Optimal design of Silo for bulk storage of Rice

Y.Aadi Shankar
Computer Science and Engineering
Chandigarh University
Mohali, India
21BCS8261@cuchd.in

Puneeth
Computer Science and Engineering
Chandigarh University
Mohali, India
21BCS10566@cuchd.in

Syed Fakruddin
Computer Science and Engineering
Chandigarh University
Mohali, India
21BCS6927@cuchd.in

Satwika Ammulothu
Computer Science and Engineering
Chandigarh University
Mohali, India
21BCS6568@cuchd.in

Alankrita Aggarwal
Apex Institute Of Technology
Chandigarh University
Mohali ,India
alankrita.e14496@gmail.com

Abstract_ The ideal design of rice silos for bulk storage is a significant undertaking that combines engineering precision, agricultural understanding, and technology innovation. This research aims to address the critical need for efficient rice storage, which is critical for maintaining food security and minimizing post-harvest losses. Rice, being a critical staple for worldwide populations, necessitates specialized storage strategies in order to retain nutritional quality, flavor , and market value.

The study goes into the various aspects required for building silos that maintain rice integrity over long periods of time. Temperature and humidity control, pest management, loading and unloading systems, structural integrity, energy efficiency, and adherence to regulatory standards are all factors to consider. The study looks into different silo designs, such as flat-bottom, hopper-bottom, and cone-bottom designs, and assesses their suitability for rice storage.

Temperature and humidity changes have a substantial impact on rice quality, thus optimizing silo design for climate management is a major concern. Integrating ventilation and aeration systems maintains consistent indoor conditions, preventing mould growth, pest infestations, and moisture-related degradation. Furthermore, cutting-edge technologies like IoT sensors and automation play a critical role in real-time monitoring and control of storage settings.

***Index Terms*—Keywords: IOT Networks, Blockchain, MachineLearning.**

I. Introduction

Silos and hoppers are common industrial containers for storing a wide range of materials and liquids. This paper focuses on silos for granular bulk solids. Their primary application is as a buffer between one transport activity or chemical process and another in numerous economic sectors such as power generation, steel production, quarrying, food processing, mining, farming, and agricultural industries. As a result, the materials stored are fairly diverse, and the structural form of the silo is highly dependent on numerous material properties such as size, shape, weight, cohesiveness, homogeneity, and so on. The particle sizes range from fine micron powders to agricultural grains, pellets, minerals, or crushed rocks.

Silos must be carefully constructed. There are numerous codes and standards have been developed to assist engineers in the construction process, they have limitations. One of the primary goals is to assure reliable, consistent, and complete solid discharge from the vessel. Flow obstructions in gravity discharge are common problems in silo operation due to the formation of a cylindrical pipe surrounding or a stable arch-shaped obstruction over the silo outlet aperture, causing a blockage or jam. However, if the bulk solid properties are well defined, dependable criteria for silo construction are set in standards, and obstruction problems are almost or totally eliminated with an appropriate dimension of the outlet size known as critical size.

First, there is a lack of understanding of critical properties in the nature of the stored material, as biomass particles or granular materials bulk solid storage, jam formation, nonlinear heteroscedastic model, optimal design . Second, the storage period, moisture, temperature, aeraon, silo degradation, and climate conditions can all affect the bulk solid nature. To reduce the likelihood of failure, isolate performance.

Because we are dealing with several tons of stored material, direct experimentation can be very costly, dangerous, and difficult to repeat, and material waste or silo damage are too expensive for the companies. As a result, the two main solutions to this challenge are computational simulation based on physical models of the dynamics of the stored material and static experimental designs.

Problem Definition

Rice preservation, a crucial staple food for a large section of theworld's population, presents considerable issues in preserving its quality and nutritional value over long periods of time. The current issue is the lack of efficient and specialized silo designs that can successfully manage the difficulties of rice storage. This deficit causes a number of problems that affect both food security and economic sustainability. Rice storage is vulnerable to a variety of conditions that degrade its quality, such as temperature variations, humidity, pests, and mechanical damage

Traditional storage methods frequently fail to provide enough protectionagainst these threats, resulting in decreased rice quality, economic losses, and significant health hazards for consumers. Inadequate silo designs impede efficient loading and unloading procedures, resulting in additional rice breakage and distribution inefficiencies.

By using silo tanks we are replacing the storage godown's.The human power requires a lot to arrange the storage using golden fiber that is jute bags. The processto carry inside the cold storages and while removing from them it is very burden for small farmers ,So it will make them to sell for the low price. Here the silo tanks will be storing them and remove the moisture we will be continuously air flow and the area should be dry.We will be planning to remove the husk and rice separate from it .Rice is a staple food for a significant portion of the world's population.

Efficient and proper storage is essential not only to prevent post-harvest losses but also toensure its quality and safety. The design of the silo tanks plays a crucial role in achieving this.

Problem Overview

One of the primary challenges is the vulnerability of rice to external factors such as temperature fluctuations, humidity levels, and pest infestations. Traditionalstorage methods fail to provide adequate protection against these challenges, resulting in significant deterioration of rice quality and nutritional content. This not only affects consumer satisfaction but also leads to economic losses for producers and distributors.

Concerns about the environment are also raised, as inefficient storage practises contributeto wasteful resource usage and carbon emissions. The lack of climate control systems and advanced technologies exacerbates these problems, adding to food waste and wasteful resource use.

Rice is a staple food for over half of the world's population, and its storage is critical for ensuring food security. Silos are the most common method for storing rice in bulk, and their design is crucial for maintaining the quality and safety of the grain. The optimal design of silos for bulk storage of rice depends on a number of factors, including the type of rice to be stored, the desired storage capacity, the available space, the budget, the local climate, and the environmental regulations. Different types of rice have different storage requirements. For example, brown rice requires more ventilation than white rice. Brown rice also has a higher moisture content than white rice, which can lead to spoilage if not stored properly.The storage capacity of the silo will need to be large enough to accommodate the expected rice harvest. The amount of rice that can be stored in a silo depends on the size and shape of the silo, as well as the density of the rice.The silo will need to be located in an area that has enough space for the structure and for the equipment that will be used to load and unload the rice. The size of the silo will also depend on the available space.The cost of the silo will depend on the size, type, and materials used. Silos made from corrugated steel are typically the most affordable option, while silos made from concrete or stainless steel are more expensive but can last for many years.The silo will need to be designed to withstand the local climate conditions, including wind, snow, and rain. Silos in areas with high winds may need to be reinforced with additional supports, while silos in areas with heavy snowfall may need to have a roof that is designed to shed snow.

A. Hardware Specification

The rice storage facility is equipped with durable tanks made of corrosion-resistant materials like stainless steel or treated concrete. These cylindrical vertical tanks with conical bottoms facilitate efficient unloading, ensuring the longevity and quality of the stored grain. Aeration systems, including fans, ducts, and diffusers, maintain uniform air circulation, preventing moisture and temperature variations that could compromise the stored rice. Digital temperature and moisture sensors strategically placed within the tanks continuously monitor grain conditions, providing essential data for precise environmental control.

Automation is a key theme in the facility, with conveyor belts and elevators streamlining the loading and unloading processes. Pest control measures, such as ultrasonic repellers and hermetic seals, deter pests and rodents, preserving the integrity of the stored rice. In anticipation of power outages, robust backup power systems, including generators and battery packs, ensure continuous operation. Security features, such as CCTV cameras and access control systems, further fortify the facility by providing real-time surveillance and restricting access to authorized personnel only. Together, these components create a comprehensive and technologically advanced rice storage facility.

B. Software Specification

The rice storage facility is equipped with a suite of specialized software systems to enhance management and operational efficiency. Storage Management Software includes inventory management for tracking quantity, age, and source of stored rice, along with quality management to monitor and predict degradation. Data Analytics Software incorporates predictive analysis to foresee issues like increased moisture or pest activity, along with data visualization dashboards for real-time and historical sensor data.

Environmental Control Software is integral for automated climate and aeration control, adjusting temperature, humidity, fan speeds, and operation times based on sensor data. Security Software features surveillance software for real-time CCTV monitoring and access log management to track silo access.

Maintenance and Alert Systems provide automated alerts for abnormalities, such as temperature spikes or equipment failures, and scheduling software for regular checks and maintenance activities. Integration Middleware ensures seamless data exchange between different software systems, enhancing overall operational coherence. Together, these software components contribute to a technologically advanced and efficiently managed rice storage facility.

II. LITERATURE REVIEW

A. Existing System

Silos have traditionally been constructed from concrete or steel, featuring a cylindrical shape with a conical or flat bottom. The height-to-diameter ratio in older silos may not have been optimized for airflow and space utilization, while modern designs prioritize taller structures to minimize footprint. Gravity-based unloading is facilitated by conical bottoms, and older systems may use manual methods like buckets for loading/unloading, whereas some employ basic conveyors.

In terms of storage management, traditional record-keeping involves logbooks or spreadsheets to track rice quantity and storage dates. Quality monitoring relies on periodic sampling and manual inspection, including physical checks for structural integrity and cleanliness between storage cycles.

However, the existing system has limitations. Manual intervention is required for monitoring and operations, leading to potential inefficiencies. The approach to addressing issues like pests or mold is reactive rather than preemptive. Limited data insights, without sophisticated sensors and analytics, make predicting issues or optimizing operations challenging. Operational costs are increased due to labor-intensive manual operations and checks, and the use of chemicals for pest control can have adverse environmental impacts.

B. Proposed System

The proposed silo features a meticulously designed physical structure aimed at ensuring optimal functionality and longevity. Constructed with corrosion-resistant materials, such as stainless steel, conical shape, and hermetically sealed doors temperature and humidity control system ,automated loading and unloading system ,Integrated pest control system taller design not only enhance durability but also maximize space utilization and airflow within the silo. This thoughtful construction promotes efficiency, reduces maintenance requirements, and establishes an environment conducive to the long-term storage of rice.

Environmental control measures are seamlessly integrated into the system, with automated aeration driven by sensors to ensure uniform air distribution. Continuous monitoring through temperature and humidity sensors allows the system to adjust aeration, preventing issues like moisture accumulation and temperature spikes. These features contribute significantly to preserving the quality of stored rice and create an environment that facilitates extended storage durations. The filling and unloading processes are streamlined through automation, employing conveyor belts and elevators with automated systems to enhance overall efficiency and reduce manual intervention, thereby minimizing the risk of errors.

Storage management undergoes a transformation with the implementation of digital inventory management. RFID or barcode systems accurately track stored rice, providing real-time data on quantity and storage dates. Quality monitoring is elevated through the use of IoT-enabled sensors that continuously monitor parameters such as temperature, humidity, and gas levels, ensuring the preservation of high-quality rice. Safety and security are paramount considerations, with CCTV and remote monitoring systems providing real-time surveillance and integrated pest management ensuring early detection and minimization of pest-related risks.

Data analytics and predictive maintenance bring a new level of sophistication to the storage system. Predictive analysis, powered by machine learning algorithms, anticipates potential issues such as temperature spikes or pest outbreaks. Real-time data visualization dashboards provide valuable insights for informed decision-making. Remote access and control are facilitated through cloud connectivity, allowing for monitoring and control via web or mobile applications. Automated alerts notify stakeholders of abnormal conditions or maintenance requirements, enabling timely responses to potential issues.

Energy efficiency and sustainability are core components of the proposed system, with the integration of solar panels powering ventilation, lighting, and monitoring systems, reducing reliance on conventional energy sources. Rainwater harvesting for non-potable use, such as cleaning, further contributes to environmental sustainability. Maintenance and upkeep are streamlined through condition monitoring using IoT sensors, ensuring the long-term efficiency of the silo. In summary, the proposed system offers a comprehensive solution with advantages ranging from increased efficiency and quality assurance to data-driven decision-making and sustainability, setting a new standard for precision, reliability, and environmental responsibility in rice storage.

PROBLEM FORMULATION

Solid rice material stored in a silo undergoes discharge via the force of gravity through an outlet at the container's bottom. The formation of blockages, a critical concern, is characterized by a random variable T, representing the time between jamming events. The probability distribution of T is estimated through n observations (t1, ..., tn) collected under various experimental conditions with different outlet diameters (φ). Experiments can be replicated for a specific diameter, and due to challenges in direct experimentation with real silos, laboratory-scale experiments become essential for obtaining valuable information.

In the laboratory experiments, researchers carefully selected possible outlet diameters, recognizing the critical importance of this choice in replicating real potential experiments. The study demonstrated the emulation of spheres in a 3D silo by spheres in a 2D silo, proving empirically that regular and identical spheres replicate irregular and non-uniform shapes like rice, lentils, or stones effectively. The increase in variability introduced by non-regular shapes in these cases was deemed negligible.

The laboratory experiments utilized both 3D and 2D silos, with the latter consisting of two vertical glass plates between which spherical beads were poured. The beads, representing the solid material, flowed constantly through an aperture at the bottom due to gravity until an arch formed, causing a jam. An arch is a stable structure, and its removal leads to the collapse of the jam, restarting the flow until a new jam is formed.

OBJECTIVES

Previously and currently, many farmers utilize gunny bags for storing various items, including rice, in sizes like 75 kilograms, 25 kilograms, and 1000 kilograms. Gunny bags provide a convenient and flexible option for storage needs.

In the pursuit of cost-effectiveness in construction and maintenance, selecting strong and durable yet economical materials is crucial for silo construction. Concrete and steel are common choices, with concrete offering durability but at a higher cost, while steel is less expensive but more susceptible to corrosion.

Maximizing storage capacity requires a thoughtful balance between the diameter and height of the silo. While a larger silo can store more rice, it comes with increased construction and maintenance costs. Safety considerations include ensuring the silo's structural integrity, a secure seal to prevent pests and moisture, and design features to prevent static electricity buildup, reducing the risk of fires.

Facilitating easy loading and unloading is essential. The silo should feature a spacious opening at the bottom or top to allow for efficient movement of the rice. The interior surfaces should be smooth to prevent rice sticking, and the sloped floor aids in the free flow of grains.

Efficient grain flow is further supported by proper ventilation to minimize moisture and heat buildup. Temperature control systems may be necessary to maintain a safe environment for the stored rice. Silo tanks are now employed for grain storage, but careful attention is required to combat moisture effects. It is crucial to ensure the grains remain dry, and the use of not only air but also nitrogen gas is recommended to preserve freshness.

For effective management, silo tanks can be divided into layers to facilitate proper airflow. Regular maintenance, including cleaning and drying, is essential, and grain unloading is typically achieved using gravity, emphasizing a straightforward and efficient process.

METHODOLOGIES

To ensure the optimal storage conditions for rice, several key factors must be carefully controlled. Firstly, temperature maintenance is crucial, aiming for stability to prevent moisture-related changes and insect infestations. Ideally, the temperature should be kept below 15°C (59°F) to inhibit insect activity, with even cooler climates favoring temperatures around 10°C (50°F). Humidity control is equally vital, necessitating a low relative humidity below 70-75% to prevent mold growth and moisture-related damage.

Proper air circulation is facilitated through ventilation and aeration systems, preventing moisture accumulation and hotspots in the silo. Integrated pest management techniques, including fumigation, sanitation, and regular inspection, are implemented to prevent insect infestations. Ensuring the silo is well-sealed prevents moisture ingress, with regular inspections for leaks and the use of moisture-absorbing materials like desiccants.

Cleaning and maintenance protocols involve thorough cleaning before filling to remove debris, residues, and contaminants. Regular cleaning and sanitation prevent the buildup of mold, bacteria, and pests. Periodic quality testing, including assessments of moisture content, appearance, and aroma, ensures the ongoing quality of stored rice. Record-keeping of maintenance activities, inspections, and any issues that arise is crucial, alongside monitoring storage duration and quality changes.

The silo's infrastructure, including the outer shell, insulation layer, and inner liner, is integral to its functionality. The weather-resistant outer shell constructed from durable materials protects the rice from external elements. The integration of insulation materials regulates internal temperature and prevents fluctuations, while the food-grade inner liner maintains cleanliness and prevents direct contact between rice and structural materials.

In terms of power needs, estimating requirements for climate control and ventilation systems is essential. Incorporating energy-efficient technologies minimizes power consumption. Adequate lighting is provided for interior inspection and maintenance tasks, and backup power sources are considered to maintain climate control and safety features during power outages. In summary, a holistic approach to silo management encompasses temperature and humidity control, pest prevention, moisture prevention, cleaning, quality testing, record-keeping, infrastructure upkeep, and careful consideration of power needs.

RESULT

The ideal design of rice silos for bulk storage is a critical issue that requires a combination of engineering expertise, agricultural knowledge, and technological advancements. This research addresses the pressing need for efficient rice storage, which is essential for ensuring food security and reducing post-harvest losses. Rice, a vital staple for populations worldwide, demands specialized storage solutions to preserve its nutritional value, taste, and market worth.

The study delves into the various considerations necessary for constructing silos that maintain rice integrity over extended periods. Factors such as temperature and humidity control, pest management, loading and unloading systems, structural integrity, energy efficiency, and compliance with regulatory standards are all crucial aspects. The research investigates different silo designs, including flat-bottom, hopper-bottom, and cone-bottom configurations, and evaluates their suitability for rice storage.

Temperature and humidity fluctuations have a significant impact on rice quality, making the optimization of silo design for climate control a primary concern. The integration of ventilation and aeration systems maintains consistent indoor conditions, preventing mold growth, pest infestations, and moisture-induced degradation. Additionally, cutting-edge technologies such as IoT sensors and automation play a pivotal role in real-time monitoring and control of storage environments.

Conclusion and Future Work

IoT security is similar to a safety lock for our smart devices, and it is becoming increasingly vital as we use more connected devices. We're considering employing smart technologies likeAI to improve these safety locks. AI can assist us by learning about new hazards and adapting our devices to protect us from them. We're also looking at tighter encryption ways to ensure that our private information remains secret no matter how sophisticated hackers get. Simultaneously, there is a significant shift towards managing data directly on our devices, such as smartphones, rather than transmitting it to remote computer centres. This makes it more difficult for hackers to gain access to our data. There's also talk of everyone working together on a global scale. Consider what would happen ifall businesses exchanged information about possible risks; it would be like a neighbourhood watch for the digital world, making everything safer. Finally, as we include more smart gadgets into our homes and lives, it is critical to determinethe best methods for keeping them secure. This includes utilising cutting-edge technology, collaborating, and ensuring that everyone understands how to use their gadgets properly.

References

Isik, E. & Izli, N. Moisture physical and mechanic properties of dent corn (ZeamaysvarindentataSturt)seeds(Ada-523).Am.J.Food Technol. 2,342–353(2007).

2. Huang, H., Danao, M. C., Rausch, K. D. & Singh, V. Diffusion and production ofcarbondioxideinbulkcornatvarioustemperaturesand moisturecontents.J.Prod.Res.55,21–26(2013).
3. Lopes, D. C., Martins, J. H., Neto, A. J. S. & Monteiro, P. M. B. Management of stored maize by AERO controller in five Brazilian locations:asimulationstudy.Biosyst.Eng.101,325–330(2008).
4. Palzer, S., Dubois, C. & Gianfrancesco, A. Generation of product structuresduringdryingoffoodproducts.DryingTechnol.30,97–105 (2012).
5. Puzzi, D. Grain supply and storage 603 (Campineiro Institute of AgriculturalEducation,Campinas,1986).
6. Reed, C., Doyungan, S., Ioerger, B. & Getchell, A. Response of storage molds to different initial moisture contents of maize (corn) storedat 25 °C, andeffectonrespirationrateandnutrientcomposition. J.StoredProd.Res.43,443–458(2007).
7. Neethirajan, S.etal. Developmentofcarbondioxide(CO2) sensorfor grainqualitymonitoring.Biosyst.Eng.106,395–404(2010).
8. Peplinski,A.J.,Paulis,J.W.,Bietz,J.A.& Pratt,R.C.Dryingofhigh-moisture corn: changes in properties and physical quality. Cereal Chem.71,129–133(1994).
9. Xu, M., Pan, Y., Leng, J., Li, H. & Li, X. Effect of different high oxygen treatments on preservation of seedless long jujube in low temperaturestorage.J.FoodProcess.Preserv.44,e14314(2020).
10. Mbofung, G. C. Y., Goggi, A. S., Leandro, L. F. S. & Mullen, R. E. Effects of storage temperature and relative humidity on viability and vigoroftreatedsoybeanseeds.CropSci.53,1086–1095(2013).
11. Ma, H., Zhang, W., & Yang, S. X. Systems modeling and intelligent control of meat drying process. In 10th IEEE System of Systems EngineeringConference,238–243(2015).
12. Hemis, M., Choudhary, R. & Watson, D. G. A. Coupled mathematical model for simultaneous microwave and convective dryingofwheatgrains.Biosyst.

Eng.112,202–209(2012).

13. Niamnuy, C., Nachaisin, M., Poomsa, N. & Devahastin, S. Kinetic modelling of drying and conversion of isoflavones during infrared dryingofsoybean.FoodChem.133,946–952(2012).
14. Park, C., Kim, Y., Park, K. & Kim, B. Changes in physicochemical characteristicsofriceduring storageatdifferenttemperatures. J. Stored Prod.Res.48,25–29(2012).
15. Coradi, P. C., Müller, A., Souza, G. A. C., Steinhaus, J. I. & Wagner, R. Quality of soybean cultivars in the drying and storage processes in realscaleandexperimental.J.FoodProcessEng.43,e13418(2020).
16. Brooker, D. B., Bakker-Arkema, F. W. & Hall, C. W. Drying and Storage of Grains and Oilseeds 450 (The AVI Publishing Company, Westport,1992).
17. Ghazanfari, A., Emani, S., Tabil, N. G. & Panigrahi, S. Thin-layer dryingofflaxfiber:II.Modelingdryingprocessusingsemi-theoretical andempiricalmodels.DryingTechnol.24,1637–1642(2006).
18. Coradi, P. C. et al. Technological and sustainable strategies for reducing losses and maintaining the quality of soybean grains in real productionscalestorageunits.J.StoredProd.Res.87,101624(2020).
19. Alencar, E. R., Faroni, L. R. D., Ferreira, L. G., Costa, A. R. D. A. & Pimentel, M. A. G. Quality of corn stored and infested by Sitophilus zeamaisandTriboliumcastaneum.Agric.Eng.19,9–18(2011).
20. Zhang,S.,Zhai,H.,Huang,S.&Cai,J.Asite-directedCO2 detection method for monitoring the spoilage of stored grains by insects and fungiin Chinesehorizontal warehouses. J. Stored Prod. Res. 59, 146–151(2014).
21. Garcia-Cela, E.etal.Influenceofstorageenvironmentonmaizegrain:

CO2 production, dry matter losses and aflatoxins contamination. Food Addit.Contam.1,175–185(2019).

22. Babalis,S.J.& Belessiotis, V. G.Influenceofthedryingconditionson the drying constants and moisture diffusivity during the thin-layer dryingoffigs.J.FoodEng.65,449–458(2004).
23. Mourad, A. L., Neto, A. R., Oliveira Miguel, A. M. R., Henriques, E. A.&Alves,R.

M. V. Storage stability of three genotypes of sunflower seeds. Ind. CropsProd.80,6–16(2016).

24. Yubonmhat, K., Chinwong, S., Nattawoot, M., Saowadee, N. & Youngdee, W. Cellular water and proton relaxation times of Thai rice kernels duringgraindevelopmentandstorage.J.CerealSci.88,65–70(2019)