Bioresources Engineering

School of Engineering

BOOK OF ABSTRACTS

2019 FINAL YEAR DESIGN PROJECT

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UKZN, UKULINGA RESEARCH FARM

DESIGN, CONSTRUCTION AND PERFORMANCE EVALUATION OF A CASSAVA PEELING MACHINE

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ABSTRACT

Cassava (*Manihotesculantacrantz*) is a starch crop that is important for food security. The processing of this crop is mechanized with exception to the peeling process. The challenge that is associated with cassava peeling arises from the irregularities in shapes, different sizes and weight of many cultivars of cassava. Although many attempts have been made, most current peeling machines have either low throughput capacities or peeling efficiencies and high flesh losses. A literature review was conducted on the engineering properties that affect cassava processing and the different peeling mechanisms such as chemical, thermal, mechanical and laser peeling. Alternative solutions of the unit operations of a cassava-peeling machine were generated, from which the best design was selected using decision matrices. A feasibility study was conducted to assess the viability of the design, focusing on the operational, technical, economic and schedule aspects. Then, a cassava-peeling machine was designed and constructed to address the above-mentioned problems. The prototype throughput capacity was found to be 180 kg.h-1 with a maximum flesh loss of 5% and a peeling efficiency of 90%. A wooden drum lined on the inside with sandpaper was constructed, which rotates at 17 rpm. The effects of residence time and drum fill on the performance of the machine were investigated. The highest mean peeling efficiency was found to be 84.2%. The lowest mean flesh loss was 0.39% and the highest machine throughput capacity was found to be 90 kg.h-1. The peeling efficiency of the machine increases with increasing residence time, while it decreases with an increasing drum fill. High speeds have negative effects on the peeling outcomes due to either no peeling occurs, or the tubers experience mechanical damage. The peeling efficiency of regular shaped tubers is higher than that of irregular tubers, due to the flatness of the surface of the peeling medium.

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UNIVERSITY OF KWAZULU-NATAL
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DESIGN, CONSTRUCTION AND EVALUATION OF A SYSTEM TO MEASURE TRACTOR ENGINE PERFORMANCE

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Supervisors: Prof. J. Smithers and Mr M. Hansen

ABSTRACT

Measuring tractor engine performance requires the use of a dynamometer. A dynamometer is a system that measures torque and the PTO rotational speed of a tractor, which can be used to determine a power curve that can be used to assess the performance of the tractors engine. The objectives of the project were to design a data acquisition system to capture readings for torque, fuel consumption, speed and power values; upgrade the manual load system to an automatic load system; design a system to calibrate the torque measurement and design a system to measure fuel consumption. Design considerations and design specifications were drawn. The design specifications included the steel being registered in the SANS code, the load cells being able to measure with 95% accuracy (Vishay Precision Group), the torque measuring system being able to measure a torque of 500 N.m, the actuator should be able to achieve the desired torque with an error of 0.1% (Arduino, 2018) and the data logging system being able to log real time data and have sufficient storage space. Numerous alternative designs were brainstormed and included - four alternative frame designs, three control systems and three fuel consumption measurement designs. The best design solutions were selected using decision matrices. A feasibility study was conducted to assess the capability of the selected design solution to meet the objectives and if the design was feasible. The construction of the frame was undertaken, and a load cell was calibrated and used for torque measurement. A test of the magnetic pickup system was carried out however, the measurements did not meet the OECD standards. Given limitations on time to complete the construction and testing, a power curve was not generated. The construction of the fuel consumption system was also successfully completed however, there was limited testing of the prototype due to time constraints. Overall, a system to measure torque has been developed but the project was not completed to lack of time and funds.

DESIGN, CONSTRUCTION, AND EVALUATION OF A MAIZE-SHELLING MACHINE

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Supervisors: Prof. J. Smithers and Mr M. Hansen

ABSTRACT

Maize is one of the most significant grain crops in the farming economy on the planet, and 50% of the population in sub-Saharan Africa depends on it. Numerous farmers grow maize, yet they cannot afford to hire imported shelling machines to process their product. The unavailability of such technology is a concern, since most developing countries rely heavily on agriculture to feed their families. Such individual farmers resort to customary methods for shelling, such as rubbing the maize grain against one another, rubbing on blocks, or stone and by using iron cylinders containing wires inside. These methods are tedious, time-consuming, and result in low productivity, high levels of losses and results in hard labour. The study was carried out to design, construct and evaluate a small-scale maize-shelling machine at affordable, safe, cost effective, and productive for small-scale farmers. The maize-sheller consists of a cylinder-concave arrangement for threshing, a fan blower for cleaning, and an electric motor as a power source. The motion and torque are transmitted via pulleys, v-belt and bearings to the shaft carrying the cylinder with spikes and a blower shaft connected to the fan. The whole maize (together with the cobs) are introduced into the machine through the inlet hopper. They reach the rotating spikes inside the threshing system by gravity. The spikes give continuous impact force on the whole maize, thereby removing the grains and chaff. Because the spikes are arranged in a spiral form, the whole maize moves along the length of the threshing chamber in the forward direction until they reach the cob exit spout. Before the whole maize reaches this point, almost all the grains (seeds) are removed thereby letting the cob go out of the machine clean. Due to the impact of the spikes some of the cobs may be broken, though both broken and whole exit through the grain exit spout. The air generated by the blower impeller is channelled to flow against the maize grain exit spout via a cleaning chamber. The air blows off unwanted chaff that exit together with the maize grains thereby keeping the maize grains clean.

DESIGN, CONSTRUCTION AND PERFORMANCE EVALUATION OF A MUSHROOM SLICER

Asavela Notshweleka, Innocent Mashiloane, Percy Chauke
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ABSTRACT

The demand for sliced mushrooms is growing rapidly. The biggest mushroom produces and packaging company in South Africa slices mushrooms manually. In this project, construction and performance evaluation of the design of the mushroom slicer prototype was conducted. The main components of the prototype were a hopper, feeding mechanism, power transmission unit and a slicing mechanism. The prototype was evaluation by using the average slicing efficiency of the machine which was found to be 79.16%. The mushroom slicer prototype was enabled to achieve the design production capacity of 68.4 kg.h^{-1}. The evaluation process of the mushroom slicing machine proved that the constructed prototype was able to slice mushrooms uniformly with a specified thickness of 10 mm by maintaining the desired orientation. There were also some damages on the slices that were noted during an evaluation. Most damages were noted on the small sized mushrooms. The reason for poor slicing quality was that during construction the design team could not outsource the rubber roller of 120 mm diameter that was designed for theoretically. Therefore, the gap between the fabricated roller and the blades were approximately 10 mm which resulted in small mushrooms not fully sliced because they were too small to obtain enough gripping between the roller and the blades. The average perfectly sliced efficiency was found to be 60% on large sized mushrooms, 58% medium and 40% on small sized mushrooms, respectively.

DESIGN, CONSTRUCTION AND EVALUATION OF A VRI SYSTEM BASED ON REAL TIME SOIL MOISTURE MEASUREMENT

Sizwe Mkhonta, Nondumiso Msibi, Lavanya Govender
Supervisors: Dr. A. Senzanje and Dr. G. Lagerwall

ABSTRACT

Over-irrigation is ubiquitous in agricultural practices. Agriculture utilises approximately 70% of the global freshwater extraction with irrigation being the major use of this allocation. (Chartzoulakis and Bertaki, 2015). South Africa is not exempt from the water scarcity facing the world. There are various precision irrigation systems that can significantly reduce the amount of water used in agriculture. Variable Rate Irrigation (VRI) systems account for soil heterogeneity to avoid both over-irrigation and under irrigation. These systems are less effective if the real time soil moisture monitoring aspect is not well considered. Precision irrigation reduces pollution from agricultural runoff and increases water-use efficiency. Four different alternative systems have been considered for measuring real time soil moisture and then automatically vary the application rate of a centre pivot. This aims to apply only the required amount of water to ensure sustainable agriculture. An RFID technology-based system has been considered the best. The system is designed to have an array of RFID sensor tags embedded in the soil that will retrieve soil moisture in real time (within 5 seconds). A UHF RFID reader was mounted on the centre pivot model lateral to read the soil moisture information from the tags and send it for processing by the Raspberry Pi. Nonetheless, the system has been simulated using a control code that randomly picks soil moisture values (0 – 100%) and use them to calculate the required irrigation rate at that particular point. The signals that should be sent to the proportional flow control valve were represented by lighting up LED lights. The centre pivot model movement was maintained at 50% speed setting by the system's control code.

DESIGN, CONSTRUCTION AND EVALUATION OF A VRI SYSTEM BASED ON REAL TIME SOIL MOISTURE MEASUREMENT

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Over-irrigation is ubiquitous in agricultural practices. Agriculture utilises approximately 70% of the global freshwater extraction with irrigation being the major use of this allocation. (Chartzoulakis and Bertaki, 2015). South Africa is not exempt from the water scarcity facing the world. There are various precision irrigation systems that can significantly reduce the amount of water used in agriculture. Variable Rate Irrigation (VRI) systems account for soil heterogeneity to avoid both over-irrigation and under irrigation. These systems are less effective if the real time soil moisture monitoring aspect is not well considered. Precision irrigation reduces pollution from agricultural runoff and increases water-use efficiency. Four different alternative systems have been considered for measuring real time soil moisture and then automatically vary the application rate of a centre pivot. This aims to apply only the required amount of water to ensure sustainable agriculture. An RFID technology-based system has been considered the best. The system is designed to have an array of RFID sensor tags embedded in the soil that will retrieve soil moisture in real time (within 5 seconds). A UHF RFID reader was mounted on the centre pivot model lateral to read the soil moisture information from the tags and send it for processing by the Raspberry Pi. Nonetheless, the system has been simulated using a control code that randomly picks soil moisture values (0 – 100%) and use them to calculate the required irrigation rate at that particular point. The signals that should be sent to the proportional flow control valve were represented by lighting up LED lights. The centre pivot model movement was maintained at 50% speed setting by the system's control code.