentrater. 2013. Effects of varying CDS levels and drying and cooling temperatures on the flowability properties of DDGS. *Cereal Chemistry 90(1):35-46.*
- **Bhadra, R.,** K. A. Rosentrater, and K. Muthukumarappan. 2012. Effects of CDS and drying temperature on the flowability behavior of DDGS. *Drying Technology 30(5): 542-558*
- **Bhadra, R.,** K. Muthukumarappan, K. A. Rosentrater, and S. Kannadhason. 2011. Drying characteristics of Distillers Wet Grains with varying Condensed Distillers Solubles and drying temperature levels. *Applied Engineering in Agriculture 27(5): 777-786.*
- **Bhadra, R.,** K. A. Rosentrater, and K. Muthukumarappan. 2011. Effects of varying CDS, drying, and cooling temperatures on glass transition temperature of DDGS. *Canadian Biosystems Engineering vol. 53: 3.9-3.18.*
- **Bhadra, R.,** K. A. Rosentrater, K. Muthukumarappan, and S. Kannadhason. 2011. Drying kinetics of Distillers Wet Grain under varying Condensed Distillers Solubles and temperature levels. *Cereal Chemistry 88(5): 451-458.*

Conferences (recent five)

- **Bhadra, R.,** Boac, J.**(Presenter),** Casada, M.E., Montross, M.D., Thompson, S.A., McNeill, S., and Maghirang, R.G. 2014. Field Measurement for grain compaction and commercial storage in US (project summary). Poster No.141899383. *Presented at 2014 ASABE international meeting, Montreal, CA.*
- **Bhadra, R.,** Kingsly, A.R. P., Casada, M.E., Simsek, S., and S. Kaliramesh **(Presenter).** 2014. No. Comparison of flow and physical properties of low-oil and regular DDGS. No.141899398. *Presented at 2014 ASABE international meeting, Montreal, CA.*
- **Bhadra, R.,** Kingsly, A.R. P., Casada, M.E., Simsek, S., and S. Kaliramesh. 2014. Intrinsic characteristics of modified DDGS and effective handling strategies. *Presented at 2014 NC-213/GEAPS meeting at Omaha, NE.*
- **Bhadra, R.,** Boac, J., Casada, M.E., Montross, M.D., Thompson, S.A., McNeill, S., and Maghirang, R.G. 2013. Field Measurement for Food Grain (6 crops) Packing Factors in US. No.131621335. *Presented at 2013 ASABE international meeting, Kansas City, MO.*
- **Bhadra, R.,** and Casada, M.E. 2013. Field measurement for stored grain packing factors: Field measurements. *Presented at 2013 NC-213/GEAPS meeting at Kansas City, MO.*

Sidney Thompson – Ph. D.
U. H. Davenport Professor
College of Engineering
University of Georgia
Athens, GA.

Earned Degrees: (Dates and Institutions)

Degree	Institution	Year
BS, Civil Engineering.	Kansas State University	1976
MS, Civil Engineering	Purdue University	1977
Ph. D., Agricultural Engineering	University of Kentucky	1981

Employment History:

U.H. Davenport Professor of Biological & Agricultural Engineering, July 1999 to Present
Professor, University of Georgia, July, 1995 to Present
Associate Professor, University of Georgia, July, 1988 to July, 1995
Assistant Professor, University of Georgia, Nov., 1980 to July, 1988.

Professional Activities:

Professional Societies:
ASABE - American Society of Agricultural and Biological Engineers
ASCE - American Society of Civil Engineers
ASEE - American Society of Engineering Education
Professional Committees:
ASME (American Society of Mechanical Engineers)
Structures for Bulk Solids Standards (SBS) Committee - writing a standard for the design of bulk solid structures
International Journal of Agro-physics, Polish Academy of Sciences, Editorial Board

ASABE Committees:
SE03- Standards Committee
SE20- Structures Committee
SE-20/4 Bulk Solids Handling & Storage

Honors & Awards:

D. W. Brooks Faculty Award for Excellence in Teaching. College of Agriculture and Environmental Sciences, University of Georgia, 1998.
Named U. H. Davenport Chaired Professor of Biological and Agricultural Engineering, University of Georgia, 1999.
Excellence in Teaching Material and Methods Award, Outstanding Teaching Methods in Technical Education, Biological and Agricultural Engineering Division, American Society for Engineering Education, 2001
Engineer of the Year in Education. State of Georgia, Georgia Engineering Alliance, 2004.
Outstanding Undergraduate Academic Advisor Award, The University of Georgia, 2005-2006.
Certificate of Merit, Outstanding Faculty Advisor, National, Academic Advising Association (NACADA), 2006
University of Georgia – Teaching Academy, class of 2007

Publications in Last Five Years: (Related to this Grant)

LoCurto, G. J., R. A. Bucklin, S. A. Thompson, A. I. Abdel-Hadi and O. R. Walton. 2014. Soybean coefficients of friction for aluminum, glass and acrylic surfaces. Applied Engineering in Agriculture. (In-Press)

Bucklin, R., S. A. Thompson, M. Montross, A. Adbel-Hadi. 2013. Grain Storage Systems Design. Handbook of Farm, Dairy and Food Machinery – Chapter 7. Academic Press. pp 123-175. (2nd Edition) – Revision

Bucklin, R. and S. A. Thompson. 2013. Encyclopedia of Agricultural, Food and Biological Engineering. Taylor & Francis (2nd Edition) – Revision

Bucklin and S. A. Thompson. 2012. Grain Storage Structures. Encyclopedia of Agriculture, Food and Biological Engineering.

Other Related Publications: (Publications Related to this Grant)

Thompson, S. A., S. G. McNeill, I. J. Ross and T. C. Bridges. 1987. Packing factors of whole grains in storage structures. Applied Engineering in Agriculture, Vol. 3, No. 2, pp 215-221.

Thompson, S. A., S. G. McNeill, I. J. Ross and T. C. Bridges. 1990. Computer model for predicting the packing factors of whole grains in flat storage structures. Applied Engineering in Agriculture. Vol. 6, No. 4, pp 465-470.

Thompson, S. A., C. V. Schwab and I. J. Ross. 1991. Calibration of a model for packing of whole grains. APPLIED ENGINEERING in Agriculture, Vol. 7, No. 4, pp 450-456.

Thompson, S. A., I. J. Ross and C. V. Schwab. 1992. Predicted packing factors for whole grains in metal grain bins. International Journal of Powder, Handling and Processing, to Bulk Solids Handling; Vol. 4, No.3, pp 265-269.

Foutz, T. L., S. A. Thompson and M. Evans. 1993. Comparison of loading response of packed grain and individual kernels. TRANSACTIONS of the ASAE. St. Joseph, MI. 36(2):568-576.

Thompson, S. A., N. Galili and R. A. Williams. 1996. Vertical floor pressures during filling of a full-scale grain bin. Transactions of the ASAE. 39(3):1093-1100.

Thompson, S. A., N. Galili and R. A. Williams. 1998. Floor and wall pressures in a full-scale corrugated grain bin during unloading. Transactions of the ASAE. 41(6):1799-1805.

McNeill, S.G., S. A. Thompson and M. D., Montross. 2004. Effect of moisture content and broken kernels on the bulk density and packing of corn. Applied Engineering in Agriculture. 20(4):475-480.

Molenda, M., Horabik, J., Thompson, S. A. and Ross. I. J. 2004. Effects of grain properties on loads in model silo. Journal of International Agro-physics. Vol. 18, No. 4. pp 329-332.

SAMUEL G. MCNEILL, PH.D., P.E.

Associate Extension Professor
Biosystems and Agricultural Engineering Department
University of Kentucky Research and Education Center
Princeton, KY 42445-0469

EDUCATION:

- Ph.D. in Agricultural Engineering. University of Tennessee, Knoxville, TN. Dissertation: Delayed harvest effects on the moisture sorption properties of soybeans. Advisor: Dr. Z. A. Henry. Dec. 1996.
- M.S. in Agricultural Engineering. University of Kentucky, Lexington, KY. Thesis: Drying Characteristics of Formed Poultry Excreta in a Deep Bed. Advisor: Dr. I. J. Ross. May 1979.
- B.S. in Agricultural Engineering. University of Kentucky, Lexington, KY. Dec. 1974.

EXPERIENCE:

- January 1, 2004 – present. Associate Extension Professor, Biosystems and Agricultural Engineering Department, University of Kentucky, Princeton, KY.
- January 1, 1998 – 2003. Assistant Extension Professor, Biosystems and Agricultural Engineering Department, University of Kentucky, Princeton, KY.
- January 28, 1979 – December 31, 1997. Extension Specialist, Agricultural Engineering Department, University of Kentucky, Princeton, KY.
- January 1, 1975 – December 31, 1977. Agricultural Engineer. University of Kentucky, Lexington.

PROGRAM EMPHASIS:

- Develop extension materials and programs for post-harvest grain and biomass processing to include handling, drying, cleaning and storage systems and optimization of energy resources. Conduct multi-disciplinary applied research to compliment extension program.

RECENTLY FUNDED PROJECTS (PAST FOUR YEARS):

- **McNeill, S.** Alliance for food security by reducing post-harvest losses of grains in Ghana. Oklahoma State University. Project duration: 1/14 – 12/18. Amount: $68,694.
- **McNeill, S.**, D. Maier, K. Hellevang. Revision of MWPS Handbook on drying, handling and storing grain. The Anderson's. Project duration: 1/14 – 12/14. Amount: $19,000.
- **McNeill, S. (PI)**, L. Meyer, G. Halich, C. Lee, M. Bomford and J. Schmitz. Developing an organic corn enterprise in Kentucky. Southern S.A.R.E. Project duration: 7/12 to 6/13. Amount received: $10,000.
- **McNeill, S.**, D. Overhults, M. Montross and S. Shearer. Energy audits for grain and poultry producers in Kentucky. USDA-NRCS-RCD. Project duration: 10/10 – 9/12. Amount: $100,000.
- Montross, M., R. Smith and **S. McNeill**. Quantifying field drying rate potential for herbaceous energy crops. DOE-ORNL. Project duration: 11/10 – 9/11. Amount: $25,000.
- Montross, M. and **S. McNeill**. Laboratory and field data for establishing new grain packing factors. USDA-RMA. Project duration: 09/09 – 12/13. Amount: $370,000.

REFEREED PUBLICATIONS:

- Day, D.L., H.P. Cole, **S. McNeill** and S. Westneat. 2011. Frequency and severity of livestock worker injuries and the safety status of cattle handling facilities. Journal of Agromedicine. In Revision.
- **McNeill, S.G.**, S.A. Thompson, M.D. Montross, I.J. Ross and T.C. Bridges. 2008. Packing factors of feed products in storage structures. Applied Engineering in Agriculture. 24(5):625-630.
- Prewitt, R.M., M.D. Montross, S.A. Shearer, T.S. Stombaugh, S.F. Higgins, **S.G. McNeill** and S. Sokhansanj. 2007. Corn stover availability and collection efficiency, using typical hay equipment. Transactions of the ASABE 50(3):705-711.
- Bridges, T.C., M.D. Montross and **S.G. McNeill**. 2005. Estimation of costs associated with aeration of wheat in the mid-South region of the United States. Applied Engineering in Agriculture. 21(1):115-124.

EXTENSION ACTIVITIES (LAST FIVE YEARS**):**

- Extension Publications……..... ...9
- Extension newsletters…….....6
- Newspaper and popular press Articles…… 38
- Television programs…… 14
- Radio programs…….…….....28
- Presentations for county and/or regional extension audiences…… 84
- Presentations at international professional meetings…… 12
- Presentations at international workshops ……..…… 19
- Decision tools for BAE website…… 6

HONORS AND AWARDS:

- Outstanding Specialist Award. Kentucky Association of County Agricultural Agents. 2014.
- Wethington Award. University of Kentucky. 2010, 2011, 2012, 2013, 2014.
- Service Award (30 years). UK Cooperative Extension Service. 2009.
- American Society of Agronomy. 2009. Publications Award: A comprehensive guide to wheat management in Kentucky. UK Cooperative Extension Service Bulletin ID-125.

PROFESSIONAL SOCIETIES:

- American Society of Agricultural and Biological Engineers (ASABE), since 1979.
  - FPE-702 Grain and Feed Processing and Storage Committee
  - ED-208 Extension Education Committee
  - P-515 Textbooks and Monographs Committee
  - T-11 Energy
- Kentucky Association of State Extension Professionals (KASEP), member since 1979.

. **JOSEPHINE M. BOAC, PH.D.**.
Postdoctoral Fellow
Department of Grain Science and Industry, Kansas State University
201 Shellenberger Hall, Manhattan, KS 66506
Phone: +1-785-532-3719; 785-776-2768 (O); Fax: +1-785-532-7010; Email: jmboac@ksu.edu

EDUCATION

Ph.D. in Biological and Agricultural Engineering 2010
Kansas State University, Manhattan, Kansas, U.S.A.
M.S. in Agrometeorology 1999
University of the Philippines at Los Baños, Laguna, Philippines
B.S. in Agricultural Engineering, *cum laude* 1996
University of the Philippines at Los Baños (UPLB), Laguna, Philippines

PROFESSIONAL POSITIONS

Postdoctoral Fellow 2012 December - Present
Department of Grain Science and Industry, Kansas State University (KSU), Manhattan, KS
Research Associate 2010 January – 2014 January
Department of Biological and Agricultural Engineering, KSU, Manhattan, KS
Graduate Research Assistant 2005 - 2009
Department of Biological and Agricultural Engineering, KSU, Manhattan, KS
Associate Professorial Lecturer 2003 - 2004
Kalayaan College, Abucay, Bataan, Philippines
Project Engineer II 2001 - 2002
UPLB Foundation, Inc., Los Baños, Laguna, Philippines
Project Technical Assistant 2001
SEAMEO-SEARCA Consulting Group, Los Baños, Laguna, Philippines
Project Research Assistant 1998 - 2000
Philippine Rice Research Institute, Los Baños, Laguna, Philippines
Teaching Associate 1996 - 1997
College of Eng. and Agro-Industrial Technology, UPLB, College, Laguna, Philippines

HONORS AND AWARDS

- ASABE Kansas Section, Young Member of the Year Award (2014)
- Sigma Xi (2014); Alpha Epsilon (Agricultural Engineering) (2006); Gamma Sigma Delta (Agriculture) (1996)
- SEAMEO-SEARCA-funded Visiting Exchange Scholar, University of British Columbia, Vancouver, Canada (1998)
- Philippine Professional Agricultural Engineering Board Exam, 4th highest score (of 331) (1996); Chancellor's List, 1 sem.; Dean's List, 6 sem.; Honor Roll List, 2 sem.

SYNERGISTIC ACTIVITIES

- American Society of Agricultural and Biological Engineers (ASABE), *Member* (since 2006) - Committee on Crop and Feed Processing and Storage, Food and Process Engineering Division (FPE 702); Committee on Bulk Solids Handling and Storage, Structures and Environment Engineering Division (SE 20/4); Committee on

Computational Methods, Simulations, and Applications, Information and Electrical Technologies Division, *Secretary* (2013-2015)
- ASABE - Kansas Section, *Chair* (2014-2015)
- The Grain Elevator and Processing Society, *Member* (since 2011)
- American Association of Cereal Chemists, KSU Chapter, *Member* (since 2008)
- Computers and Electronics in Agriculture, *Technical Reviewer* (since 2012)
- Transactions of the ASABE, *Technical Reviewer* (since 2010)

CONFERENCE PAPERS AND PRESENTATIONS *(MOST RECENT)*

- Bhadra, R., **J. M. Boac (Presenter)**, M. E. Casada, M. D. Montross, S. A. Thompson, S. G. McNeill, and R. G. Maghirang. 2014. Field Measurement for grain compaction and commercial storage in US (project summary). ASABE Poster No.14-1899383. Presented at the *2014 ASABE Annual International Meeting (AIM)*, July 13-16, Montreal, QC, Canada.
- **Boac, J. M.**, M. E. Casada, R. G. Maghirang, and J. P. Harner III. 2013. Particle models for discrete element modeling of bulk grain properties of wheat kernels. ASABE Paper No. 13-1619002. Presented at the *2013 ASABE AIM*, July 21-24, Kansas City, MO.
- **Boac, J. M.**, M. E. Casada, R. G. Maghirang, and J. P. Harner III. 2012. Discrete element modeling of commingling of insect-infested and sound grain kernels. ASABE Paper No. 12-1337463. Presented at the *2012 ASABE AIM*, July 29-August 1, Dallas, TX.
- **Boac, J. M.**, M. E. Casada, R. Bhadra, M. D. Montross, S. A. Thompson, S. G. McNeill, and R. G. Maghirang. 2012. Updating the pack factor for calculation of bushels from volumetric measurements. Presented at the *2012 Grain Elevator and Processing Society (GEAPS) Exchange* Educational Session (Double session with NC-213 Consortium), March 3-6, Minneapolis, MN.

REFEREED PUBLICATIONS *(MOST RECENT)*

- **Boac, J. M.**, R. Bhadra, M. E. Casada, S. A. Thompson, M. D. Montross, S. G. McNeill, and R. G. Maghirang. 2013. Stored grain pack factors for wheat: comparison of three methods to field measurements. *Transactions of the ASABE. (In Review).*
- Turner, A. P., M. D. Montross, J. J. Jackson, N. K. Koeninger, S. G. McNeill, M. E. Casada, **J. M. Boac**, R. Bhadra, R. G. Maghirang, S. A. Thompson. 2014. Error analysis in the measurement of stored grain volume. *Transactions of the ASABE. (In Review).*
- Bhadra, R., **J. M. Boac**, A. P. Turner, M. E. Casada, S. A. Thompson, M. D. Montross, S. G. McNeill, and R. G. Maghirang. 2014. Commercial corn bin measurements for grain packing factors. *Transactions of the ASABE. (In Review).*
- Bhadra, R., **J. M. Boac**, M. E. Casada, S. A. Thompson, M. D. Montross, S. G. McNeill, and R. G. Maghirang. 2014. Comparison of test weight with and without dockage for HRW wheat samples. *Transactions of the ASABE. (In Review).*
- **Boac, J. M.**, R. P. Kingsly Ambrose, M. E. Casada, R. G. Maghirang, and D. E. Maier. 2014 Applications of discrete element method in modeling of grain postharvest operations. *Food Engineering Reviews*: 1-22. DOI: *http://dx.doi.org/10.1007/s12393-014-9090-y.*
- **Boac, J. M.**, M. E. Casada, R. G. Maghirang, and J. P. Harner III. 2012. 3-D and quasi-2-D discrete element modeling of grain commingling in a bucket elevator boot system. *Transactions of the ASABE* 55(2): 659-672.

CURRENT & PENDING SUPPORT

Name: Mark E. Casada

Instructions:
Who completes this template: Each project director/principal investigator (PD/PI) and other senior personnel that the Request for Applications (RFA) specifies
How this template is completed:

- Record information for active and pending projects, including this proposal.
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- Provide analogous information for all proposed work which is being considered by, or which will be submitted in the near future to, other possible sponsors, including other USDA programs.
- For concurrent projects, the percent of time committed must not exceed 100%.

Note: Concurrent submission of a proposal to other organizations will not prejudice its review by CSREES.

NAME (List/PD #1 first)	SUPPORTING AGENCY AND AGENCY ACTIVE AWARD/PENDING PROPOSAL NUMBER	TOTAL $ AMOUNT	EFFECTIVE AND EXPIRATION DATES	% OF TIME COMMITTED	TITLE OF PROJECT
	Active:				
R.P.K. Ambrose, M.E. Casada, S. Simsek, R. Bhadra	Anderson Team Grant	$149,480	1/1/2013-12/31/2014	2.5%	Intrinsic characteristics of modified DDGS and development of effective handling strategies
	Pending:				
Casada, M Ambrose, K Montross, M Bhadra, R Thompson, S McNeill, S Boac, J	The Andersons Team Grant (this proposal)	$100,000	01/01/2015-12/31/2016	5%	Determining Time, Aeration, and Loading Cycle Effects on Grain Packing

CURRENT & PENDING SUPPORT

Name: R. P. Kingsly Ambrose

Instructions:
Who completes this template: Each project director/principal investigator (PD/PI) and other senior personnel that the Request for Applications (RFA) specifies
How this template is completed:

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- For concurrent projects, the percent of time committed must not exceed 100%.

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NAME (List/PD #1 first)	SUPPORTING AGENCY AND AGENCY ACTIVE AWARD/PENDING PROPOSAL NUMBER	TOTAL $ AMOUNT	EFFECTIVE AND EXPIRATION DATES	% OF TIME COMMITTED	TITLE OF PROJECT
	Active:				
Ambrose, K Campabadal, C McKinney, L Miller, B	US Dept. of Labor SH-23539-12-60-F-20	$120,000	09/30/2012- 09/30/2014	10%	Combustible Dust Hazards in Grain Handling Facilities: Preventive Precaution, Awareness Creation
Ambrose, K Maier, D	Kepler Weber Industrial S/A	$95,344	09/01/2012- 08/31/2014	4.17%	Development of Simulation Models to Predict Airflow, Grain Flow, and Heat and Mass Transfer for the Newly Developed Grain Dryer by Kepler Weber, Brazil
Ambrose, K Campabadel, C Maier, D Miller, B	US Dept of Labor SH-24936-13-60-F20	$104,901	09/30/2013- 09/30/2014	11.8%	Training on Advanced Methods of Grain Dust Control Within the Grain Handling and Processing Industry
Ambrose, K	The Andersons, Inc	$150,000	01/01/2013- 12/31/2014	4%	Intrinsic characteristics of Modified DDGS and Development of Effective Handling Strategies
Ambrose, K	National Grain and Feed Association	$84,760	01/01/2013- 12/31/2017	4%	Compiling And Reporting Information On Agricultural Dust Explosions
Aldrich, G Ambrose, K Jones, C	Fats and Proteins Research Foundation, Inc.	$45,000	01/01/2013- 06/30/2014	2%	Evaluation of Techniques Used to Extend Shelf-Life and Methods for Analysis of Rendered Protein Meals in Pet Foods
Bhadriraju, S Ambrose, K Channaiah, L Maier, D	CRC Plant Biosecurity PBCRC 3038	$274,380	04/01/2013- 03/31/2015	8.33%	Evaluating Chlorine Dioxide and Ozone as Alternative Methods for Controlling Phosphine-resistant Insects in On-Farm and Commercial Bulk Storages
Bhadriraju, S Maier, D Ambrose, K Channaiah, L	CRC Plant Biosecurity	$117,619	04/01/2013- 03/31/2015	2%	Evaluating Chlorine Dioxide and Ozone as Alternative Methods for Controlling Phosphine-resistant Insects in On-Farm and Commercial Bulk Storages– PhD Proposal
Maier, D Ambrose, K	The Andersons, Inc	$19,640	01/01/2014- 12/31/2014	1%	Third Edition of the Grain Drying, Handling and Storage Handbook (MWPS-13)- Using NC-213 Multi-State Expertise for National Impact
Maier, D Ambrose, K Bhadriraju, S	CRC Plant Biosecurity PBCRC63051	$167,829	01/01/2014- 03/31/2017	5%	Modeling VaporPhos and ProFume Distribution in Bulk Storages to Improve Efficacy Against Insects – PhD Proposal
Maier, D Ambrose, K	CRC Plant Biosecurity PBCRC 3040	$273,360	04/01/2013- 03/31/2015	8.33%	Modeling VaporPhos and ProFume Distribution in Bulk Storages to Improve

Bhadriraju, S					Efficacy Against Insects
Campabadal Teran, C Ambrose, K Maier, D O'Neil III, H	USDA	$30,195	06/01/2014- 10/31/2014	0%	Cochran Program on Grain and Feed Procurement Vietnam
	Pending:				
Bhadriraju, S Ambrose, K	PBCRC	$143,119	01/01/2013- 12/31/2016	0%	New Non-chemical Technologies to Protect Grain during Storage and Transport PHD
Ambrose, K Boac, J Casada, M Maghirang, R Maier, D	USDA	$496,405	01/01/2015- 12/31/2017	8.33%	Mechanisms and Mitigation of Dust Generation During Grain Handling and Processing
Ganyjal, G. Ambrose, K.	USDA through Washington State University	$80,000	01/01/2015- 12/31/2016	2.08%	Waxy Wheat: Furthering the Quality, Nutrition, and Sensory Attributes
Ambrose K. Dogan, H. Ilelji, K. Ganjyal, G.	USDA	$500,000	01/01/2015- 12/31/2017	0%	Elucidating the Mechanisms of Stress Crack Development in Corn Kernels Using Neutron Tomography
Mosher, G Ambrose, K	The Andersons, Inc. through Iowa State University (pending submission)	$61,500	01/01/2015- 12/31/2016	0%	Conceptual model of data collection needs for a segregation-based handling system
Casada, M Ambrose, K Montross, M Bhadra, R Thompson, S McNeill, S Boac, J	The Andersons, Inc. (this proposal)	$100,000	01/01/2015- 12/31/2016	0%	Determining Time, Aeration, and Loading Cycle Effects on Grain Packing

CURRENT & PENDING SUPPORT

Name: Michael Montross

Instructions:
Who completes this template: Each project director/principal investigator (PD/PI) and other senior personnel that the Request for Applications (RFA) specifies
How this template is completed:

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Note: Concurrent submission of a proposal to other organizations will not prejudice its review by CSREES.

NAME (List/PD #1 first)	SUPPORTING AGENCY AND AGENCY ACTIVE AWARD/PENDING PROPOSAL NUMBER	TOTAL $ AMOUNT	EFFECTIVE AND EXPIRATION DATES	% OF TIME COMMITTED	TITLE OF PROJECT
	Active:				
Nokes, Montross, Crofcheck, DeBolt, Halich, Knutson, Lee, Lynn, Mueller, Rankin, Seay, Shearer, Smith, Stombaugh, Anex, Flythe, Webb, Chinn, Veal	USDA-DOE Biomass Research Development Initiative	$6,932,786	7/11-6/15	10%	On-farm biomass processing: towards an integrated high solids transporting / storing / processing system.
Montross	CNH America, LLC	$82,000	8/14-4/15	2%	Methods to increase bale density
	Pending:				
R.P.K. Ambrose, M.E. Casada, S. Simsek, R. Bhadra	Anderson Team Grant (This proposal)	$149,480	1/1/2013-12/31/2014	1%	Determining Time, Aeration, and Loading Cycle Effects on Grain Packing

CURRENT & PENDING SUPPORT

Name: Rumela Bhadra

Instructions:
Who completes this template: Each project director/principal investigator (PD/PI) and other senior personnel that the Request for Applications (RFA) specifies
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NAME (List/PD #1 first)	SUPPORTING AGENCY AND AGENCY ACTIVE AWARD/PENDING PROPOSAL NUMBER	TOTAL $ AMOUNT	EFFECTIVE AND EXPIRATION DATES	% OF TIME COMMITTED	TITLE OF PROJECT
	Active:				
Casada, Thompson, Montross, McNeill, Maghirang	USDA-FDIC Interagency Agreement	$1,200,000	08/09-04/14	20%	Developing New Stored Grain Packing Factors
Ambrose, Casada, Simsek, Bhadra	Anderson Team Grant – 2012	$149,480	01/13-01/15	80%	Intrinsic characteristics of modified DDGS and development of effective handling strategies
	Pending:				
Casada, M Ambrose, K Montross, M Bhadra, R Thompson, S McNeill, S Boac, J	The Andersons, Inc. (this proposal)	$100,000	01/01/2015-12/31/2016	0%	Determining Time, Aeration, and Loading Cycle Effects on Grain Packing

CURRENT & PENDING SUPPORT

Name: Sidney A. Thompson

Instructions:
Who completes this template: Each project director/principal investigator (PD/PI) and other senior personnel that the Request for Applications (RFA) specifies
How this template is completed:

- Record information for active and pending projects, including this proposal.
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Note: Concurrent submission of a proposal to other organizations will not prejudice its review by CSREES.

NAME (List/PD #1 first)	SUPPORTING AGENCY AND AGENCY ACTIVE AWARD/PENDING PROPOSAL NUMBER	TOTAL $ AMOUNT	EFFECTIVE AND EXPIRATION DATES	% OF TIME COMMITTED	TITLE OF PROJECT
	Active:				
Casada, M Ambrose, K Montross, M Bhadra, R Thompson, S McNeill, S Boac, J	Pending: Anderson Team Grant (This proposal)	$150,000	1/1/2015-12/31/2016	2.5%	Determining Time, Aeration, and Loading Cycle Effects on Grain Packing

CURRENT & PENDING SUPPORT

Name: Samuel G. McNeill

Instructions:
Who completes this template: Each project director/principal investigator (PD/PI) and other senior personnel that the Request for Applications (RFA) specifies
How this template is completed:

- Record information for active and pending projects, including this proposal.
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	Active:				
G. Opit	Oklahoma State University	$ 68,694	1/14 – 12/18	2.5%	Alliance for Food Security by Reducing Post-Harvest Losses of Grains in Ghana
D. Maier, K. Hellevang	The Anderson's Team Grant	$ 19,000	1/14 – 12/14	5.0%	Revision of MWPS Handbook on drying, handling and storing grain
K. Ileleji, G. Opit	USDA-FAS-OCBD	$ 70,311	2/10 – 9/14	6.5%	Nigeria Commodity Storage – Technical Assistance
	Pending:				
G. Atungulu, C. Jones, C. Singh, J.. Ward	AMCOE	$ 90,000	1/15 – 12/17	1.0%	Reducing Aflatoxin Contamination of Corn in On-Farm Bin Drying and Storage Systems
Casada, M Ambrose, K Montross, M Bhadra, R Thompson, S McNeill, S Boac, J	Anderson Team Grant (This proposal)	$ 150,000	1/1/2015-12/31/2016	1.0%	Determining Time, Aeration, and Loading Cycle Effects on Grain Packing

CURRENT & PENDING SUPPORT

Name: Josephine M. Boac

Instructions:
Who completes this template: Each project director/principal investigator (PD/PI) and other senior personnel that the Request for Applications (RFA) specifies
How this template is completed:

- Record information for active and pending projects, including this proposal.
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	Active:				
	None				
	Pending:				
Ambrose, K Boac, J Casada, M Maghirang, R Maier, D	USDA	$496,405	01/01/2015- 12/31/2017	100%	Mechanisms and Mitigation of Dust Generation during Grain Handling and Processing
Casada, M Ambrose, K Montross, M Bhadra, R Thompson, S McNeill, S Boac, J	The Andersons, Inc. (this proposal)	$100,000	01/01/2015- 12/31/2016	0%	Determining Time, Aeration, and Loading Cycle Effects on Grain Packing

ANDERSONS RESEARCH FUND – RESEARCH PROPOSAL BUDGET

Total Project Budget

Category	Year 1 (2015)	Year 2 (2016)	Total
Salaries and Wages			
Post-Ph.D. research associate(s)	50,175	51,332	
Graduate assistant			
Stipend			
Tuition and fees			
Hourly wage			
Other			
Subtotal	**50,175**	**51,332**	**101,507**
Fringe Benefits			
Post-Ph.D. research associate(s)	17,956	18,618	
Graduate assistant	0	0	
Hourly wage			
Other			
Subtotal	**17,956**	**18,618**	**36,574**
Materials/Supplies/Other	1,800	1,314	3,114
Travel	4,616	4,188	8,804
Total	**74,547**	**75,452**	**150,000**

Kansas State University Budget

Category	Year 1 (2015)	Year 2 (2016)	Total
Salaries and Wages			
Post-Ph.D. research associate(s)	34,875	35,573	
Graduate assistant			
Stipend			
Tuition and fees			
Hourly wage			
Other			
Subtotal	**34,875**	**35,573**	**70,448**
Fringe Benefits			
Post-Ph.D. research associate(s) (33%)	11,509	11,739	
Graduate assistant (5.8%)	0	0	
Hourly wage			
Other			
Subtotal	**11,509**	**11,739**	**23,248**
Materials/Supplies/Other	500	-	500
Travel	3,116	2,688	5,804
Total Costs	**50,000**	**50,000**	**100,000**

University of Kentucky Budget

Category	Year 1 (2015)	Year 2 (2016)	Total
Salaries and Wages			
Post-Ph.D. research associate(s)	15,300	15,759	
Graduate assistant			
Stipend			
Tuition and fees			
Hourly wage			
Other			
Subtotal	**15,300**	**15,739**	**31,059**
Fringe Benefits			
Post-Ph.D. research associate(s)	6,447	6,879	
Graduate assistant			
Hourly wage			
Other			
Subtotal	**6,447**	**6,879**	**13,326**
Materials and Supplies	1,300	1,314	**2,614**
Travel	1,500	1,500	3,000
Total Costs	**24,548**	**25,453**	**50,000**

Budget Narrative

Budget Justification - Kansas State University ($100,000 for two years)

Salary and Fringe Benefits ($93,696)

A 0.70 FTE postdoctoral Research Associate is required to perform the research at Kansas State University. This partial salary request for this Research Associate is $34,875 for the first year and $35,573 (2% increase) the second year, with fringe benefits in an additional amount of $11,509 the first year and $11,739 the second year. The post-doc will be responsible for field data collection, database maintenance, and assisting with DEM models.

Materials/Supplies/Other ($500)

$500 is requested in the first year for the cost of shipping laboratory samples and compositional analysis. LEICA DISTO laser meter, advanced capability tripods to host LEICA DISTO, bin climbing lanyards, and data entry devices (like laptops, tablets, etc.) are already purchased by Kansas State University, BAE department and are available for this project. Available gear will be used in this project, without any additional cost. EDEM software is already stationed at USDA-ARS, Manhattan, KS and will be used for DEM technique part in this proposal.

Travel ($5,804)

The cost of travel by project personnel to measure gain packing at field sites and collect samples for laboratory studies is requested at $3,116 for the first year and $2,688 for the second year. We propose two people to travel to 14 field locations over the two years as follows:

(a) Nine day trips (4 in year 1, 5 in year 2) – 175- to 250-mile round-trips, no overnight stay.

(b) Three two-day trips (2 in year 1, 1 in year 2) – 750- to 800-mile round-trips, one night lodging and per diem for two people.

(c) Two three-day trips (1 in each year) – 900- to 1000-mile round-trips, two nights lodging and per diem for two people.

Totals from these trips are: 14 nights (for two persons for two-day and three day trips) lodging @ $77 per night ($1,078); 28 days per diem @ $46 per day ($1,288); and approximately 6,139 miles at $0.56 per mile ($3,438) totaling $5,804.

Budget Justification – University of Kentucky ($50,000 for two years)

Personnel – Faculty

Faculty time committed to the project includes Drs. Montross and McNeill for 1% of their time. The Anderson's Grant Program does not allow for the direct charge of faculty. Benefits for Dr. Montross include: 7,332 per year for health insurance, 10% retirement, 7.65% Social Security, and 3.7% other fringe benefits. Benefits for Dr. McNeill include: 4,800 per year for health insurance, 17% retirement, 1.45% Medicare, and 0.8% other fringe benefits. Health insurance fees are adjusted by 10.5%/year for the life of the grant. Salaries plus fringe are adjusted 3% yearly for the life of the grant. Salaries and benefits are prorated for the percentage of time commitment to the project.

Personnel – Professional Staff/Post Ph.D. Research Associate

Aaron Turner will work 37% of his time during year 1 and year 2 on the project. Benefits for this position are charged as follows: 24 per year for life insurance, 10% retirement, 7.65% Social Security, and 3.4% other fringe benefits. The benefits are prorated for the percentage of time commitment to the project.

Supplies

Supplies include sample bags and tags, grain samples, small hand tools, data processing supplies, agricultural chemicals, concrete, tarps, steel, welding supplies, and shop supplies. Estimated total supplies are 996 during year 1 and 1,000 during year 2.

Travel

Funds in the amount of $1,500 each year for travel are requested. This includes travel to field sites, professional meetings and project meetings.

Indirect Costs

Indirect costs are calculated using the University of Kentucky federally negotiated indirect rate of 40% modified total direct costs for agricultural research. The Anderson's Grant Program does not allow for indirects.

APPENDIX

Letters of Support from Industry Partners

1. David Krejci, GEAPS Executive Vice President, International Secretary

2. David Jacobson, Plant Manager, Busch Agricultural Resources, LLC, Sutton, N. Dakota

3. Rick Schwein, Sr. Vice President, Grain Millers, Inc.; President, Grain Millers Canada Corp.

GEAPS
Grain Elevator and Processing Society
The Knowledge Resource for the World of Grain Handling Industry Operations

29 August, 2014

Dr. Steven A. Slack, Review Panel Chair
Administrative Advisor - NC-213
Ohio Agricultural Research and Development Center
Ohio State University
1680 Madison Avenue
Wooster, Ohio 44691

Dear Dr. Slack,

I am writing to endorse for NC-213 review-panel funding consideration, the proposed study: "Time and Aeration Effects on Grain Compaction - Laboratory, Modeling, and Field Studies" as submitted by Mark Casada, Kingsly Ambrose, Mike Montross, and their colleagues.

In commercial grain storage operations, pack factors cannot be directly measured for inventory and auditing purposes. Grain storage facility operations managers must rely of predictive modeling. Continual improvement in the precision and reliability is critical to improving efficiency by reducing losses ... real and perceived. In that regard I understand that this research team recently achieved a major step forward in predicting packing of stored grain by calibrating a basic pack factor prediction tool with field data. As I understand it, the new tool predicts pack factors for grain bins based on readily measured parameters: grain type and quality along with bin material and dimensions. With that basic prediction tool now available, additional research to more reliably take into consideration additional factors that might not be directly measurable, but also affect grain packing, would further increase efficiency.

The two most common factors we need to take into consideration: (1) the length of time grain has been in storage and; (2) the effect of partially unloading then refilling bins. It is very important for us to have accurate and repeatable data on how much these factors affect grain packing to increase the precision and reliability of inventory determinations. The plan to investigate additional factors such as the effect of GMO varieties and extreme quality characteristics would likely increase the accuracy of "pack factors" for a wider range of conditions.

Overall the proposed research would likely make a much-needed contribution to our understanding of these additional factors that currently confound the accuracy and precision of inferred inventory calculations. In that regard, thank you in advance for your consideration of the proposal.

Sincerely,

David Krejci, CAE
Executive Vice President, International Secretary

4248 Park Glen Road, Minneapolis, Minnesota 55416 USA
(00-1) 952-928-4640 ● Fax: (00-1) 952-929-1318 ● Info@GEAPS.com ● www.geaps.com

Busch Agricultural
Resources, LLC
ONE OF THE ANHEUSER-BUSCH COMPANIES

August 25, 2014

Dr. Steven A. Slack, Review Panel Chair
Administrative Advisor - NC-213
The Ohio State University
Ohio Agricultural Research and Development Center
1680 Madison Avenue
Wooster, Ohio 44691

Dear Dr. Slack,

I encourage your Review Panel to approve funding for the proposed study, "Time and Aeration Effects on Grain Compaction - Laboratory, Modeling, and Field Studies," submitted by Mark Casada, Kingsly Ambrose, Mike Montross, and their colleagues.

This research team has recently taken a major step forward in predicting packing of stored grain by calibrating a new pack factor prediction tool with field data from around the U.S. The new tool predicts pack factors for grain in bins based on the readily measured parameters of grain type and quality along with bin material and dimensions.

With this tool now available, the industry needs additional research to account for other concerns that may not be directly measurable parameters, but also affect grain packing. The biggest remaining issue for our work is aeration effects and the length of time grain has been in storage. We often store grain for periods approaching one year and need to be able to account for the effect of time and aeration during the storage period. I believe the other issues in the proposed study — the effect of partially unloading then refilling bins and evaluating additional factors, such as the effect of GMO varieties and extreme quality issues — are important for many in the industry and we need this information so we can accurately measure grain inventories in these situations.

This proposed research will make a much needed contribution to our understanding of these additional factors that currently limit our ability to accurately predict pack factor for grain inventories. I believe the information resulting from this research will be very worthwhile for the grain industry.

Thank you very much for your consideration of our endorsement of this proposal.

Respectfully,

David Jacobson
Plant Manager

Elevator Operations
500 Railroad Ave.
Sutton, ND 58484
701-769-2302

GRAIN MILLERS

August 28, 2014

Dr. Steven A. Slack, Review Panel Chair
Administrative Advisor - NC-213
The Ohio State University
Ohio Agricultural Research and Development Center
1680 Madison Avenue
Wooster, Ohio 44691

Dear Dr. Slack,

I'm writing to encourage your Review Panel to approve funding for the proposed study, "Time and Aeration Effects on Grain Compaction - Laboratory, Modeling, and Field Studies," submitted by Mark Casada, Kingsly Ambrose, Mike Montross, and their colleagues.

This research team has recently taken a major step forward in predicting packing of stored grain by calibrating a new pack factor prediction tool with field data. The new tool predicts pack factors for grain in bins based on readily measured parameters of grain type and quality along with bin material and dimensions.

Now that this new prediction tool is available the industry needs additional new research to allow us to take into account additional items that, while they are not directly measurable parameters, they also significantly affect grain packing. Two common issues we still face are: (1) the length of time grain has been in storage, in conjunction with aeration during storage and (2) the effect of partially unloading then refilling bins, in conjunction with the newer side-draw unloading systems. It is very important for us to have scientific information on how these factors also affect grain packing so we can obtain accurate inventories. I also feel the plan to investigate certain additional factors, such as the effect of GMO varieties and extreme quality issues is a helpful addition to allow us to have accurate pack factors for a wider range of conditions.

This proposed research will make a much needed contribution to our understanding of these additional factors that currently limit our ability to predict pack factor accurately for our inventories. I believe the results of this study will be very important and I feel it is very worthwhile research to fund for the benefit of the grain industry.

Thank you very much for your consideration.

Sincerely,

Rick L. Schwein
Sr. Vice President
Grain Millers, Inc.
President
Grain Millers Canada Corp.

Grain Millers, Inc.
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