Design, Development and Evaluation of a Mass Flow Sensor for Grain Combine Harvesters

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Received: 18-02-2012
Accepted: 23-12-2012

Abstract

In grain yield monitoring system, the amount of clean grain mass flow rate to the storage bin is the most important yield property. In this research, an impact-plate type grain mass flow sensor was designed, developed and evaluated. After construction of the impact sensor, it was calibrated by loading the impact plate with static weights ranging from 0.5 to 4.5 kg every 0.5 kg and its linear response to the applied loads was proved with a correlation coefficient of 0.99. Then, grain mass flow measurement tests and data collection were conducted according to the ASABE standard S587, developed for grain mass flow sensors. The tests were conducted in three phases: 1- constant and steady state flow, 2- linear variation of flow, 3- oscillating flow. The results showed that the output of impact plate sensor varies proportionally and linearly with increasing wheat grain (Rowshan cultivar) mass flow rate. The error in prediction of actual flow rate was decreased by increasing the mass flow rate such that the calculated errors at 25%, 50%, 75% and 100% of flow capacity (4.25 kg s⁻¹) were 8.3%, 6.3%, 5.2% and 4.9%, respectively. The high coefficient of determination ($R^2 = 0.9975$) between accumulated mass flow data of impact plate sensor and the reference scale data indicated high accuracy and sensitivity of impact plate sensor in prediction of mass flow variations. The average percent error of impact sensor in variable flow rate in “ramp-up-ramp-down”, “ramp-down-ramp-up” and oscillating flows were 7.4%, 8.6% and 8.3%, respectively.

Keywords: Yield monitoring, Mass flow sensor, Precision agriculture, Grain combine harvesting

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Comparing Two Types of Fertilizer Distributor (centrifuge) in Order to Optimize the Pattern of Fertilizer Distribution

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Received: 28-05-2012
Accepted: 29-12-2012

Abstract

Increasing demand for food production in the recent years has raised the usage of granular fertilizers. Consequently, the growing use of fertilizers has reduced the quality and quantity of crop production. In addition, pollution problems such as soil and water (surface and subterranean water) contaminations has increased. Consistent spreading of fertilizers in the farmlands is of fundamental rules in conventional framings. In present study, the effects of the number and the arrangement (position) of blades of a single disk fertilizer distributor and for two different fertilizers were investigated in order to obtain optimized distribution of fertilizer. The tests were conducted in factorial arrangement and in a completely randomized model. The variables were the number of blades in three levels of 4, 6 and 8, the blade position angles (in two patterns of radial and non-radial) and the type of fertilizer (phosphate and nitrate). Statistical analysis of results indicated that the number of blades on the disk and type of fertilizer are not effective parameters in order to reach a consistent distribution pattern of fertilizer while the position of blades on the disk has significant influence for this purpose. The best pattern of distribution was obtained from the disk with four non-radial blades and nitrate fertilizer.

Keywords: Distribution pattern, Position angle, Spreader disc, Centrifugal fertilizer

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Performance Analysis of a Solar Dryer Equipped with a Recycling Air System and Desiccant Chamber

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Received: 19-09-2011
Accepted: 06-08-2012

Abstract

Drying is a high energy consuming process. Solar drying is one of the most popular methods for dehydration of agricultural products. In the present study, the performance of a forced convection solar dryer equipped with recycling air system and desiccant chamber was investigated. The solar dryer is comprised of solar collector, drying chamber, silica jell desiccant chamber, air ducts, fan and measuring and controlling system. Drying rate and energy consumption in three levels of air temperature (40, 45 and 50 °C) and two modes of drying (with recycling air and no-recycling with open duct system) were measured and compared. The results showed that increasing the drying air temperature decreased the drying time and increased the energy consumption in the mode of non-recycling air system. The dryer efficiency and drying rate were better in the mode of recycling air system than open duct system. The highest dryer efficiency was obtained from drying air temperature of 50 °C and the mode of recycling air system. In general, the efficiency of solar collector and the highest efficiency of the dryer were 0.34 and 0.41, respectively.

Keywords: Dryer efficiency, Solar collector, Solar dryer, Recycling air system

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Received: 01-03-2012
Accepted: 25-12-2012

Abstract

In this study, a knowledge-based fuzzy logic system was developed on experimental data and used to predict the draft force and energy requirement of tillage operation. In comparison with traditional methods, the fuzzy logic model acts more effectively in creating a relationship between multiple inputs to achieve an output signal in a nonlinear range. Field experiments were carried out in a sandy loam soil on coastal plain at the Edisto Research and Education Center of Clemson University near Blackville, South Carolina (Latitude 33° 21"N, Longitude 81° 18"W). In this paper, a fuzzy model based on Mamdani inference system has been used. This model was developed for predicting the changes of draft force and energy requirement for subsoiling operation. This fuzzy model contains 25 rules. In this investigation, the Mamdani Max-Min inference was used for deducing the mechanism (composition of fuzzy rules with input). The center of gravity defuzzification method was also used for conversion of the final output of the system into a classic number. The validity of the presented model was achieved by numerical error criterion, based on empirical data. The prediction results showed a close relationship between measured and predicted values such that the mean relative error of measured and predicted values were 3.1% and 2.94% for draft resistant force and energy required for subsoiling operation, respectively. The comparison between the fuzzy logic model and the regression models showed that the mean relative errors from the regression model are greater than that from the fuzzy logic model.

Keywords: Mamdani inference, Tillage energy, Fuzzy logic approach, Subsoiling, Draft force

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Investigation of the Effects of Tire Inflation Pressure and Forward Speed of Driven Wheel on Horizontal Impact of Passing Rectangular Obstacle

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Received: 14-11-2011
Accepted: 13-02-2013

Abstract

The tire-mechanics models have been developed for the study of wheel movement on the road or soil surface while these models are unlikely to describe the motion of wheels on uneven surfaces. Due to dynamical complexity of this phenomena and the importance of this subject for farm conditions and the wheel carrier devices, the present research aimed to investigate the effects of several parameters on the wheel passing the obstacle. The experiments were carried out using single wheel tester in soil bin condition. The results indicated a relatively linear relationship between the impact force applied on tire and forward speed of wheel and also the height of rectangular obstacle. The effect of inflation pressure was inversed in the range of complete formed tire’s body on impact force and in low levels of tire inflation pressure; tire’s body damps the maximum impact forces. The medium levels of pressure (about 150-200 kPa) resulted in less horizontal force that applied on the wheel for different levels of forward speed and obstacle’s height. Tractive force for passing obstacle was increased by raising forward speed and the obstacle’s height.

Keywords: Single wheel tester, Soil bin, Obstacle interaction, Wheel

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Investigation of Specific Heat and Thermal Conductivity of Rasa Grape (*Vitis Vinifera L.*) as a Function of Moisture Content

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Received: 22-04-2012
Accepted: 23-12-2012

Abstract

Kurdistan Rasa grape is one of the delicious and sweet fruits with black color. It contains vitamins E, C and some protectors such as antioxidants. In order to design equipments and facilities for drying, preservation and processing of Rasa grape, it is necessary and important to know about its specific heat and thermal conductivity. In this paper the specific heat and thermal conductivity of Rasa grape were studied. The method of mixtures and hot wire as a heating source was used for measuring the specific heat and thermal conductivity, respectively. The experimental variables were temperature at four levels of 40, 50, 60 and 70 °C and moisture content at four levels of 22.36, 37.56, 52.13 and 71.53%. The results showed that the specific heat and thermal conductivity of Rasa grape increased linearly from 1.6523 kJ kg⁻¹°C⁻¹ to 3.3253 kJ kg⁻¹°C⁻¹ and 0.1252 W m⁻¹°C⁻¹ to 0.4202 W m⁻¹°C⁻¹ respectively, with increasing moisture content and temperature. The results also showed that the effect of moisture content on increasing the specific heat and thermal conductivity was more significant than that from temperature rise.

Keywords: Rasa grape, Temperature, Thermal conductivity, Specific heat, Moisture content

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Effect of Calcium Chloride Concentration on Some Mechanical Properties of Apple during Storage

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Received: 08-02-2012
Accepted: 23-12-2012

Abstract

Today, the use of coatings is common to maintain the quality of fruits in storage period. Previous studies have shown that the calcium compounds can improve and preserve the strength of fruit’s cell wall. In this research, the effect of calcium chloride dehydrate (CaCl₂·2H₂O) concentration on two varieties of apple (Golden Delicious and Red Delicious), was studied. The apples were immersed in the calcium chloride dihydrate solution and then transferred to a cold storage. The effect of three concentration levels: 0, 3 and 6 percent, and three storage durations: no storage, one month and two months, were investigated on the apples mechanical properties such as failure stress, failure strain, modulus of elasticity and toughness. Statistical factorial experiments in the form of completely randomized design were used to analyze the obtained results. The ANOVA results showed that the effect of calcium chloride concentration was significant on the modulus of elasticity (P<0.05) and the yield stress (P<0.01), but is not significant on the toughness and the yield strain. The average yield stress at 0, 3 and 6% CaCl₂ concentration levels were 178, 183 and 193 kPa, respectively. Comparison of means with Duncan test showed a significant increase (P<0.01) for all concentration levels on the yield stress of apple tissue. The effect of storage duration was significant on the modulus of elasticity, the yield stress and the yield strain (P<0.01) and the toughness (P<0.05). Also the effect of variety was significant for all the mechanical properties. None of the interaction effects, i.e. variety × concentration, variety × storage and concentration × variety on the modulus of elasticity and the toughness were significant.

Keywords: Post harvest, Modulus of elasticity, Coating materials, Concentration, Storage

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The Effect of Ultrasonic Waves on Sugar Extraction and Mechanical Properties of Sugar Beet

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Received: 16-06-2012
Accepted: 12-03-2013

Abstract

Sugar, which can be extracted from sugar cane and sugar beet, is one of the most important ingredients of food. Conducting more research to increase the extraction efficiency of sugar is necessary due to high production of sugar beet and its numerous processing units in northern Khorasan province. In this research, the effect of temperature, time and the frequency of ultrasonic waves on mechanical properties of sugar beet and its extraction rate of sugar in moisture content of 75% were studied. In this regard, an ultrasonic bath in laboratory scale was used. The studied parameters and their levels were frequency in three levels (zero, 25 and 45 KHz), temperature in three levels (25, 50 and 70 °C) and the imposed time of ultrasonic waves in three levels (10, 20 and 30 min). Samples were prepared using planned experiments and the results were compared with control sugar beet samples. A Saccharimeter was used to measure the concentration of sugar in samples. Two different types of probe including semi-spherical end and the other one with sharpened edges were used to measure mechanical properties. The studied parameters of frequency, temperature and time showed significant effect on sugar extraction and their resulted effect in optimized levels revealed up to 56% increase in sugar extraction compared with control samples. The obtained values of elastic modulus and shear modulus showed a decreasing trend. The obtained values of total energy of rupture, the total energy of shear, the maximum force of rupture, and the yield point of rupture showed an increasing trend. The frequency had no significant effect on the yield point of rupture and shear force.

Keywords: Ultrasonic wave, Sugar beet, Mechanical properties, Sugar content

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Technical and Economical Evaluations of Canola Harvesting Losses in Different Maturity Stages Using Three Different Combine Harvester Heads

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Received: 20-12-2011
Accepted: 06-08-2012

Abstract

Rapeseed cultivation in Iran is growing rapidly while this product has been facing specific problems. Every year a significant portion of edible oil is imported to the country from other countries. Despite this deficit, a great amount of canola is being lost every year. Therefore, in compliance with technical points, adding a suitable platform to the existing machineries may reduce the losses. A field study was conducted in Moghan Agricultural Research Centre to study the technical and economical characteristics of harvesting machineries and evaluate Canola harvesting losses in different maturity stages, using three different combine harvester heads. The experiments were conducted in a completely randomized split split plot design with four replications. The main plot included seed maturity stage at three levels: A) 60%, B) 70% and C) 80%, and the subplot was the harvester’s ground speed at three levels: A) 1.5, B) 2.5 and C) 3.5 km h⁻¹. The sub-subplot was combine head type with three forms: A) Mechanical, B) Hydraulically Joybar and C) Hydraulically Biso's Head. The results of ANOVA showed that maximum cutter bar losses occurred with Mechanical Head (5.36%) while the loss of Hydraulically Joybar's and Biso's head were 4.28 and 4.13 %, respectively. The results also showed that the maximum cutter bar losses occurred when 80% of seeds were matured and adequate time for canola harvesting was 70% of seeds maturity. The results of analysing the effects of harvesting ground speeds showed that the maximum cutter bar losses occurred with the speed of 3.5 km h⁻¹. Finally, the results showed that the minimum cutter bar loss was obtained with Hydraulically Joybar's head considering the benefit per cost ratio. The cost for Mechanical head and Hydraulically Biso's head were 13500 and 262500 Rial ha⁻¹, respectively.

Keywords: Technical Evaluation, Harvesting losses, Canola, Maturity Stages, Combine

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Study of Primary Tillage Timeliness Cost for Irrigated Wheat in Fars Province Using System Dynamics

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Received: 23-04-2012
Accepted: 27-07-2012

Abstract

Delay in irrigated wheat primary tillage operations causes yield reduction and hidden timeliness cost in Fars province. Mechanization of primary tillage operations for irrigated wheat in Fars province was simulated using System Dynamics approach. A part of the model structure was related to the agricultural operations timeliness costs. For the mentioned simulation, causal relations between system components were known and the model was run based on time step of 0.125 of one year. The simulation results showed that the operations timeliness cost remained constant (approximately one million rials per hectare) from 2001 to 2004 in the province. The timeliness cost increased from 2004 to 2007 due to the non-uniform distribution of atmospheric precipitation and reached to 1211724 rials per hectare in 2007. The upward trend of this cost continued for the period of 2007 to 2010 because of using depreciated moldboard plows. The model predicted the amount of 2090511 rials per hectare for the timeliness cost in 2018. Furthermore, it was found that reduction in the timeliness cost could be reached either by increasing the plowing speed by %30 in the permissible domain or increasing the daily working hours by 4 hours.

Keywords: System Dynamics, Primary tillage, Wheat, Timeliness cost

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