engineering proceedings

MDPI

Proceeding Paper

Plan for Developing a Cost-Effective and Sustainable Sago Machine to Increase Productivity and Ingenuity †

Iniovaine Lekakali, Reichi Taniyaola, Liam Lee, Ora Renagi and Aezeden Mohamed *

Department of Mechanical Engineering, PNG University of Technology, Lae MP411, Papua New Guinea; 21301262inle@student.pnguot.ac.pg (I.L.); 21301402reta@student.pnguot.ac.pg (R.T.); 21301255lile@student.pnguot.ac.pg (L.L.); ora.renagi@pnguot.ac.pg (O.R.)
* Correspondence: aezeden.mohamed@pnguot.ac.pg
† Presented at the 5th International Conference on Innovative Product Design and Intelligent Manufacturing Systems (IPDIMS 2023), Rourkela, India, 6–7 December 2023.

Abstract: This paper describes the creativity, design, and construction of a customized sago machine with a kneading pipe, filter, storage tank, and shredder. The main objective of this innovation is to maximize the conversion of sago stems into superior starch. Sago, an essential food staple in many areas, is typically processed by hand, which results in tedious and time-consuming processes. This project focuses on developing an automated and efficient system to drastically increase productivity and the simplicity of use and transform the sago processing sector.

Keywords: creativity; design; machine; optimization; sago; shredder; vessel

Citation: Lekakali, I.; Taniyaola, R.; Lee, L.; Renagi, O.; Mohamed, A. Plan for Developing a Cost-Effective and Sustainable Sago Machine to Increase Productivity and Ingenuity. *Eng. Proc.* **2024**, *66*, 39. https://doi.org/10.3390/engproc2024066039

Academic Editors: B. B. V. L. Deepak, M. V. A. Raju Bahubalendruni, Dayal Parhi, P. C. Jena and Gujjala Raghavendra

Published: 24 July 2024

1. Introduction

Sago is a staple food in many Southeast Asia and the Pacific Islands regions. It is made from the pith of various tropical palm plants. Its multipurpose applications span from industrial to culinary [1,2]. Manual sago processing machinery has substantially impacted the efficiency and quality of sago production, as traditional methods of sago extraction have changed throughout time [3,4].

In the past, obtaining sago starch required labor-intensive procedures like removing the pith from palm trunks, crushing it, and then washing it [4]. Large-scale production was limited by this method's time-consuming and physically taxing nature, notwithstanding its effectiveness.

A significant breakthrough in sago manufacturing was the creation of manual processing machines. These devices enhanced output and decreased the need for manual labor by automating different steps of the sago extraction process [4,5].

Diverse manual sago processing machine types have been created to accommodate varying phases of sago extraction. A typical variety is the mechanical crusher, which effectively breaks down the pith and separates the fibers from the starch. The sago washer is an additional variety to eliminate extraneous fibers and contaminants from starch. These devices improve the overall effectiveness of sago processing.

The development of manual sago processing equipment has improved sago production in several ways. First, greater efficiency enables machines to accelerate the extraction process considerably, leading to more significant production rates. Second, higher-quality sago products are produced as a result of automated steps that guarantee constant quality [4]. Thirdly, cost-effectiveness, wherein machines minimize labor requirements and lower long-term manufacturing costs despite requiring an initial investment. Finally, economic growth in which areas dependent on sago as a critical industry benefit from increased production capabilities.

Despite the advantages, difficulties still exist. For small-scale producers, maintenance and upfront investment expenditures may be obstacles. Further, technological developments are required to improve process efficiency and increase machine accessibility for smaller communities [6,7].

Traditional sago extraction techniques have been transformed by manual sago processing machines, which have increased process efficiency, consistency, and cost-effectiveness [4–7]. Even though there are still difficulties, more research and development are necessary to guarantee that these devices are accessible and reasonably priced, supporting sago production and the communities who depend on this vital resource.

This paper aims to create a sago extraction machine that is sustainable, high-quality, affordable, and efficient. Using automation, heightened productivity, preservation of starch purity, and decreased waste, the machine is essential in bolstering the expansion of the sago sector and satisfying the needs of a fiercely competitive market.

2. Methodology

The methods and approaches utilized in the design, construction, and assessment of the sago machine are described in the methodology portion of this work. Its goal is to comprehensively explain the techniques employed in developing the machine design, including tools, supplies, detailed instructions, and techniques for gathering and analyzing data. The significance of this section is in guaranteeing the results' reliability and reproducibility, which enables other researchers to confirm the study's conclusions.

Three sections comprise the technique, each corresponding to a distinct facet of the machine design. The construction and operation of the shredder are explained in the first section. The evolution of the kneading pipe is covered in detail in the second section. The filter and storage vessel are covered in the last section, clarifying the design and testing procedures. This methodical dissection guarantees a thorough comprehension of the techniques utilized at every phase of the sago machine's advancement.

3. Results and Discussion

3.1. Design Details

An analysis of the sago machine's performance is conducted, considering crucial parts, including the kneading pipe, filtration and storage tank, and shredder. Each component's dimensions significantly impact the overall operability and efficiency of this sago machine design. The machine's intricate SolidWorks designs are shown to provide a thorough understanding. These drawings provide a clear visual representation of the design, highlighting every essential part's exact dimensions and angles. This comprehensive investigation guarantees a careful analysis of the structural elements, providing insightful knowledge on the operation and efficiency of the sago machine.

3.2. Material Selection

Preferred material as shown in Table 1 for shredder would be alloy steel, tool steel, 1.2767-45NiCrMo16. Typical applications and features include cold work steel, fully hardenable, and super high strength, shear blades, cutting tools, bending tools, and shredder. Further properties are illustrated in Figures 1–5.

Table 1. Alloy steel composition.

Element	**Fe**	**C**	**Cr**	**Mn**	**Mo**	**Ni**	**P**	**S**
Composition %	92	0.5	1.5	0.5	0.35	4.3	0.03	0.03

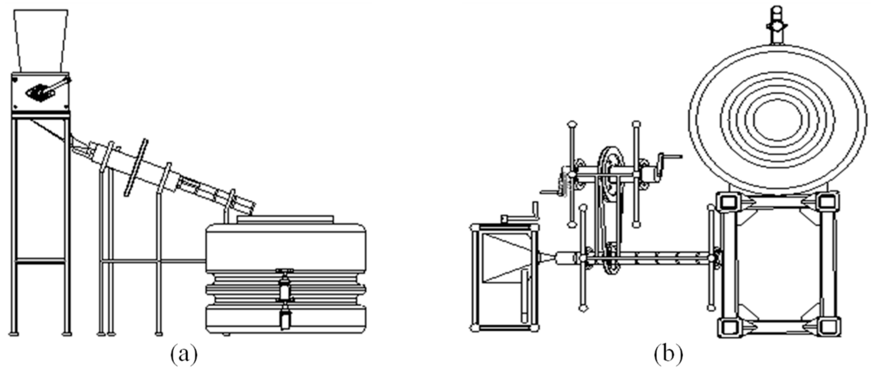

Figure 1. Manual sago extraction machine model. (**a**) Side view; (**b**) top view.

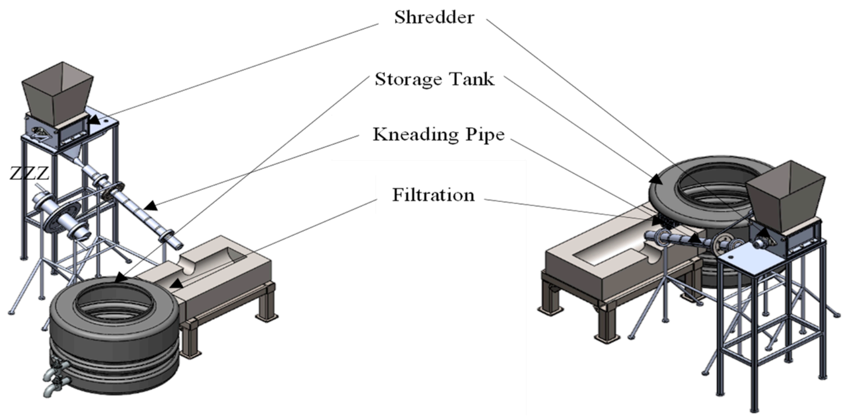

Figure 2. Three-dimensional manual sago extraction machine model (Isometric Views).

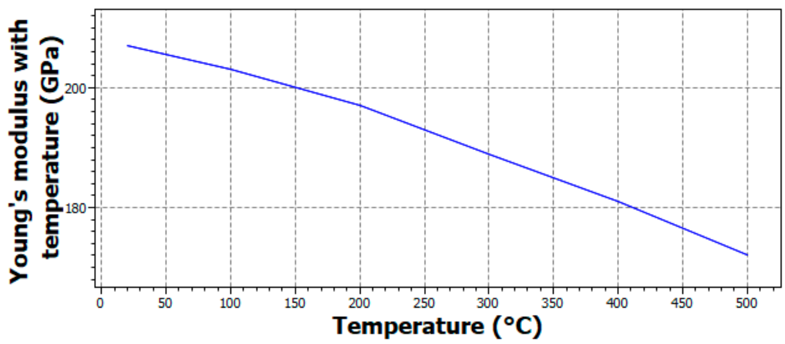

Figure 3. Young's modulus with temperature, obtained by Granta Software.

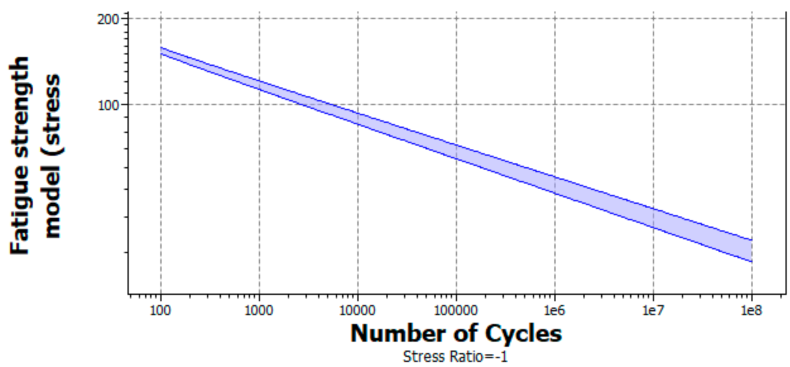

Figure 4. Fatigue strength model and number of cycles for pulley material, obtained by Granta Software.

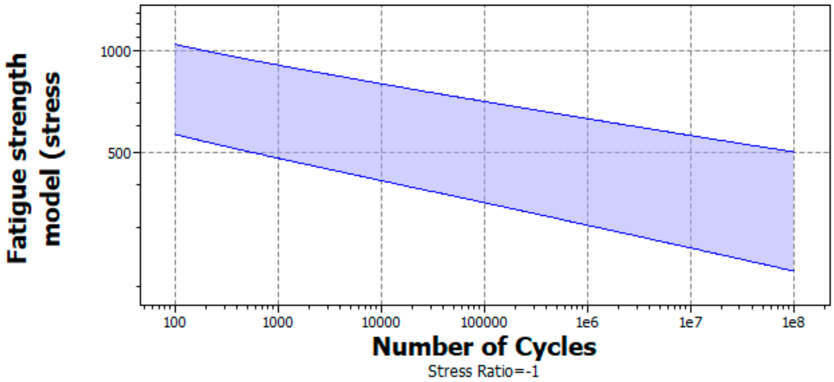

Figure 5. Fatigue strength of low-alloy steel with number of cycles at a stress ration of 1, obtained by Granta Software.

Density for alloy special steel, tool steel, 1.2767-45NiCrMo16 is 7860 kg·m^3. It has a young's modulus of 207 GPa as depicted in Figure 3.

Aluminum is used for the housing, frames, pulleys and support tables to prevent corrosion, for longevity and durability. It has a wide range of uses, high strength, low density, and good thermal and electrical conductivity and has no brittleness at low temperatures.

Low-alloy steel bearings will be used to support the rotating components. For the V belt, rubber is used for the outside section, while tensile fabric is used inside. Low-alloy steel has a fatigue strength at maximum cycling stress 10^7 of 470 MPa, a tensile strength of 1120 MPa, and a yield strength of 638 MPa. Due to these properties, these types of bearings are considered for sago machines.

For the V belt, rubber carbon black belts are used for the outside section. This specific rubber has a composition detail of about 70% polymer, 8% plasticizer, and 30–50% carbon powder. Specific properties that make this the candidate material include a density of 1230 kg/m^3, a yield strength of 0.15 GPa, and a tensile strength of 17.3 MPa.

4. Conclusions

The manual sago machine that was built respects customs and fits in with socio-cultural settings, which guarantees community acceptance and sustainability. Further, refining the design, obtaining customer feedback, and investigating scalability and pricing are very important. Subsequent investigations may expand on these ideas, including processing additional agricultural products and demonstrating the cooperative endeavor between conventional knowledge and cutting-edge engineering. This multidisciplinary strategy tackles essential issues in food processing and agriculture.

Author Contributions: Conceptualization, O.R., I.L. and A.M.; methodology, R.T.; validation, L.L. and O.R.; formal analysis, A.M.; investigation, I.L.; resources, R.T.; data curation, I.L.; writing—original draft preparation, R.T.; writing—review and editing, L.L. and O.R.; visualization, A.M.; supervision, A.M. and O.R.; project administration, O.R. and A.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: All data are provided in the article.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Sidiq:, F.F.; Coles, D.; Hubbard, C.; Clark, B.; Frewer, L.J. Sago and the indigenous peoples of Papua, Indonesia: A review. *J. Agric. Appl. Biol.* **2021**, *2*, 138–149. [CrossRef]
2. Cipto, C.; Parenden, D. Sago Extraction Machine Design. *MATEC Web Conf.* **2022**, *372*, 01002. [CrossRef]
3. Darma. Improvement of sago processing machinery. In *Sago Palm: Multiple Contributions to Food Security and Sustainable Livelihoods*; Springer: Singapore, 2018; pp. 231–245. [CrossRef]
4. Mohamed, A. First Year Engineering, Hands-on, Team Design Project Course; Reflections of a Ph. D. Student Teaching Assistant. *Educ. Pract. Innov.* **2015**, *2*, 1–8. [CrossRef]
5. Mohamed, A.; Piso, K.; Mogili, U.; Muduli, K. OEE in Sustainable Can-Making Manufacturing. In *Recent Trends in Product Design and Intelligent Manufacturing Systems: Select Proceedings of IPDIMS 2021*; Springer Nature: Singapore, 2022; pp. 353–369.
6. Mogili, U.R.; Deepak, B.B.V.L. An intelligent drone for agriculture applications with the aid of the MAVlink protocol. In *Innovative Product Design and Intelligent Manufacturing Systems: Select Proceedings of ICIPDIMS 2019*; Springer: Singapore, 2020; pp. 195–205.
7. Mohamed, A.; Muduli, K.; Yadav, D.K.; Jena, P. Corrosion Performance in Grain Structure of C22 in Acidic Environment. In *Recent Advances in Industrial Production: Select Proceedings of ICEM 2020*; Springer: Singapore, 2022; pp. 469–476.