Optimal design of Silo for bulk storage of Rice

Project Synopsis

Submitted in the partial fulfillment for the award of the degree of

BACHELOR OF ENGINEERING

IN

COMPUTER SCIENCE WITH SPECIALIZATION IN

ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

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August,2023

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 minimising post-harvest losses. Rice, being a critical staple for worldwide populations, necessitates specialised storage strategies in order to retain nutritional quality, flavour, 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 optimising 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 .Finally, a simulation study checks the performance of the approximations, first with the Fisher Information matrix, then with the linearization of the function to be estimated. The results are useful for experimenting in a laboratory and then translating the results to a real scenario.

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1.Introduction

Silos and hoppers are usual containers in industry for storing a large variety of solids and liquids. In this work we focus on silos for granular bulk solids. Their main use is as a buffer between one transport activity or chemical process and another inmany economic activities as power generation, steel making, quarrying plastics, food processing, mining, farming and agricultural industries. Therefore, materials stored are quite variable and the structural form of the silo depends greatly on several properties of the material, as size, shape, weight, cohesion, homogeneity, etc. Particle sizes range from fine powders of micron size to agricultural grains, pellets, minerals or crushed rocks.

Silos require careful structural construction to avoid failures. Many codes and standards have been published to help engineers in the construction process, but they havelimitations. One of the main goals is to ensure reliable, steady and complete discharge of solid from the vessel. Flow obstructions in the discharge under gravity are common problems in the operation of a silo because of the formation of a cylindrical pipe around or a stable arch-shaped obstruction over the silo outlet opening , causing a blockage or jam.
However, if the bulk solid properties are well known, reliable criteria for silo construction are established in the standards and obstruction problems are almost or completely eliminated with a right dimension of the outlet size called critical size.

First the lack of knowledge of critical properties in the nature of the stored material, as biomass particles or granular materials bulk solid storage, jam formation, non- linear heteroscedastic model, optimal design . Second, the bulk solid nature can be modified by the storage period, moisture, temperature, aeration, silo degradation, climate conditions. silo performance to minimize the chance of failures.

Direct experimentation can be very costly, risky and difficult to replicate because we are dealing with several tons of stored material, and waste of material or silo damage are too expensive for the companies. So that, computational simulation based on physical models of the dynamics of the stored material and statistical experimental designsare the two main solutions to deal with this problem.

1.1 Problem Definition

Rice preservation, a crucial staple food for a large section of the world'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 specialised 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 temperaturevariations, 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 coldstorages 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 to ensure its quality and safety. The design of the silo tanks plays a crucial role in achieving this.

Volume of Each Tank: Total storage capacity per tank. Number of

Tanks: Total number of storage tanks in the silo.

Material Used: Type of material used for constructing the tank (e.g., steel, concrete).

Height to Diameter Ratio: For cylindrical tanks, this ratio can impact the efficiency of spaceutilization and the quality of stored rice.

Cost: The total cost for constructing and maintaining each tank.

1.2 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 contribute to 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 the staple food in Asian countries and thus, is a main consideration in food security. The moisture content of grains is one of the important parameters for grain quality control especially during harvesting, milling, and storage [1]. **Table 1** presents the ideal moisture contents of the different types of grain during harvest and safe storage. The moisture content of harvested paddy is usually high (19–25%) and thus needs to be dried to 14% or less for safe storage [2,3]. Grain wastage often occurs due to improper storage conditions where high moisture content promotes the growth of mould and insect infestation whereas very dry grains are brittle and susceptible to breakage.Moisture content in the grain is also affected by the weather where moisture content becomes high during the rainy season, otherwise too low in the summer or hot season. Therefore, continuous monitoring is critical especially in tropical climate where the weather varies throughout the year.

After harvesting, grains are typically stored in silos (cylindrical storage) [4]. Since silos are quite large (e.g., a diameter and height range from 4.6 m to 18.3 m and 4.6 m to 28.7 m,respectively), the moisture content may not be uniformly distributed in the silo. The moisture content measurements are not carried out frequently enough to observe the dynamics of moisture content changes within the bin continuously. Over-drying usually occurs in the bottom layer of the silo during the drying process. Therefore, a system to continuously monitor the moisture content in the storage container is important. Various methods are available for moisture content measurement as presented in **Section 2**. However, most of the existing methods are expensive, complex and do not provide continualautomated monitoring.

1.3 Hardware Specification

- Storage Tanks:
  Material: Corrosion-resistant material like stainless steel or treated concrete toensure durability.
  Design: Cylindrical vertical tanks with conical bottoms for efficient unloading.

- Aeration Systems:
  Aeration Fans: To provide uniform air circulation.
  Ducts and Diffusers: To distribute air evenly throughout the storage mass.

- Temperature and Moisture Monitoring Sensors:
  Digital Temperature Sensors: Placed at different levels to monitor grain temperature.Moisture Sensors: To monitor the moisture content of the stored rice and the surrounding environment.

- Automated Loading and Unloading Mechanisms: Conveyor Belts: For moving rice in and out of the silo.Elevators: To lift rice to the top of the silo for filling.

- Pest Control Systems:
  Ultrasonic Repellers: To repel pests and rodents.
  Hermetic Seals: To prevent pest intrusion.

- Backup Power Systems:
  Generators: To ensure continuous operation even during power outages.Battery Packs: For emergency power to critical systems.

- Security Systems:
  CCTV Cameras: For monitoring the premises.
  Access Control Systems: Biometric or card-based systems for authorized access.

1.4 Software Specification

- Storage Management Software:
  Inventory Management: To track the quantity of rice stored, its age, and source.Quality Management: To monitor the quality of rice and predict when it might degrade.

- Data Analytics Software:
  Predictive Analysis: To foresee potential issues like increase in moisture content orpest activity.
  Data Visualization: Dashboards to display real-time and historical data from sensors.

- Environmental Control Software:
  Climate Control: Automated systems to control temperature and humidity based onsensor data.
  Aeration Control: Adjusting fan speeds and operation times based on the rice'scondition.

- Security Software:
  Surveillance Software: For real-time monitoring via CCTV.
  Access Log Management: To track who accessed the silo and when.

- Maintenance and Alert Systems:
  Automated Alerts: Notifications for any abnormalities, like temperature spikes orequipment failures.
  Maintenance Scheduling: Software to schedule regular checks and maintenanceactivities.

- Integration Middleware:
  To integrate different software systems and ensure seamless data exchange betweenthem.

2. LITERATURE SURVEY

2.1 Existing System

Material: Traditionally, silos are constructed from concrete or steel.Shape:

Typically cylindrical with a conical or flat bottom.

Height-to-Diameter Ratio: Older silos might not have optimized this ratio for airflow and space utilization. Modern silos aim for a taller design to minimize the footprint.Gravity- Based Unloading: Silos with conical bottoms allow gravity-assisted unloading.MechanicalConveyance: Older systems may use more manual methods of loading/unloading like buckets, whereas some have basic conveyors.

Storage Management:

Record Keeping: Traditional logbooks or spreadsheets to track the amount of rice stored, date of storage, etc.Quality Monitoring: Relies on periodic sampling and manual inspection.Manual Inspection: Physical checks for structural integrity, rust, wear and tear,etc.Cleaning: Manual cleaning between storage cycles to ensure removal of residues.

Limitations of the Existing System:

Lack of Automation: Requires manual intervention for monitoring and operations, which might lead to inefficiencies.Reactive Approach: Problems such as pests ormold are addressed after they become evident rather than being preemptively managed.Limited Data Insights: Without sophisticated sensors and data analytics, predicting issues or optimizing operations is challenging.

Operational Costs: Manual operations and checks can be more labor-intensive, increasingoperational costs.

Environmental Impact: Use of chemicals for pest control can be harmful to theenvironment.

2.2 Proposed System

1. Physical Structure of Silo:

Material: Utilize corrosion-resistant materials like stainless steel to ensure durability. Optimized Shape: Cylindrical with a taller design to maximize space utilization and airflow.

2. Environmental Control:

Automated Aeration: Incorporate sensor-driven ventilation systems to ensure uniform airdistribution.

Temperature and Humidity Sensors: Monitor conditions and adjust aeration to preventmoisture accumulation and temperature spikes.

3. Filling & Unloading:

Automated Loading/Unloading: Conveyor belts and elevators with automation for seamlessand efficient operations.

4. Storage Management:

Digital Inventory Management: Implement RFID or barcode systems for accurate tracking ofstored rice.

Quality Monitoring: Utilize IoT-enabled sensors to monitor quality parameters liketemperature, humidity, and gas levels.

5. Safety and Security:

CCTV and Remote Monitoring: Deploy security cameras and remote monitoring systems forreal-time surveillance.

Integrated Pest Management: Implement sensors and electronic traps for early pestdetection and minimization.

6. Data Analytics and Predictive Maintenance:

Predictive Analysis: Utilize machine learning algorithms to predict potential issues liketemperature spikes or pest outbreaks.

Data Visualization: Provide real-time data visualization dashboards for better decision-making.

7. Remote Access and Control:

Cloud Connectivity: Enable remote access for monitoring and control through web ormobile applications.

Automated Alerts: Receive notifications for abnormal conditions or maintenancerequirements.

8. Energy Efficiency and Sustainability:

Solar Power: Implement solar panels to power ventilation, lighting, and monitoringsystems.

Rainwater Harvesting: Collect rainwater for non-potable use like cleaning.

9. Maintenance and Upkeep:

Condition Monitoring: Use IoT sensors to monitor structural integrity and wear-and-tear ofcomponents.

Automated Cleaning: Implement automated cleaning mechanisms to remove residuesbetween storage cycles.

10. Advantages of the Proposed System:

Efficiency: Automation and predictive analytics optimize operations, reducing losses andcosts.

Quality Assurance: Continuous monitoring ensures rice quality is maintained, reducingspoilage.

Data-Driven Decisions: Real-time data insights facilitate better decision-making and riskmanagement.

Sustainability: Integration of renewable energy and water conservation measures reducesenvironmental impact.

2.3 Literature Review Summary

“Godfray, H.C.J.; Beddington, J.R.; Crute, I.R.; Haddad, L.; Lawrence, D.; Muir,J.F.; Pretty, J.; Robinson, S.; Thomas, S.M.; Toulmin, C. Food security: The challenge of feeding 9 billion people. *Science* 2010, *327*, 812–818. ”

The effects of climate change are a further threat. But the world can produce more food and can ensure that it is used more efficiently and equitably.A multifaceted and linked global strategy is needed to ensure sustainable and equitable food security, different components of which are explored here.

“Kitinoja, L.; Saran, S.; Roy, S.K.; Kader, A.A. Postharvest technology for developing countries: Challenges and opportunities in research, outreachand advocacy. *J. Sci. Food Agric.* 2011, *91*, 597–603.”

Key issues include building capacity at the local level in postharvest science, university teaching and extension, and continued adaptiveresearch efforts to match emerging postharvest technologies to local needs as these continue to change over time. Development of appropriate postharvest technology relies upon many disciplines that are relevant to the overall successof horticulture, i.e. plant biology, engineering, agricultural economics, food processing, nutrition, food safety, and environmental conservation.

“Food and Agriculture Organization of United Nations. *Global Initiative onFood Losses and Waste Reduction*; FAO: Rome, Italy, 2014.”

A hypothesized model that combines many factors considered in the recent literature in a single framework to understand the individual’s decision- making process about food waste behaviour in Cairo-Egypt. Results showed that these factors were found to be relevant in explaining this behaviour for the surveyedsample of the size of 1000 respondents. Taking into consideration the studies on food waste in developing countries at the consumer level are scarce.

“Gesellschaft für Internationale Zusammenarbeit. *Post-Harvest Losses ofRice in Nigeria and Their Ecological Footprint*; Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH: Bonn/Eschborn, Germany, 2014.”

We found that the major stages of PHL were at harvesting and postharvest handling, point of processing, at storage, and during transportation to place of storage or marketing. PHL was higher with paddy rice and occurred mostlyduring harvesting while the losses for milled rice occurred mostly during storage. The causes at various stages were due to spillage, breakage due to over drying, rodent attack, theft, and spillage due to poor packaging materialsused during transportation. Based on findings from the study, we conclude that Postharvest loss.

“Gesellschaft für Internationale Zusammenarbeit. *Post-Harvest Losses ofRice in Nigeria and Their Ecological Footprint*; Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH: Bonn/Eschborn, Germany, 2014.”

It needs to increase in order to sustain food security at home and maintain our share in world markets. The quality of produce also suffers due to defective harvesting methods and out-dated processing technology and admixturesduring various stages of processing and marketing.

“**Grover, D.; Singh, J. Post-harvest losses in wheat crop in Punjab: Past andpresent. *Agric. Econ. Res. Rev.* 2013, *26*, 293–297”**

The crop losses during the process of harvesting, threshing, transportation and storage of foodgrains are quite significant. The present study has estimated the extent of losses occurring during post- harvest phase of wheat crop based on theexperience of 120 wheat-growing farmers of various farm-size categories from Ludhiana and Ferozepur districts of Punjab.

3. PROBLEM FORMULATION

Solid material rice stored in a silo and its discharge due to the force of gravity through an outlet at the bottom of the container. Consider, in particular, the problem of the formation of blockages. The time T when a first jam happens, or between two jamming events, is a random variable that depends on the diameter φ of the outlet at the bottom of the silo. To estimate the probability distributionof T, an experimenter may collect n observations t1,...,tn of the times between two jams for $r \leq n$ experimental conditions chosen according to an experimental design.

Experiments can be replicated for a particular diameter.

Due to the difficulties of direct experimentation with real silos, collecting data in a smaller scale experiment in a laboratory may be needed to obtain the desired information. Then, the choice of the possible diameters of the outlet to perform the experiments is of critical importance for the physicists made a thoughtfulstudy of how the laboratory experiment can be used to replicate the real potential experiment in a similar phenomenology. In particular, they proved how the spheres in a 3D silo can be emulated by spheres in a 2D. Additionally they proved empirically that the experiment with regular and identical spheres replicates good enough other irregularand non-uniform shapes such as rice, lentils or stones. In particular, the increase in variability introduced by non-regular shapes in those cases is negligible. T

The 3D and 2D silos they used in the laboratory to do the experiments. In this paper we refer to the experimental study presented in Janda et al. (2008), and further studied in Amo-Salas et al. (2016) and in Amo-Salas, Delgado- Márquez and López-Fidalgo (2016). A two-dimensional silo is reproduced in laboratory, consisting of two vertical glass plates between which spherical beads are poured. The beads flow constantly through an aperture at the bottom of the silo due to gravity, until an arch is formed at this outlet. An arch is indeed a structure where particles are mutually stable and hence it generates a jam. If one of the particles that form an arch is removed, the arch collapses and the flow restarts until the formation ofnew jam.

4. OBJECTIVES

- Periviously and till now gunny bags are used by many farmers to store not onlyrice but many items. Gunny bags are best to store in the requirement size like 75kilograms,25kilograms,1000kilograms .

- To minimize the cost of construction and maintenance: The materials used to construct the silo should be strong and durable, but also cost-effective. Concreteand steel are two common materials used for silo construction. Concrete is moreexpensive than steel, but it is also more durable and can last for many years. Steel is less expensive than concrete, but it is more susceptible to corrosion.
- To maximize the storage capacity: The diameter and height of the silo will affectits storage capacity. A silo with a larger diameter and height will be able to storemore rice. However, a larger silo will also be more expensive to construct and maintain.
- To ensure the safety of the stored rice: The silo should be structurally sound andhave a good seal to prevent pests and moisture from entering. The silo should also be designed to prevent the buildup of static electricity, which can cause fires.

- To facilitate easy loading and unloading of the rice: The silo should have a largeopening at the bottom or top for loading and unloading the rice. The opening should be wide enough to allow for the efficient movement of the rice.
- To allow for efficient grain flow: The interior surface of the silo should be smooth to prevent the rice from sticking to the walls. The floor of the silo should be sloped to allow the rice to flow freely.
- To minimize the risk of grain spoilage: The silo should be well-ventilated to preventthe buildup of moisture and heat. The silo may also need to have atemperature control system to keep the rice at a safe temperature.
- Now the silo tanks are using to store the grains but the moisture effects a lot to the grains ,the main thing need to be taken care is the grains should be dry .Noteven air ,nitrogen gas is also required to have the fresh grains.
- The tanks will be divided into layers to have good flow of air. The tanks will be maintained in clean and dry in a frequent manner .The grains unloading will bedone using the gravity.

Hoppers Bottom Silo **Mild Steel Silo** **Cylindrical Silos** **Bolted Silos**

5. METHODOLOGY

1. Temperature Control:

Maintain a stable temperature to prevent rice from undergoing moisture-related changes or insect infestations. Ideally, the temperature should be kept below 15°C (59°F) to inhibit insect activity. In cooler climates, maintaining temperatures around10°C (50°F) is beneficial.

2. Humidity Control:

Maintain a low humidity level to prevent mold growth and moisture-related damage.Relative humidity should be kept below 70% to 75%.

3. Ventilation and Aeration:

Proper air circulation is crucial to prevent the accumulation of moisture and hotspotsin the silo. Implement ventilation and aeration systems to control temperature and humidity.

4. Pest Control:

Implement integrated pest management techniques to prevent insect infestations. Thismay include fumigation, sanitation, and regular inspection. Regularly monitor for signs of pests and take action promptly if detected.

5. Moisture Prevention:

Ensure the silo is well-sealed to prevent moisture from entering. Inspect seals andjoints regularly for any leaks. Use moisture-absorbing materials like desiccants to control excess moisture.

6. Cleaning and Maintenance:

Clean the silo before filling it with rice to remove any debris, residues, or potential contaminants. Regularly clean and sanitize the silo to prevent the buildup of mold, bacteria, and pests.

7. Quality Testing:

Periodically test the quality of stored rice, including moisture content, appearance, andaroma. Rotate or use the stored rice to maintain its freshness and quality.

8. Record Keeping:

Maintain detailed records of maintenance activities, inspections, and any issues that arise during storage. Keep track of storage duration and any quality changes in the rice.

9. Upkeep of Silo Infrastructure:

Regularly inspect the silo's structural integrity, including foundations, walls, and roofs.Address any wear and tear promptly to avoid compromising the safety of both the stored rice and personnel.

Silo Structure and Layers:

- **Outer Shell**: Construct a weather-resistant outer shell using durable materials like galvanized steel or concrete to protect the rice from externalelements.
- **Insulation Layer**: Integrate insulation materials to regulate internal temperature and prevent temperature fluctuations.
- **Inner Liner:** Install a food-grade inner liner to maintain cleanliness and prevent direct contact between rice and the structural materials.

Power Needs:

- **Climate Control:** Estimate the power requirements for maintaining temperature and ventilation systems. Incorporate energy-efficient technologies to minimize power consumption.
- **Lighting:** Provide adequate lighting inside the silo for inspection andmaintenance tasks.
- **Emergency Power:** Consider backup power sources to maintain climate control and safety features during power outages.

6.EXPERIMENTAL SETUP

Setup Components:

A. Prototype Silos:Construct multiple scaled-down prototype silos with variations in design(e.g., height-to-diameter ratio, vent placements, aeration mechanisms).

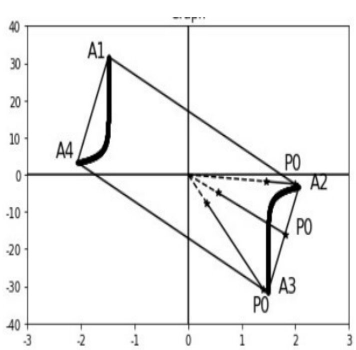
B. Sensors:Temperature and humidity sensors for internal monitoring.Grain quality sensorsto detect potential spoilage or pest activity.Weight sensors to monitor quantity and detect any losses.

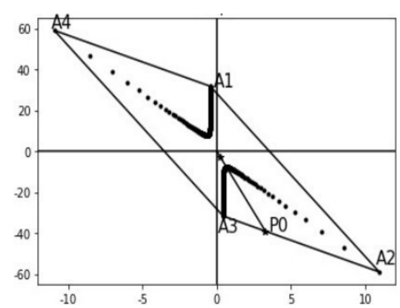
C. Controlled Environment:An enclosed space where external environmental factors (temperature, humidity) can be controlled.

D. Rice Samples:Source rice of consistent quality for testing, ensuring diversity to simulatevarious real-world conditions.

E. Data Collection and Analysis Tools:Software to collect and analyze data from sensor Computational tools for simulation and modeling.

Procedure:





A. Calibration:Ensure all sensors are calibrated and functional before introducing rice intothe prototype silos.

B. Filling the Silos:Fill each prototype with the rice sample up to its maximum capacity.

Monitor and record initial conditions including rice temperature, humidity, and weight.

C. Storage Period:Store rice for a predetermined period (e.g., 3 months).Continuouslymonitor and record data from the sensors.

D. Vary Environmental Conditions:In the controlled environment, simulate different conditions like increased external humidity or temperature spikes. Observe how each prototype responds.

E. Analyze Rice Quality Periodically:Extract rice samples from each silo at regular intervals.Conduct laboratory tests to assess grain quality, moisture content, and any signs ofspoilage.

F. Unloading and Final Analysis:After the storage period, unload the rice.Analyze the rice for any losses, signs of pests, and overall quality.Compare results across different prototypesilos to determine which design maintained the best rice quality.

$$K = (\partial g(\theta;T0)/\partial L|\theta 1=C0,\theta 2=L0\ )/(\partial g(\theta;T0)/\partial C|\theta 1=C0,\theta 2=L0)\ .$$

Data Analysis:

A. Storage Efficiency:Calculate the efficiency of each silo in terms of space utilization andrice preservation.

B. Quality Maintenance:Use laboratory test results to evaluate how well each design maintained rice quality.

7. CONCLUSION

In this paper we consider the problem of estimating the parameters of a non-linear model for the time elapsed between two jams in the emptying of a silo. This may be applied to a number of phenomena such as delivering some material ona mine through a vertical tunnel. In most of the cases a jam might be rather dramatic involving some expensive procedures to break the jam. In the case of the mine some explosive has to be used including costs, risks and delays. Then, determining the diameter of the outlet, say φ, to guarantee a period of time long enough is of great interest.

This could be considered as a specific expected time, say T0, or else a specific probability of reaching a target time without jams. Either "expected time" (T0) or probability of "success" (reach target time jam-free) entails the estimation of a lower bound expressed as a non-linear function that depends on the unknown parameters. To obtain an analytical solution of the problem, first we use the classical Fisher Information approximation for the covariance matrix of the estimates of the parameters. Then the non-linear lower bound, which is the target for estimation, is linearized in such a way its gradient will play the role of the c–vector for c–optimality.

A model with two parameters is chosen, and the Elfving graphic procedure to find the c-optimal design is used. The main characteristics of theconvex hull depending on the parameter values and then an explicit expression for thec-optimal design can be provided in all cases. Actually, the latter indicates that the c- vector may intersect the convex hull in three possible sides of the convex hull depending on three intervals where T0 can lie. The vertices produce one–point c- optimal experimental designs, otherwise two points are needed. Thus, the optimal experiment involves only two outlet diameters, which is very convenient in the laboratory.

8. TENTATIVE CHAPTER PLAN FOR THE PROPOSED WORK

CHAPTER 1: INTRODUCTION

- Background of rice as a staple food and its global significance.
- Importance of post-harvest storage.
- Brief on silos and their role in grain storage.
- Old usage to new usage difference.
- Use of Jute bags for the processing.

CHAPTER 2: LITERATURE REVIEW

- Historical development of grain silos.
- Existing designs and technologies in rice storage.
- Challenges and shortcomings of current systems.
- Recent advancements and innovations.

CHAPTER 3: OBJECTIVE

- Materials commonly used and their pros and cons.
- Factors affecting the design (environmental, economic, and operational).
- Importance of height-to-diameter ratio.
- Overview of aeration, temperature, and moisture control.

CHAPTER 4: METHODOLOGIES

- The role of IoT in modern silos.
- Automated systems for loading, unloading, and management.
- Digital inventory management and real-time monitoring.
- Predictive maintenance and analytics.

CHAPTER 5: EXPERIMENTAL SETUP

- Challenges posed by pests in rice storage.
- Integrated pest management systems for silos.
- Quality control mechanisms and technologies.
- Laboratory methods for periodic rice quality assessment.
- Cost analysis of traditional vs. modern silo designs.
- Return on investment considering post-harvest loss reduction.
- Financial benefits of quality maintenance and premium market prices.
- Funding, grants, and financial supports for advanced silo constructions.

CHAPTER 6: CONCLUSION AND FUTURE SCOPE

- Summarizing key findings and insights from previous chapters.
- Providing clear recommendations for stakeholders (farmers, governments, agri-businesses) on silo design.
- Future scope and areas for further research.

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