THEORETICAL POWER ANALYSIS OF A DRIVING UNIT FOR A SWEET POTATO HARVESTER UNDER DEVELOPMENT

Md Nasim Reza[1,2], Gusti Ayu Putri Mei Ulianti[1], Sakib Robin[2], Emmanuel Bicamumakuba[1], Su Young Lee[1], Pabel Kanti Dey[1], Md Aminur Rahman[1], Sun-Ok Chung[1,2*]

[1] Department of Agricultural Machinery Engineering, Graduate School, Chungnam National University, Daejeon 34134, Republic of Korea. [2] Department of Smart Agricultural Systems, Graduate School, Chungnam National University, Daejeon 34134, Republic of Korea

*Corresponding Author: sochung@cnu.ac.kr

ABSTRACT

Mechanized harvesting has become increasingly essential in modern agriculture to enhance productivity and reduce labor dependency, particularly for root crops like sweet potatoes, which traditionally involve intensive manual labor. This study presented a theoretical analysis of a driving mechanism for a sweet potato harvester under development. A theoretical analysis was conducted to evaluate the power requirements, torque distribution, and transmission efficiency of the mechanism. This analysis involved calculating critical performance parameters such as gear ratios, rotational speeds, torque demands, and potential energy losses. To validate these theoretical predictions, a dynamic simulation was performed using a commercial motion analysis tools, enabling visualization and quantification of mechanical behavior under realistic operating conditions. The simulation focused on assessing the interaction between mechanical components, stress distribution, power losses, and overall efficiency. Results from the theoretical calculations closely matched the outcomes of simulation analyses, confirming the accuracy of the theoretical model and highlighting potential areas for optimization. The simulation provided valuable insights for improving component design. The findings confirmed the viability of the designed mechanism for efficient power transmission in sweet potato harvesters, demonstrating robustness under operational loads. Future work will involve prototyping and empirical testing to validate performance and implement design optimizations. This study provides practical insights to advance the efficiency of mechanized sweet potato harvesting and agricultural machinery development.

Keywords: Agricultural machinery, sweet potato, power analysis, torque, simulation.

INTRODUCTION

Mechanization of root crop harvesting has become increasingly important for addressing labor shortages and improving productivity in agriculture. Sweet potato (*Ipomoea batatas*) cultivation is highly labor-intensive due to the underground nature of tubers, which require careful handling to prevent damage during harvesting (Tedesco et al., 2023). Traditional manual harvesting methods are inefficient, time-consuming, and physically demanding, limiting large-scale production efficiency. To address challenges, mechanized harvesting solutions have

focused on soil loosening, lifting, and conveying mechanisms. The driving unit is the major, transmitting power from the prime mover to components for reliable operation under varying soil and load conditions. The objective of this study was to conduct a theoretical analysis of the power transmission system of a sweet potato harvester currently under development.

MATERIALS AND METHODS

The driving unit consisted of a power input shaft, multiple gear stages, and transmission elements designed to operate harvesting tools such as lifting blades and conveyor systems. Theoretical analysis was performed to calculate key parameters of the system. Input power (P) was calculated using the specifications of the prime mover and expected operating conditions. Gear ratios (i) were determined for each stage to achieve the required rotational speeds and torque outputs. Torque demand was calculated as $T = P/\omega$, where, ω is the angular velocity. Transmission efficiency (η) was evaluated by considering gear mesh efficiency, bearing friction, and energy losses (Habermehl et al. 2020). The calculations were used to estimate total power demand and identify potential overload conditions during field operation. A dynamic simulation of the gear train, shafts, and loads, using torque, speed, and soil resistance, evaluated efficiency, torque distribution, stress, and frictional losses to assess mechanical reliability.

RESULTS AND DISCUSSION

Theoretical analysis showed the designed gear ratios provided sufficient torque for lifting and conveying, with input power within the limits and transmission efficiency of 89–92%, accounting for gear meshing and bearing losses. Simulation results closely aligned, indicating uniform torque distribution and stresses within safety limits. Simulated efficiency ranged from 88–91%, with frictional losses matching predictions. Theory and simulation confirmed the design and indicated housing optimizations to reduce losses and improve durability.

CONCLUSIONS

This study validated the driving unit of a sweet potato harvester through theoretical and simulation analyses, confirming high efficiency, strong torque, and safe stress limits. Future work will focus on prototyping, field testing, and design refinements for greater durability.

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