Design an acorn hulling machine

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In the Netherlands, there is an abundance of acorns. Despite being it an edible nut, similar to a walnut or hazelnut, their culinary potential is often overlooked. There are few countries already utilizing the acorn in specific dishes, for example South Korea. Nonetheless, the majority of the countries, including the Netherlands, are still missing out.

Recognizing the acorns potential, a Dutch project group, 'The Acorn Cooperation,' envisions a future in the Netherlands where acorns play a vital role in the local diet, thereby encouraging farmers and landowners to cultivate more oak trees. Their innovative idea won a Dutch prize for agriculture and food transition in 2018 [1] and since then, they embarked on a plan to develop acorn products. Their ultimate goal is to build a food system by fostering local acorn farms and communities.

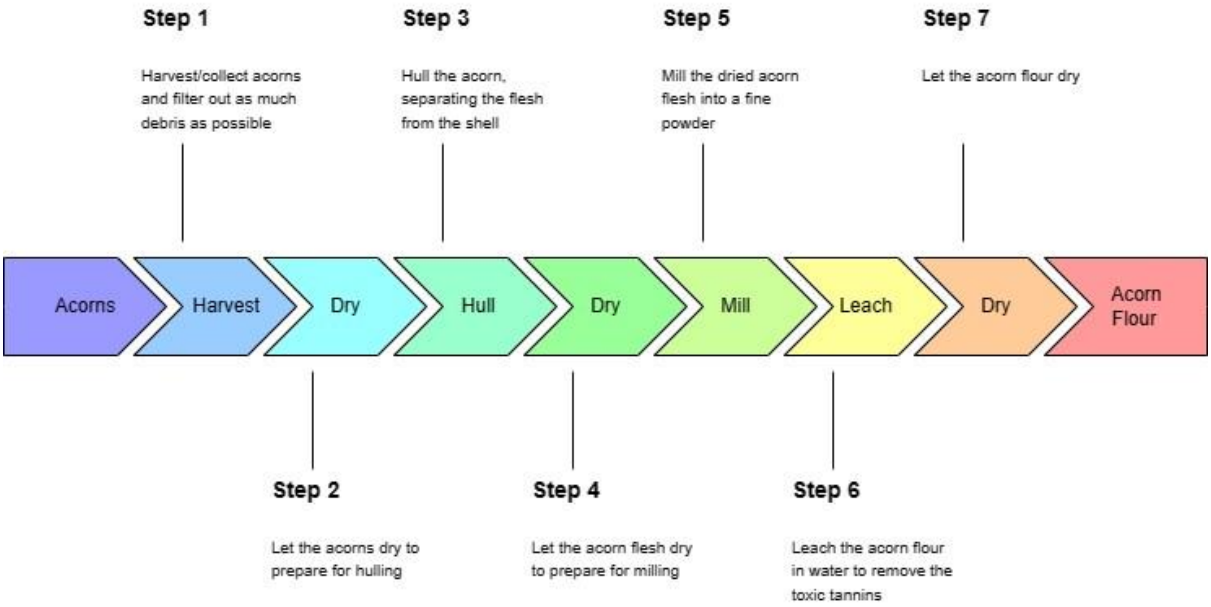

Figure 1: Acorn processing

The process of turning acorns into usable acorn flour can be found in figure 1. The Acorn Cooperation's current primary challenge is with hulling dried acorns. The current option is by hand, but it is extremely labour intensive and time consuming. Existing hulling techniques and machines for similar nuts are not perfectly suitable for acorns and do not work optimally due to the structural differences in nuts. While some acorn hullers exist in other countries, little is known about their specific workings and internal mechanisms.

Thus, the following research question can be formulated:

How can the quality and speed of acorn hulling and sorting be improved through the design of an acorn specific hulling and sorting machine that meets the requirements and wishes of the client?

A list of requirements has been created based on the client's preferences in combination with an analysis of stakeholders and the client, and market research. Considering the scope and the time constraints of this project, the main focus is on the technical aspect of the huller. Therefore, the

requirement list primarily consists of functional requirements whereas other requirements are put on the wish list.

Requirement	Importance
The machine should effectively remove the shell from different sizes of dried acorns	5
The machine should to prevent damage to the acorns flesh during hulling	4
The machine should separate the broken shell from the flesh in the end	3
The machine should effectively handle debris (such as leaves, sticks, rocks, etc.) during the hulling process without malfunctions	2
The machine should sort the acorns on quality	1

Tabel 1: Primary list of requirements

In order to analyse complex hulling machines, Functional Analysis System Technique (FAST) is used to breakdown the machine into its core functions. FAST provides a structured approach to understand a system's basic functions. Next to breaking down the system into its fundamental functions, FAST also serves as a visual aid for easy communication to stakeholders as well as helping with decision making. [2]

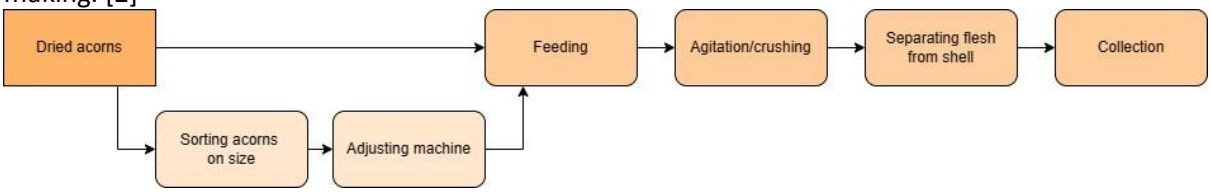

Figure 2: Hulling machine functions

With the FAST method, the core functions of machines are defined where each machine has a solution in their system to solve that function. Next, all solutions can be compared to each other to analyse which solutions are better, taking into account the list of requirements.
The next phase is the ideation phase where different singular solutions are combined into different machines. Then, three concept designs are created and discussed with the client which concept would be the best design considering the pro's, con's, list of requirements as well as the clients personal opinion.

This resulted in the following final design:

Figure 3: Final model

Figure 4: Final model inside

This design utilizes a double roller mechanism, where two rollers are rolling in roll in opposite direction at the same speed due to the same size gears attached to shaft. The rollers apply a force to the acorn from opposite directions resulting in a cracked acorn.

An important feature of this design is that the gap distance between the two rollers can be adjusted. Considering the average diameter of an acorn, the gap can be set from 11 mm to 23 mm. Utilizing a screw thread mechanism and a small thread pitch of 1,25 ensures precise gap adjustment. The screw is mounted to the bearing holder with some plates and nuts. The slot at the back of figure 6 holds the shaft in place.

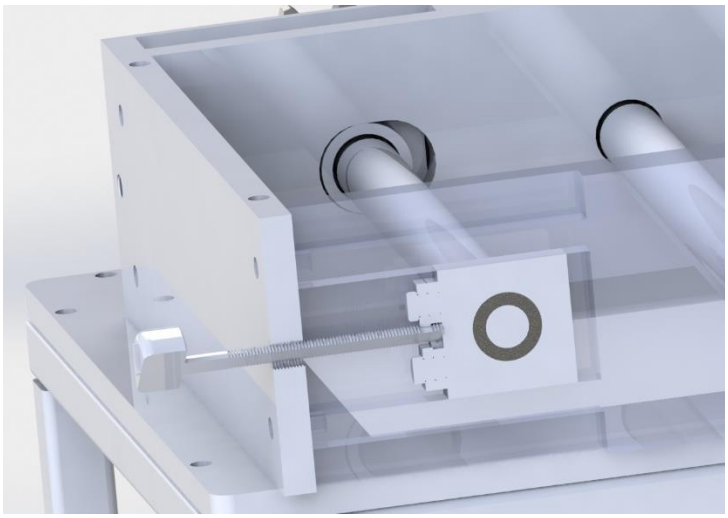

Figure 5: Section view gap adjustment mechanism

The design introduces solutions to various issues while maintaining simplicity and resemblance to other nut hulling machines. In terms of the envisioned end product, the design appears promising. However, certain details are still missing, introducing an element of uncertainty without thorough testing. Hence, prototyping becomes crucial. Unfortunately, this crucial step was not finalized, raising questions about meeting the requirements.
The conducted research and the final design definitely provide an improvement to the current knowledge and research there is available. But is also important to recognize that additional efforts, are necessary to discover the effectiveness and feasibility of the proposed solution.

References

[1] Iedereen aan de eikels - Prijsvraag Brood & Spelen. (n.d.). Washulp.Nl. Retrieved November 22, 2023, from https://prijsvraagbroodenspelen.nl/blog/wateeneikelsinhettwentselandschap-iedereenaandeeikels/

[2] Lambert, M., Riera, B., & Martel, G. (1999). Application of functional analysis techniques to supervisory systems. Reliability Engineering & System Safety, 64(2), 209–224. https://doi.org/10.1016/s0951-8320(98)00064-7