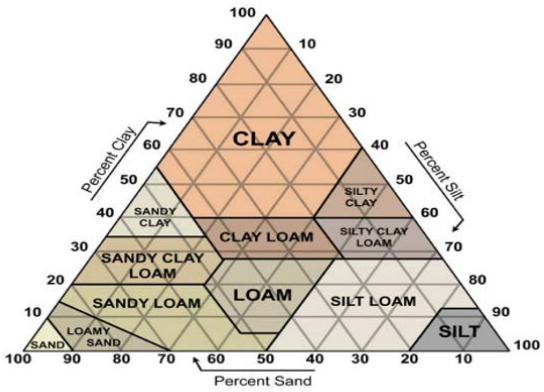

Figure 1. Soil preferences for the groundnuts

After determining the harvesting period, the farmer's struggle will be to determine the harvesting method suitable. On large scale groundnut production, weather forecast is very important because some weather conditions can interrupt the process. The method used to harvest groundnuts is on a large scale production is cut into three stages. The first stage is lifting groundnuts from the underground onto the surface. The process is highly mechanized and to the extent that there are machines manufactured for that process only. The uprooted groundnuts are freed from soil or mud during the lifting process and are left lying on the field with the pods on top of the leaves. On the second stage, the groundnuts are left in field for a minimum of 6 days depending on the weather. This is a drying process, and when the pods have the required moisture content, then it will be time for stage three. The average required moisture content ranges between 14-20% but a moisture content of as low as 6% can be used (Kumar, 2013). The minimum moisture content is 4%, below this value the seeds will be of poor quality. The final stage is threshing of the dried plants. Threshing is the process of separating shells or pods from the stem.

2.1 Anatomy of harvesting machine

The machine to be designed has to carry out all the process done in harvesting. These process includes digging of groundnuts, shaking off the soil and separating the pods from the main plant. The machine uses a tractor as the power source and the power will be taken via the P.T.O. shaft. Also the tractor will be pulling the machine moving around the field. For lifting or digging the groundnuts, ploughing discs are to be used. The soil will be removed using controlled vibrations. This process will take place while the groundnuts are being transported into the machine where separation of pods will take place. For that, a special belt will be designed which allows transportation at the same time allowing soil to fall off. Inside the heart of the machine, a special

mechanism will be formulated which ensures that the pods will be separated from the main plant without damaging the seeds inside. Also the mechanism will allow the roots and leaves to be thrown out and the pods be packed. The drying of the groundnuts will now take at any place which is more secure and which can be controlled in terms of the surrounding conditions.

2.2 Harvesting in a nice way

A several number of fungi such as Penicillium, Aspergillus, Alternaria, Nigrospora, Cladosporium and Fusarium species are capable of infecting agricultural crops both in the field and during storage (Hocking, 1991). The fungal infection reduces yield and produce the harmful substances called mycotoxins. According to (Smith & Moss, 1985) mycotoxins are poisonous chemicals produced by fungi and they can be grouped according their chemical structure and fungal origin. All diseases in animals and humans which are a result of consumption of food with mycotoxins are called mycotoxicoses diseases. To reduce amount of aflatoxins in groundnuts products such as peanut butter, Kingaroy Blanching is done. The main objectives for doing Kingaroy Blanching is to make safe, high quality groundnuts and to avoid total loss of contaminated groundnuts. Kingaroy Blanching is a process that includes roasting of groundnuts to loosen skins for easy removal by Blanching roller. The rough surface on the Blanching rollers is responsible for removing the skins. This process makes the groundnuts more presentable but most importantly it makes it easier for the color sorters to observe the contaminated groundnuts. These sorters compares the color of a groundnut seed with the color preset in the sorter's program. Groundnuts with an unacceptable color are ejected from the process by a jet of compressed air (Australian Centre for International Agricultural Research, 1999). The greater the amount of contaminated groundnuts the greater the loss because all the contaminated groundnuts are lost. So it can be concluded that aflatoxins reduces the profit of groundnut growing business.

3. Methodology

The purpose of this design is to create an affordable harvesting machine that can speed up the harvesting process. The disadvantages from other existing harvesting methods will be used to create some of the technical specifications that will help the author in reaching the objectives. Some of the specifications are derived from the desire of trying to make the machine efficient. Since this machine has to obtain its power from the tractor, it is necessary to make some specifications that will help in linking the harvesting machine to the tractor.

Maximum P.T.O. shaft power $= 50hp$,

P.T.O shaft speed $= 540\ r.p.m$,

$Tractor\ maximum\ working\ speed = 1.11m/s\ (4km/hr)$,

Maximum speed to achieve objective number two $= 0.588m/s\ (2.118km/hr)$,

$Length\ of\ cutting\ blade = 0.9m$,

Cutting depth of blade $= 0.15m$,

Bulk density of soil $= 1.8Mg/m^3$,

Density of mild steel $= 7\ 800Kg/m^3$,

Yield under irrigation $= 4\ tonnes$,

Spacing under irrigation $= 30\ cm$,

$$Number\ of\ rows = \frac{100}{0.3},$$

$$= 334rows,$$

$$Yield\ per\ row = \frac{4000}{334},$$

$$= 12kg/row,$$

$$Mass\ of\ four\ rows\ (2\ trips) = 12 \times 4,$$

$$= 48\ kg.$$

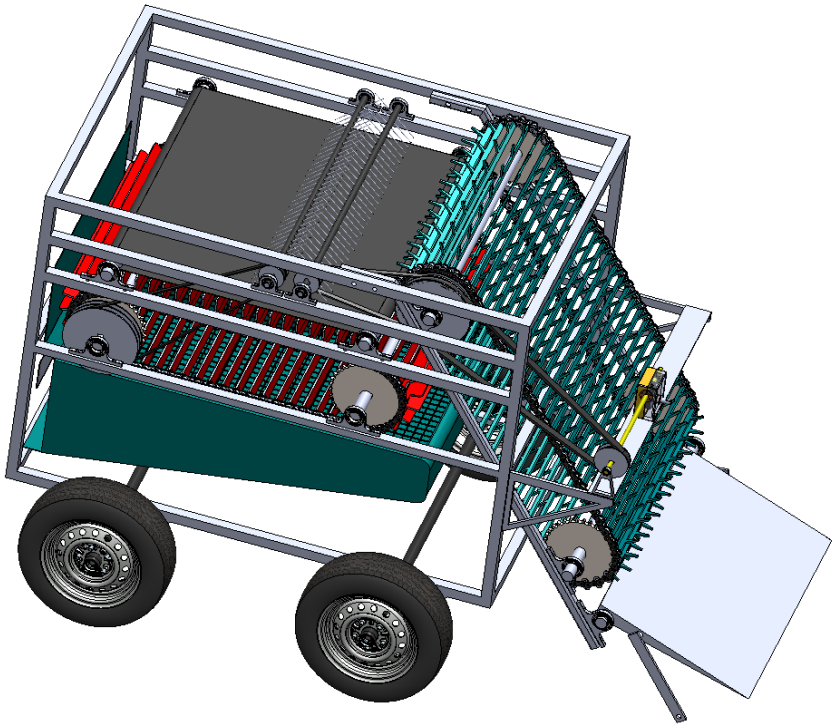

Figure 2. Groundnut harvester.

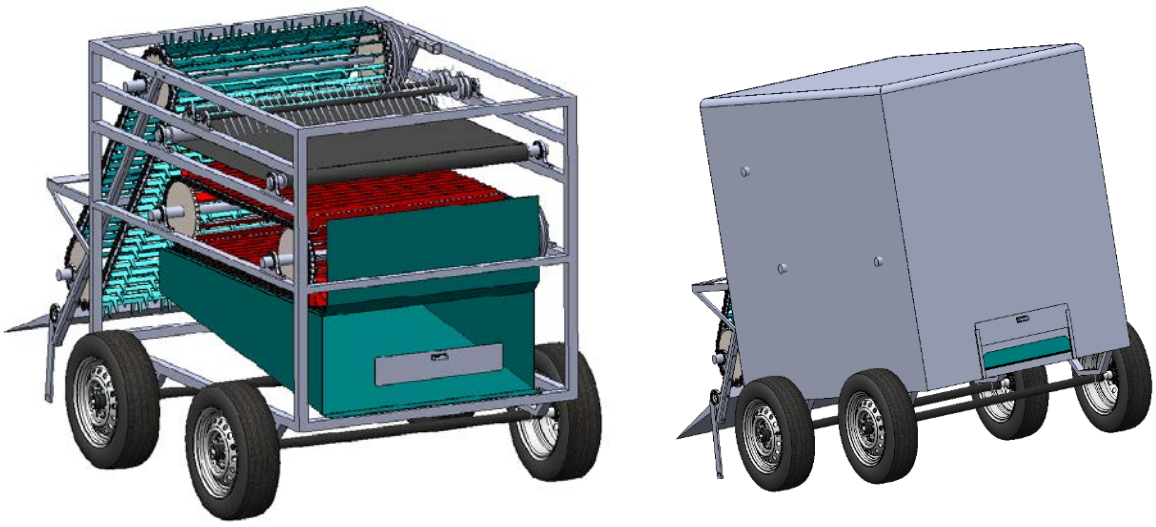

Figure 3. Internal and external views of groundnut harvester

4. Results and discussions

After calculating the forces acting on the machine it was found that the power required to move the machine is 3.933kW and the power required from the PTO shaft to various moving components that makes up the machine is 9.704kW. This resulted in a total of 13.6kW required from the tractors engine to operate the groundnut harvester. The fuel consumption of the tractor was estimated and the values ranged from 8.316l/hr to 14.931l/hr. At a fuel price of 1.25$/l, the

cost of operating the machine was found to range from $41.58 to $74.66. These variations in fuel consumption and cost of operating the groundnut harvester are due to the operating conditions such as soil type, soil moisture content, blade cutting depth and operating speed. The minimum speed for the machine to harvest one hectare in four hours was found to be 0.588m/s (2.11km/hr) and the maximum speed which ensures minimum pod damage and high machine efficiency was found to be 1.11m/s (4km/hr). The machine was designed to carry a maximum mass of 64kg to reduce the fuel consumption.

5. Recommendations and Conclusion

The machine has many moving and rotating parts some of which are not covered, so the end users of this machine are recommended and encouraged to follow the operating manual provided below.

Groundnut harvester operating manual

1. Make sure all the belts and chains are tight, also make sure the bolts holding the gearbox are well tightened
2. With the tractor switched off, connect the blade to the hydraulic arms of the tractor and the gear box to the PTO shaft.
3. Disengage the PTO gear, make sure there is no one behind the tractor and start the engine
4. Lift the hydraulic arms
5. Drive the tractor to the area to be harvested
6. Stop the tractor 3m away from groundnut plants, lower the hydraulic arms until the blade touches the ground and engage the PTO gear.
7. Move the tractor at a speed of 2km/hr and slowly lower the blade into the ground by lowering the hydraulic arms until a desired depth is reached.
8. Start harvesting until the collector is full.
9. Offload groundnuts in a separate container and repeat the operation

Maximum speed of operation = 4km/hr.
Maximum holding capacity of collector = 64kg

When the PTO gear is engaged all the moving elements on the machine will rotate so it is greatly advised that the driver of the tractor should check first to see if there is a person behind the tractor before starting the PTO.

- Never try to fix a problem while the PTO gear is engaged
- Never carry people on the machine
- In case of any accident or emergency that involves the groundnut harvester, turn of the engine and pull the hand brake, this stops all the operations.

This machine was designed to do harvesting of groundnuts, other designers who are interested may include the option of packaging of harvested groundnuts for easy handling of the products. To add functionality and reduce pod damage during harvesting it is recommended that other designer can include artificial intelligence which can detect and measure the amount damaged

pods then compare it to the allowed value. This system can also be modified such that it can increase the efficiency of the machine by minimizing the amount of soil fed on the conveyor belt by measuring accurately the cutting depth of the blade and keep it at the minimum depth possible.

References

Asuming-Brempong, s., 2009. *Land Management Practices and Their Effects on Food Crop Yields in Ghana.* Accra: University of Ghana.

Mudzonga, E. and Chigwada, T, 2009. *A case study of Zimbabwe's food Security.* Minitoba: International institute for Sustainable Development..

Shahzad, T., Muhammad, F., Pasha, I. & Saeed, F., 2011. *Characterization of Different Groundnut Varieties Grown in Pakistan.* Pakistan: University of Agriculture,.

Prasad, V. P. V., Kakani, V. G. & D, U. H., 2011. GROWTH AND PRODUCTION OF GROUNDNUT. In: Manhattan: Kansas State University, p. 2.

Sanders, et al., 2000. Occurrence of Reseveratrol in edible. *J Agric Food Chem,* 4(48), pp. 1263-1269.

Kumar, D. A., 2013. Seasonal variance on groundnut. *Round year experiences,* 4(12), pp. 67-69.

Hocking, A., 1991. *Xerophillic fungi in intermediate and low moisture foods.* 3rd ed. New York: Foods and Feeds.

Smith, J. & Moss, M., 1985. *Mycotoxins: Formation, Analysis and Significance.* 1st ed. Chichester: John Wiley & Sons.

Australian Centre for Internat ional Agricultural Research, 1999. *Elimination of Aflatoxin Contamination in Peanut.* 1st ed. Canberra: Australian Centre for Internat ional Agricultural Research.

Biographies

Takudzwa Dhliwayo is a final year student at the University of Zimbabwe where he is studying Mechanical Engineering. His interest in Engineering began when he was at Mutambara High School where he participated in various science projects and competitions. Takudzwa aspires to pursue a career in automation of industrial processes and equipments in developing countries to reduce labour cost and work accidents. He has decided to start by studying Mitsubishi programmable micro controllers, actuators and sensors as this will give him the basic knowledge of how automated industrial machines are designed. When he is not busy studying the design and automation of machines, he enjoys playing basketball with friends because he believes it helps him to become a good team player at work.

Dr. Tawanda Mushiri received his Bachelor of Science Honors Degree in Mechanical Engineering (2004-2008) and a Masters in Manufacturing Systems and Operations Management (MSc. MSOM) (2011-2012) from the University of Zimbabwe, Harare, and a Ph.D. from the University of Johannesburg, South Africa (2013-2017). He also obtained a Certificate with Siemens in Programmable Logic Controllers in the year 2013 where he worked with SCADA and PLC Programming. His doctorate involved fuzzy logic and automated machinery monitoring and control. Currently, he is a Senior Lecturer and Senior Research Associate at the University of Zimbabwe and University of Johannesburg, respectively. In the past (2012-2013), he has also lectured at the Chinhoyi University of Technology, Zimbabwe, lecturing mechatronics courses. He has also been an assistant lecturer for undergraduate students at Chinhoyi University of Technology, tutoring advanced manufacturing technology, robotics and machine mechanisms.