Developing a web application

Grain Management System

LAB University of Applied Sciences
Bachelor of Engineering, Industrial Information Technology Engineering
2024
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Abstract

Author(s) Nada Rahali	Publication type Thesis, UAS	Completion year 2024
	Number of pages 39	
Title of the thesis **Developing a web application** Grain Management System		
Degree, Field of Study Bachelor of Engineering, Industrial Information Technology Engineering		
Name, title and organisation of the client Simo Sinkko		

Abstract

This project report outlines the development of a web application for managing the process of grain drying. The application is fundamentally built on a dashboard that in-corporates analysis, performance indicators, and setting management.

Through the integration of web technologies, a functional and engaging platform tailored was achieved to meet the needs of the user effectively. The platform was thoughtfully engineered and developed, with each element created having been minutely discussed.
At the heart of the process was user feedback cycle, serving as a compass in the walk to the most appropriate performance and user experience enhancement.

Every step through the journey reinforced the continuous dedication to superiority. This thesis highlights the realization of the vision, dynamic pursuit of innovation, and the summing up of all the labour in reengineering grain drying management norms.

Keywords

Grain moisture, management system, web application.

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1 Introduction

Despite Finland's challenging climatic conditions, the agricultural sector has adapted accordingly and has become increasingly advanced and innovative. Agriculture in Finland has always been an essential component of the country's economy and plays a vital role in ensuring food security and self-sufficiency. One of the key aspects of modern agriculture in Finland is the development of grain drying systems.

Grain drying systems are crucial for farmers in Finland, where the harvest season is relatively short, and the weather conditions can be unpredictable. These systems allow farmers to dry their grain efficiently, ensuring its quality and storage suitability. With a well-developed grain drying infrastructure, farmers can minimize losses caused by wet weather conditions, thereby maximizing their harvest yield and profitability.

The development of mobile devices and digital technology offers new chances to design complex systems which can contribute to the efficiency enhancement of farmers' grain drying process. This technological advancement aligns with the modernization of agriculture in Finland and reflects the industry's dedication to embracing cutting-edge developments for sustainable and productive farming practices.

The main objective of the thesis is to create a website for a grain drying system that focuses on moisture measurement in the drying process. This development of the sampling system aims to streamline and simplify the process of obtaining moisture content readings, including the generation of graphical representations illustrating optimal moisture levels and other relevant data. Notably, the thesis does not encompass the automation and device aspects of the system, focusing solely on the pivotal component of moisture measurement and analysis during the grain drying process. This novel approach underscores the continual evolution and refinement of grain-drying technologies within the realm of Finnish agriculture.

Another focus of the thesis is to create a prototype of the mobile app, providing a visual representation of how the app will look and function. By creating the prototype, the thesis aims to obtain a tangible and realistic understanding of the mobile app's design and user experience. This prototype will serve as a valuable tool for evaluating and refining the app's functionality, user interface, and overall design. The prototype serves as a vital step in ensuring that the final version of the mobile app meets the needs and expectations of users. Through this iterative process, the thesis seeks to enhance the usability and effectiveness of the mobile app for farmers in managing grain drying processes.

2 Background of grain drying

2.1 Introduction

Drawing from the Information on Agriculture in Finland, the agricultural sector in Finland aims not only to adopt cutting-edge technologies for improving cereal farming efficiency but also to champion climate and environmental enhancement initiatives. In the Finnish agricultural landscape, reliance is primarily placed on grassland and wheat varieties suited to the northern climate. Notably, the predominant energy consumption in the agricultural sector stems from grain drying, cooling, and storage, with heat serving as the primary energy component, underscoring the potential impact of technological advancements and process efficiency enhancements on overall energy consumption.

Referencing the insights from the Information on Agriculture in Finland, Finnish cuisine stands out for its commitment to cleanliness and ecological sustainability, attributed to the nation's geographical positioning, agricultural practices, and manufacturing methods. Notably, organic production accounted for approximately 13% of arable land in 2018, reflecting Finland's dedication to sustainable agricultural practices. Moreover, Finland boasts a vast agricultural expanse of around 2.3 million hectares, with cereal crops occupying over 1 million hectares and grassland covering about 0.7 million hectares.

Citing the Information on Agriculture in Finland, barley and oats emerge as the primary grains cultivated in Finland, closely followed by wheat and rye. With an estimated 47,000 farms in 2018, predominantly family-owned, Finland's agricultural sector is characterized by familial involvement, with farmers and their family members contributing a significant 80% of all agricultural labor.

2.2 Theory of grain drying

Grain drying has been a fundamental aspect of agriculture in Finland for centuries. In the old days, Finnish farmers relied on age-old methods to dry their grains after harvest. One such method was sun drying, where grains were spread out in thin layers and left to dry under the warmth of the sun. Another common practice was stack drying, where grains were piled up with adequate ventilation to allow for natural air circulation.

While these traditional methods served their purpose, they were not without their challenges. Sun drying, for instance, was highly dependent on weather conditions, with rainy or overcast days slowing down the drying process. Stack drying, on the other hand, often results in uneven drying and increases the risk of mold and spoilage, especially in humid climates.

Despite these limitations, Finnish farmers made do with what they had, relying on their ingenuity and resourcefulness to preserve their harvests. The importance of grain drying was underscored by its role in ensuring food security throughout the long, harsh winters that Finland experiences.

However, as agricultural practices evolved and technology advanced, so too did the methods of grain drying. The introduction of mechanical dryers marked a significant turning point in the history of grain drying in Finland. These dryers, powered by electricity or fossil fuels, provided farmers with a more controlled and efficient means of drying their grains. By blowing heated air over the grains, these machines reduced drying time and minimized the risk of spoilage, revolutionizing the way grains were preserved in Finland.

The history of grain drying in Finland is a testament to the ingenuity and resilience of its farmers. From humble beginnings with traditional methods to embracing modern technology, the evolution of grain drying has been instrumental in ensuring the continued success of agriculture in Finland.

2.3 Principles of drying

2.3.1 The meaning of grain drying

Grain drying holds immense significance in agriculture, serving as a crucial step in preserving harvested grains for storage and consumption. By reducing the moisture content of grains to safe levels, drying helps prevent spoilage and maintains their quality over time (Figure 1). This process is particularly vital in regions like Finland, where long winters necessitate careful storage of grains to ensure food security throughout the year. Beyond mere preservation, grain drying also enables farmers to optimize their harvests, allowing for better marketability and increased profitability. Moreover, in today's world, where sustainability and environmental concerns loom large, efficient grain drying practices play a pivotal role in reducing food waste and minimizing the environmental impact of agricultural activities. Thus, grain drying stands as a cornerstone of agricultural practice, bridging the gap between the bounties of the harvest and the nourishment of communities.

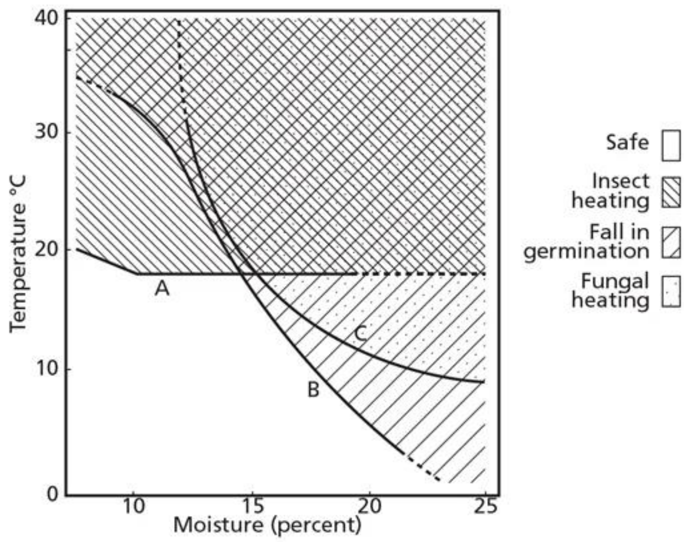

Figure 1. Grain moisture and temperature effects when stored (MecMar Group)

2.3.2 Types of grain dryers

The three major continuous-flow grain drying systems employed in the commercial grain industry are (in order of numbers operating worldwide): (1) crossflow, (2) mixed-flow, and (3) concurrent-flow. They are classified according to the directions the grain and the air move through the dryer (Figure 2). However, it can be argued that no dryer, no matter what dryer type is widely used, is suitable for every large-scale grain drying process.

In the case of a crossflow dryer, the direction of airflow is perpendicular to the grain movement, while it is parallel with the grain movement in the concurrent flow dryer. All parts of the airflow in mixed flow dryer (with current, counter, and crossflow) are considered the direction of grains (crossflow dryer). It is important to realize that these patterns have a significant effect on drying capacity, energy efficiency, grain quality, and grain kernel temperature. Crossflow dryers are most widely used in the United States and Canada, while mixed-flow (rack) dryers are predominant in Europe, Asia, and Latin America. In Argentina, crossflow and mixed-flow dryers share the market approximately half and half. Concurrent-flow dryers are a more recent design and have been used for a few specialty applications in the U.S. (Maier & Bakker-Arkema 2002,16)

In Finland, the most commonly used grain dryer aligns with the prevailing practices in Europe and Asia, where mixed-flow (rack) dryers hold dominance. These dryers are characterized by airflow patterns that include concurrent, counter, and crossflow movements relative to the grain. This flexible design comes with drying capacity, energy efficiency, and grain quality advantages, which makes it a natural fit for the different climate zones and cereal types present in Finland. While crossflow dryers, prevalent in North

America, and concurrent-flow dryers, a newer design primarily used for specialized applications in the U.S., are less common in Finland, mixed-flow dryers have emerged as the preferred choice among Finnish farmers for their reliability and effectiveness.

Generally, silos with high grain drying capacity are found with cooling sections (though grain might be cooled down in bins or silos after high-temperature drying process with the dry ration). The function of the cooler is to reduce the temperature of the dried grain to approximately 3-6ºC below the surrounding temperature. As per the grain-flow rate inside its dryer, grain loses 0. 5-1% of moisture released during the cooling process. The uniformity of the airflow and grain in the cooler area of crossflow and mixed-flow dryers as well as counter-flow concurrent-flow dryers is the same. (Maier & Bakker-Arkema 2002,16)

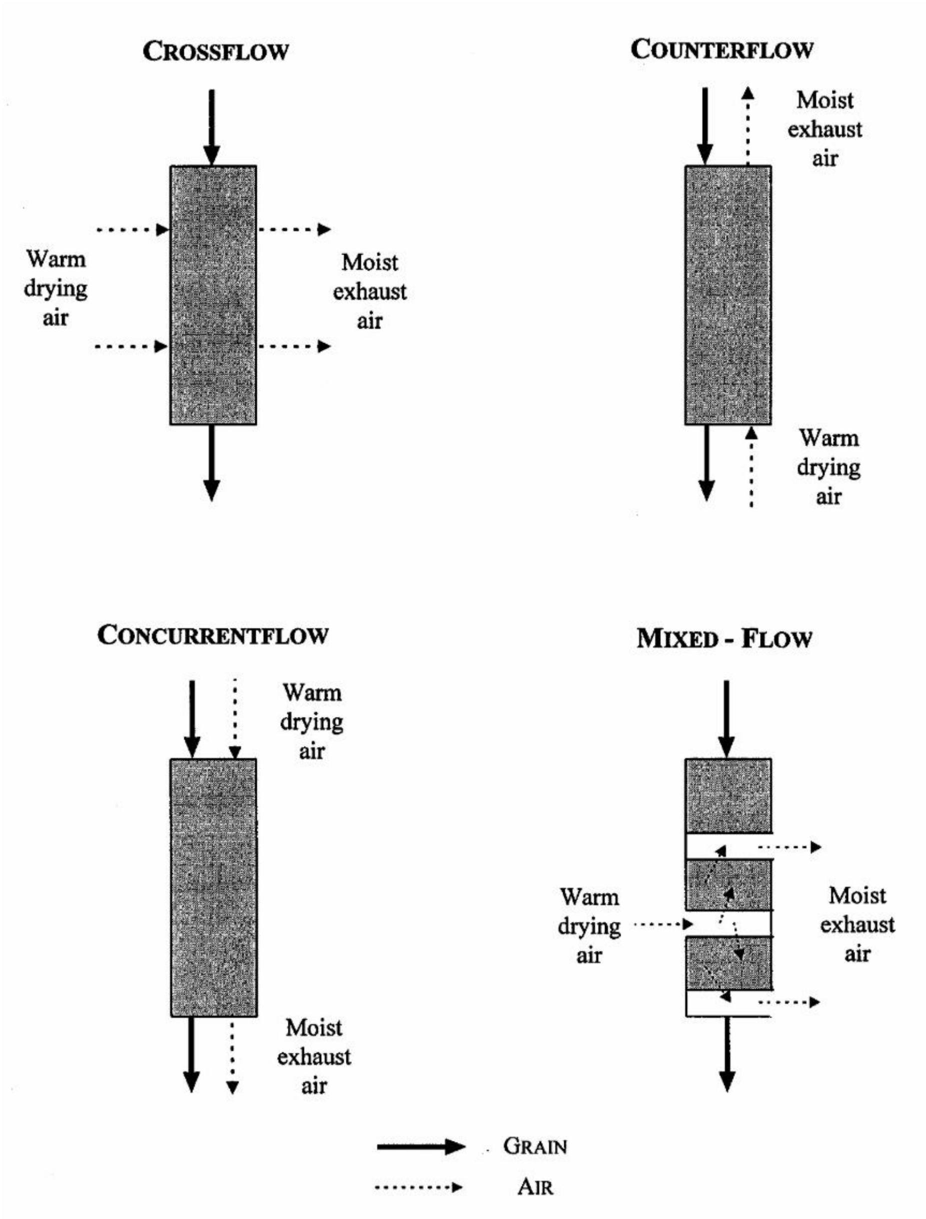

Figure 2. Schemes of the major types of high-temperature grain dryers (Maier & Bakker-Arkema 2002, 43)

2.3.3 Principles of drying

The grain drying process involves the removal of moisture until grains reach a safe moisture content, typically between 12 to 14% for cereal grains. This essential step aims to preserve grain quality during storage by inhibiting the growth of harmful bacteria, fungi, and pests. Moisture reduction also prevents grain spoilage and maintains nutritional integrity. Heat is utilized to facilitate moisture removal, either through natural air or artificial heating, creating a concentration gradient that drives moisture from the grain's interior to its surface (Bala 2017). This concept aligns with the principles of moisture migration described by

Zareiforoush et al., highlighting the importance of understanding moisture movement for effective drying (Zareiforoush 2015, 45-47).

The effectiveness of drying is influenced by several factors, including air temperature, grain moisture content, relative humidity, and grain type and maturity. Maintaining proper airflow and temperature control is crucial to ensure uniform drying and prevent overdrying or underdrying (Raghavan & Ramaswamy 2003). To maintain quality, controlling drying air temperature within recommended limits is imperative. For instance, the safe maximum drying temperature for seed grains and paddy grains is 43°C, while for milling wheat, it's 60°C (Rai & Arora 2003, 112-113).

Excessive high-temperature drying can induce physical and chemical changes in grains, potentially reducing their quantity and quality. This underscores the importance of temperature management in grain storage (Jaya & White 2016, 29). Conversely, products like malt and tea benefit from high-temperature drying to achieve desired characteristics for beverage production (Wilfred 2009, 85).

2.3.4 Importance of drying

Grain drying holds significant importance in agricultural practices for a multitude of reasons. Firstly, it facilitates the long-term storage of grains without compromising their quality. By reducing the moisture content to safe levels, drying prevents spoilage and deterioration, ensuring that farmers can store their harvests for extended periods without concerns about quality loss. This capability is particularly crucial in regions with distinct seasons or unpredictable weather patterns, where the availability of fresh grains may fluctuate throughout the year. Additionally, the ability to store grains enables farmers to strategically time their sales, taking advantage of favourable market conditions and maximizing profits.

Moreover, grain drying enhances the overall quality of the harvested product. By eliminating excess moisture, drying helps preserve the integrity of grains, reducing the risk of mold growth, insect infestations, and other forms of contamination. This results in higher-quality grains that are not only more visually appealing but also safer for consumption. Furthermore, superior-quality grains command higher prices in the market, providing farmers with a competitive edge and increasing their revenue potential. Additionally, by ensuring a consistent supply of high-quality grains, drying cultivates consumer trust and loyalty, strengthening relationships between farmers and buyers.

In addition to quality preservation and market advantage, grain drying also contributes to operational efficiency and productivity on the farm. Early drying enables farmers to expedite the harvest process, reducing the risk of field damage and losses associated with adverse weather conditions. This allows for smoother and more efficient harvesting operations, minimizing downtime and maximizing yield potential. Furthermore, efficient grain drying practices optimize resource utilization, enabling farmers to make the most of their available land and labor. By strategically planning drying schedules and workflows, farmers can streamline operations, reduce waste, and improve overall farm productivity.

2.3.5 Influence of drying conditions

The effectiveness of grain drying is heavily influenced by various drying conditions, including airflow rate, air temperature, and relative humidity. Generally, higher airflow rates, elevated air temperatures, and lower relative humilities contribute to faster drying speeds (Figure 3). Increasing the temperature of the drying air enhances its moisture-carrying capacity while simultaneously reducing relative humidity. A simple guideline suggests that every -6.67 degrees Celsius increase in air temperature doubles its moisture-holding capacity and halves the relative humidity.

Furthermore, the rate of drying is contingent upon the disparity in moisture content between the drying air and the grain kernel. Moisture moves swiftly from high-moisture grain to low-relative-humidity air, facilitating rapid drying. However, when dealing with wet grain and moist air, moisture movement may be minimal or absent. Interestingly, at high relative humidifies, dry grain may even absorb moisture from the surrounding air.

Moreover, airflow rate plays a crucial role in drying speed. Higher airflow rates carry moisture away from the grain, resulting in accelerated drying rates. However, airflow is influenced by factors such as fan design, fan speed, fan motor size, and grain resistance. Deeper grain depths and increased airflow rates create higher static pressures against the fan, consequently reducing fan output.

As air penetrates the grain, it absorbs some moisture, causing a slight cooling effect as shown in Figure 3. This leads to a gradual decrease in air temperature and an increase in relative humidity as the air traverses through a deep grain mass, eventually nearing equilibrium with the grain. In scenarios where air reaches equilibrium with the grain, further drying ceases. Conversely, if high relative humidity air encounters dry grain, some moisture is extracted from the air and absorbed by the grain. This slightly dried air will subsequently absorb moisture upon encountering wetter grain.

In practice, air in a grain column of 30.48 to 40.64 centimeters typically does not reach equilibrium with the grain, allowing for continuous drying processes to occur. These intricate interplays between airflow, temperature, and relative humidity underscore the complexity of grain drying processes and emphasize the importance of optimizing drying conditions for efficient moisture removal.

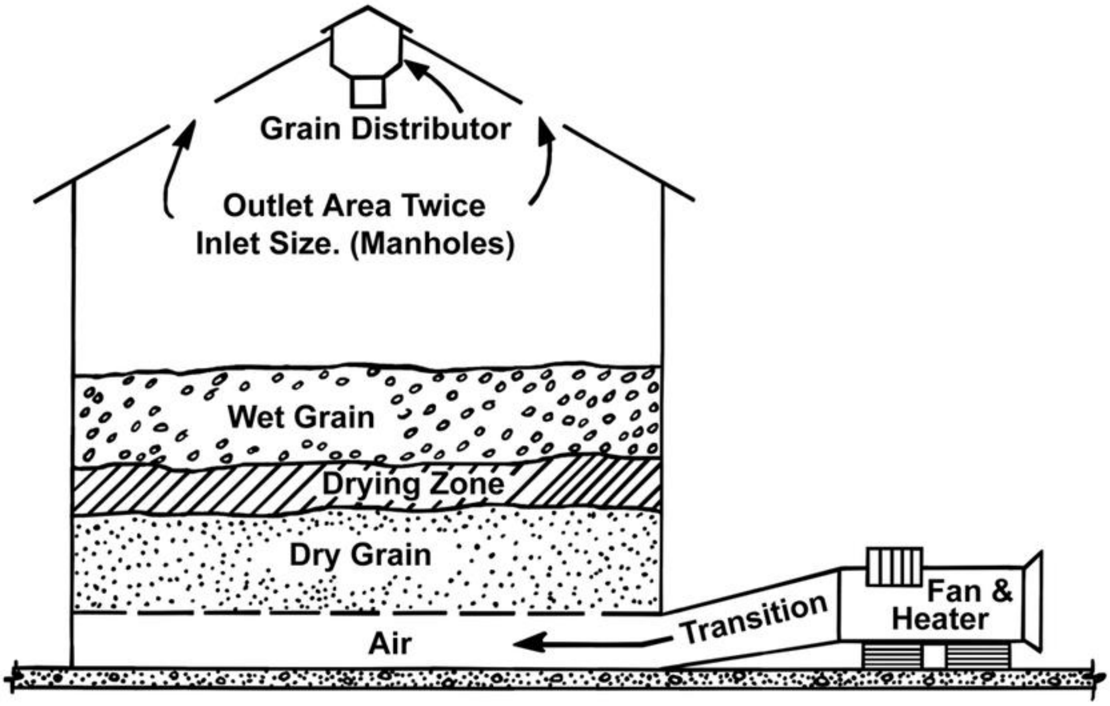

Figure 3. Grain Drying Dynamics for Movement of Drying Front with Airflow (Sumner & Williams 2009, 4)

3 Design and Fabrication of a Grain Sampling Device for Moisture Measurement

3.1 Overview

The grain dryer nestled within the heart of Lappeenranta, Finland's agricultural landscape stands as an emblem of the region's dedication to efficient farming practices. As the primary cultivation hub for wheat, alongside occasional forays into barley, oats, and caraway, this farm relies on the seamless operation of its grain drying infrastructure to ensure the preservation and quality of its yields. Located within a protective enclosure, the grain dryer enjoys a degree of insulation against the capricious Finnish weather, shielding it from the relentless rains and fluctuating humidity levels that characterize the region's climate. However, this sanctuary comes with its own set of challenges, chief among them being the pervasive presence of dust particles within the drying environment. While the protective structure offers respite from the elements, it also serves as a magnet for dust accumulation, posing a significant obstacle to the efficient operation of the grain drying process.

Figure 4. Farmpro grain analyzer

Central to the efficacy of the grain drying operation is the accuracy of its moisture measurement system, a critical determinant of grain quality and subsequent market value. Despite efforts to enhance precision through the integration of a Farmpro moisture analyzer, the system's manual operation introduces a host of inefficiencies and limitations (Figure 4). Human intervention becomes a requisite for each measurement iteration, disrupting the flow of the drying process and introducing potential sources of error. Moreover, the need for manual intervention restricts the frequency and granularity of moisture measurements, leaving gaps in the data crucial for optimizing drying parameters. Recognizing the imperative for a more streamlined and automated approach, a proactive response has emerged in the form of a mechanical sampling device, conceived through the collaborative efforts of a group of enterprising students. This device represents a paradigm shift in moisture measurement methodology, promising to transcend the limitations of manual operation through the integration of advanced mechanical functionalities.

At its core, the mechanical sampling device seeks to revolutionize the moisture measurement process by imbuing it with a suite of automated functionalities, each designed to address specific pain points inherent in the current manual system. Among its primary functions are dosage, crushing, and measurement, each serving as a cog in the intricate machinery of grain moisture analysis. The dosage function aims to streamline the collection of grain samples, ensuring consistency and accuracy in measurement iterations. By standardizing sample collection procedures, the device minimizes variability and error, thereby enhancing the reliability of moisture measurements. Complementing this function is the crushing mechanism, which pulverizes collected grain samples between two surfaces, facilitating the extraction of moisture content data. This process of comminution serves to homogenize grain samples, ensuring uniformity in moisture distribution and enabling more precise measurement outcomes. Finally, the measurement function serves as the linchpin of the device, orchestrating the acquisition and analysis of moisture content data with precision and efficiency. Through the seamless integration of these mechanical functionalities, the sampling device heralds a new era of automation and optimization in grain moisture analysis, promising to revolutionize the way farmers approach the drying process.

The introduction of the mechanical sampling device marks a significant advancement in the realm of grain drying technology, offering a solution to the challenges posed by manual moisture measurement processes. By automating key functions such as dosage, crushing, and measurement, the device streamlines the grain moisture analysis process, enhancing accuracy and efficiency. This innovation not only addresses the limitations of manual operation but also paves the way for improved grain quality and market competitiveness. The collaborative efforts of the students behind the development of this device exemplify the spirit of innovation and problem-solving that drives progress in agricultural practices. As farmers embrace this new technology, they stand to benefit from increased productivity, reduced errors, and enhanced crop quality, ultimately leading to a more sustainable and profitable farming industry in Lappeenranta and beyond.

3.2 Mechanical design and its functions

Based on the thesis writer’s (Sennikova 2024, 28) meticulous research and analysis, the proposed automatic grain moisture measurement system showcases a sophisticated mechanical design that intricately weaves together a multitude of components and functionalities, each meticulously crafted to serve specific roles within the broader framework of grain analysis. At the core of this design philosophy lie four fundamental functions: dosage, crushing, measurement, and cleaning, each representing a critical element in the intricate machinery of grain moisture analysis (Figure 5).

The dosage function, as elucidated by Sennikova 2024, 29), stands as the initial step in the measurement process, tasked with the precise collection of grain samples for subsequent analysis. This function is brought to life through the integration of a sophisticated sampling mechanism, meticulously engineered to extract a predetermined quantity of grain from the bulk supply with unparalleled accuracy. The dosage mechanism must delicately balance efficiency and precision, ensuring that each sample collected is a true representation of the overall grain composition while minimizing wastage and variability. To achieve this delicate balance, the design may incorporate cutting-edge sensing technologies such as load cells or optical sensors, enabling real-time monitoring and adjustment of sample collection parameters to accommodate fluctuations in grain density and moisture content.

In perfect harmony with the dosage function is the crushing mechanism, a pivotal component responsible for preparing collected grain samples for moisture analysis. This crucial function, as highlighted by (Sennikova 2024, 29-30), involves the meticulous pulverization of grain kernels between two surfaces, effectively homogenizing the sample and facilitating the extraction of moisture content data. The design of the crushing mechanism must consider various factors such as particle size distribution, grinding efficiency, and sample integrity to ensure optimal measurement outcomes. Depending on the specific requirements of the application, the crushing mechanism may employ a variety of techniques such as impact, compression, or attrition to achieve the desired degree of comminution while minimizing energy consumption and wear.

Following the dosing and crushing stages, the grain sample proceeds to the measurement function, where its moisture content is quantified with precision and accuracy. This pivotal step, as outlined by (Sennikova 2024, 30-31) is made possible through a sophisticated array of sensors and analytical instruments capable of discerning subtle variations in grain properties indicative of moisture levels. Common measurement techniques include capacitance, impedance, and infrared spectroscopy, each offering distinct advantages in terms of sensitivity, speed, and cost-effectiveness. The design of the measurement subsystem must ensure reliable operation under diverse environmental conditions, mitigating sources of interference such as temperature fluctuations, electromagnetic noise, and mechanical vibrations to uphold measurement integrity.

Lastly, the cleaning function, as detailed by (Sennikova 2024, 31), represents the culmination of the measurement process, ensuring the efficient removal of crushed grain residues from the sampling chamber to prepare for subsequent measurement cycles. This function plays a pivotal role in preventing cross-contamination between samples and upholding the long-term reliability of the system. The design of the cleaning mechanism may incorporate advanced features such as pneumatic suction, mechanical agitation, or automated flushing to dislodge and evacuate residual particles effectively. Additionally, considerations such as material compatibility, ease of maintenance, and energy efficiency must be meticulously addressed to optimize the performance and longevity of the cleaning subsystem.

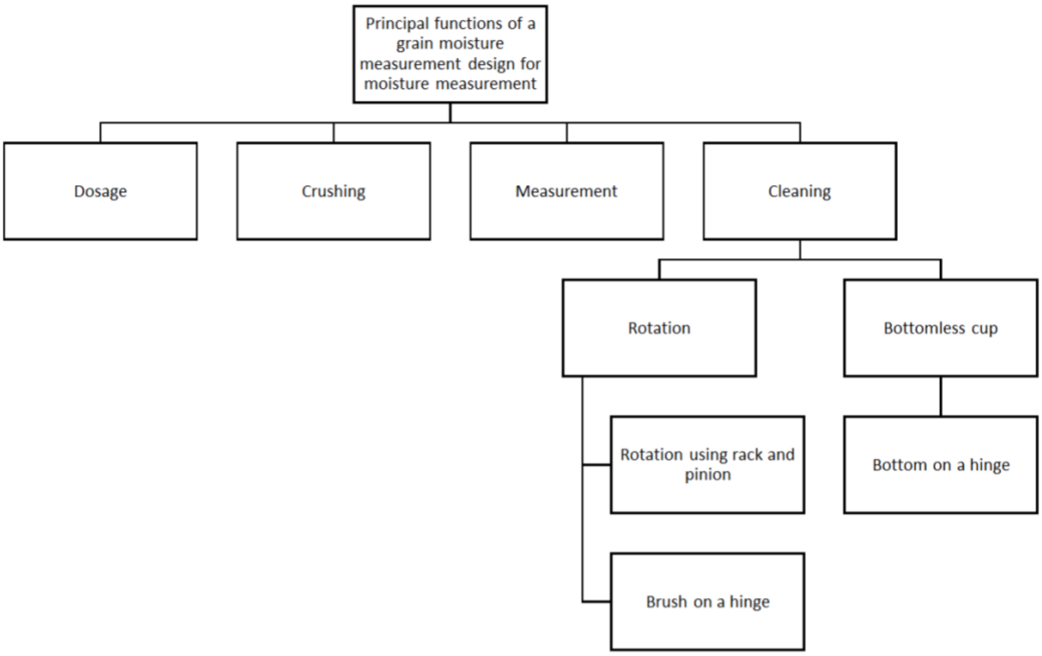

Figure 5. Functions of grain moisture measurement design (Sennikova 2024, 30)

In essence, based on the insightful contributions of the thesis writer (Sennikova 2024, 56-57) the mechanical design of the automatic grain moisture measurement system embodies a harmonious fusion of precision engineering, state-of-the-art sensing technologies, and innovative design principles. By seamlessly integrating dosage, crushing, measurement, and cleaning functionalities, the system holds the promise of revolutionizing grain analysis in agricultural settings, offering farmers unparalleled insights into grain quality and empowering data-driven decision-making for optimal crop management.

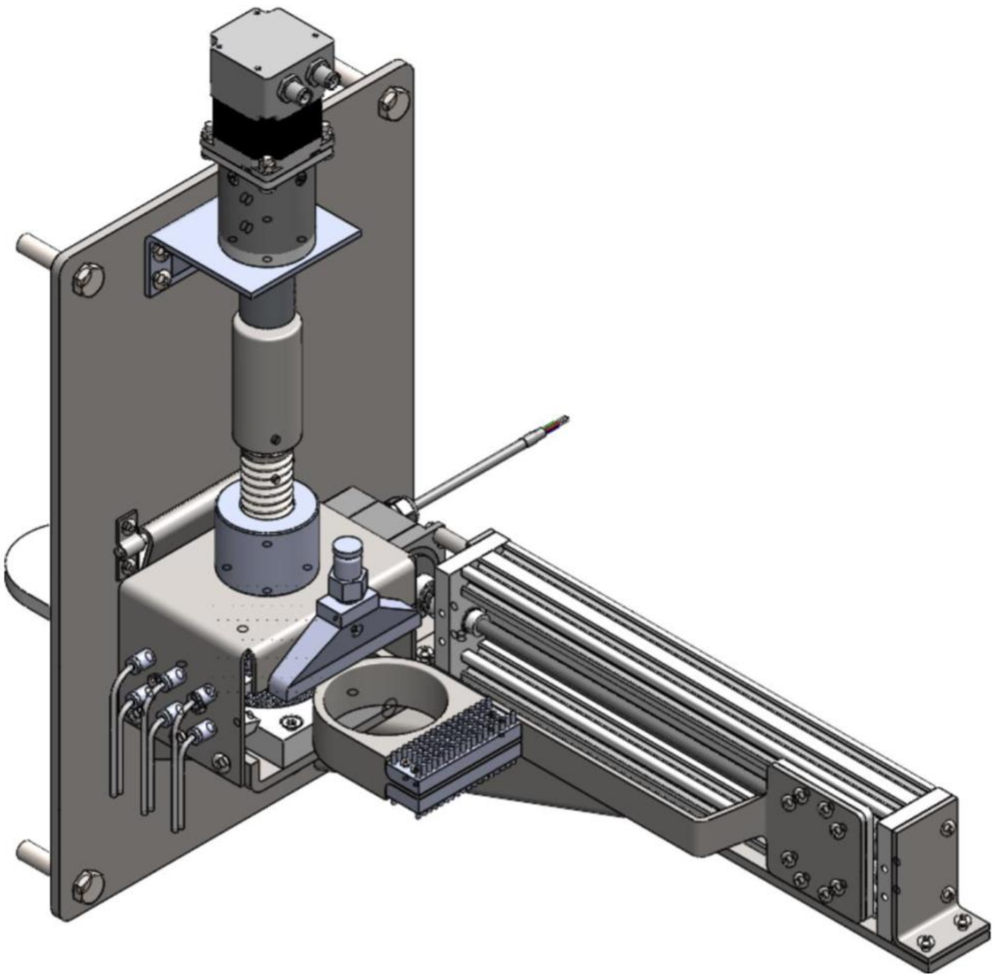

Figure 6. 3D assembly of grain moisture measurement design (Sennikova 2024, 57)

4 Technologies Overview

4.1 WEB development

In developing the web application, a range of web development technologies were utilized to create a smooth and efficient user experience (Figure 7). HTML was employed for structuring the content of the pages, ensuring that everything was organized and easy to navigate. CSS helped style the web pages, making them visually appealing and consistent across different devices and screen sizes. JavaScript and Python were crucial for adding interactivity to the application, allowing users to perform actions like starting and stopping patch processes with just a click. Libraries like Boxicons were incorporated to enhance the visual elements of the interface, giving it a modern and polished look. Overall, by leveraging these web development technologies, a user-friendly and functional web application that meets the needs of the users effectively was created.

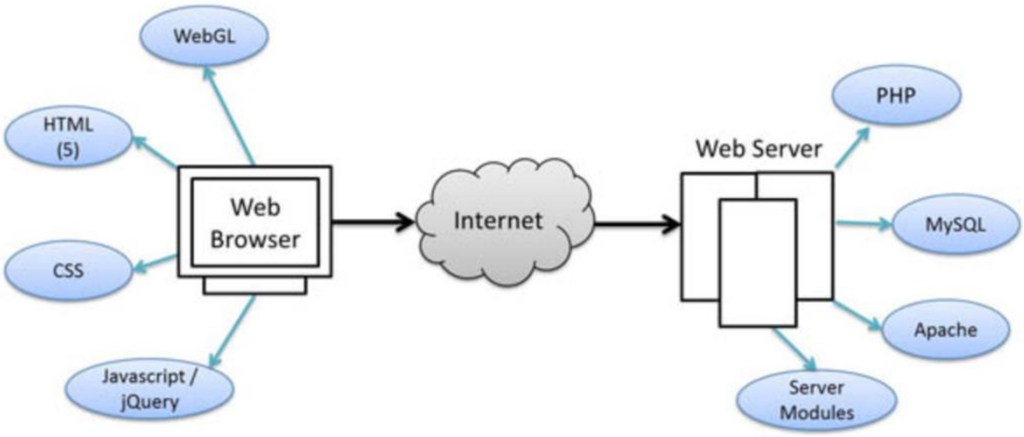

Figure 7. WEB Technology Structure (Scorchsoft)

4.2 Firebase

Firebase stands as a cornerstone platform for both mobile and web application development, providing developers with a comprehensive suite of backend services to bolster their projects. By offering a robust arsenal of tools and services, Firebase allows developers to channel their efforts into crafting innovative applications, free from the complexities of infrastructure management and backend operations. From authentication and real-time database functionality to cloud messaging, storage, and hosting, Firebase covers a broad spectrum of development needs (Figure 8).

The appeal of Firebase lies in its intuitive interface, scalability, and versatility, making it a preferred choice among developers navigating the ever-evolving landscape of application development. With Firebase, developers can accelerate the development and deployment process, unencumbered by concerns surrounding server maintenance, scalability challenges, or availability issues.

Beyond its backend services, Firebase distinguishes itself by providing client-side libraries tailored for popular platforms like Android, iOS, and the web. This seamless integration streamlines the incorporation of Firebase services into applications, facilitating the development of cross-platform solutions with seamless ease.

In the realm of web application development, Firebase plays a pivotal role in streamlining processes and enriching user experiences. By seamlessly integrating backend services, Firebase simplifies tasks such as user authentication, real-time data synchronization, cloud messaging, and data storage for web applications. This integration alleviates the need for developers to grapple with complex backend infrastructure, enabling them to focus on crafting engaging and dynamic web experiences. Additionally, Firebase's robust support for web platforms ensures developers can leverage its functionalities across diverse devices and browsers, facilitating the creation of responsive and scalable web applications effortlessly. With its adaptability and versatility, Firebase emerges as an indispensable asset in the realm of web development, empowering developers to deliver innovative and feature-rich web experiences efficiently.

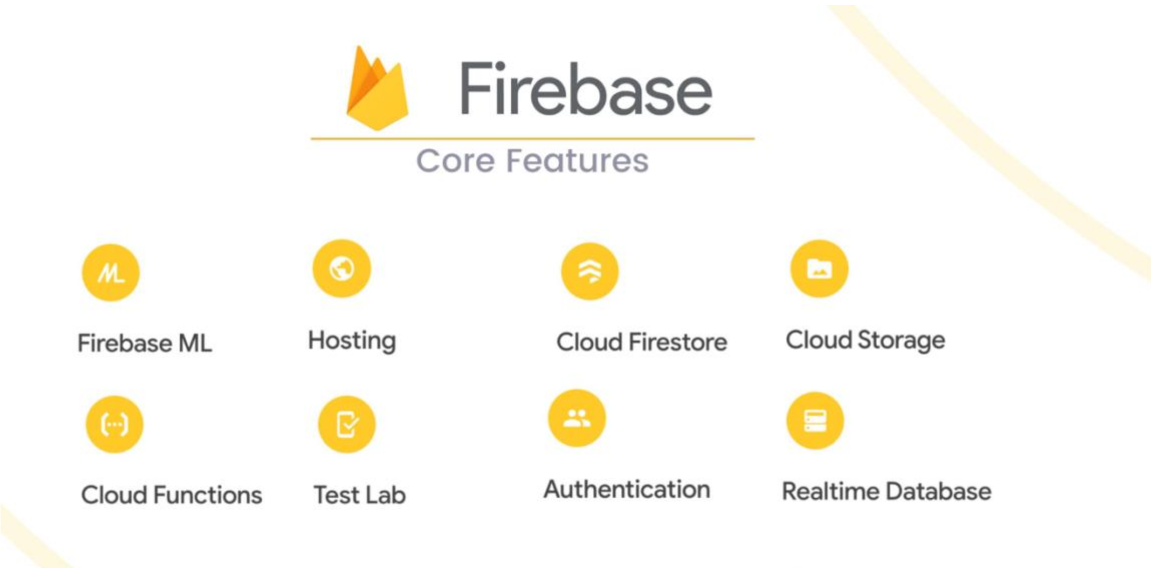

Figure 8. Firebase core features (Firebase)

5 Development Environment

5.1 Comprehensive Overview

Firebase is a dynamic and comprehensive platform designed to fulfill the different demands of developers working on mobile and online applications. Firebase's primary offering is a diverse set of backend services that have been rigorously designed to expedite development operations and improve application functionality. These include a variety of vital features such as authentication procedures, real-time database capabilities, cloud messaging functionality, secure storage solutions, dynamic hosting possibilities, and more. Firebase's comprehensive array of services allows developers to focus their efforts on creating engaging user experiences and creative features rather than dealing with the complexities of managing backend infrastructure.

One of Firebase's most enticing features is its simple and user-friendly interface, which allows for easy navigation and accessibility for developers of all skill levels. This accessibility extends to Firebase's scalability, which enables apps to easily accommodate growing user bases and increased demand without sacrificing speed or dependability. Furthermore, Firebase's versatility is demonstrated by its extensive support for a wide range of platforms, including major ecosystems such as Android, iOS, and web development. This cross-platform portability guarantees that developers may use Firebase's capabilities for a wide range of projects and contexts, increasing its popularity and accessibility throughout the development community.

Moreover, Firebase sets itself apart with its focus on developer efficiency and productivity. As demonstrated in figure 9, Firebase reduces development overhead and speeds up time-to-market by making its services easier to integrate into applications through the provision of client-side libraries and software development kits (SDKs) that are optimized for particular platforms. This tactical approach facilitates innovation and collaboration among developers, allowing them to easily iterate and improve their applications while also streamlining the development process.

Within the field of web development, Firebase is essential for optimizing workflows and improving user experiences. Firebase streamlines processes like cloud messaging, real-time data synchronization, user authentication, and data storage for online applications by seamlessly integrating backend services. Because of this connection, developers can now concentrate on building dynamic and interesting online experiences rather than worrying about maintaining complicated backend infrastructure. Furthermore, Firebase's extensive web platform support guarantees that developers can make use of its features on many devices and browsers, making it simple to create responsive and scalable online apps.

Essentially, Firebase is a pillar of the contemporary development environment, giving programmers a flexible and strong toolbox to execute their innovative ideas. Firebase is a top option for developers looking to create feature-rich, scalable apps that appeal to users on a variety of platforms because of its extensive suite of backend services, user-friendly interface, scalability, flexibility, and close relationship with web development. Developers may start their development adventure with Firebase knowing they have the resources and assistance necessary to realize their ideas and have a significant effect on the digital world.

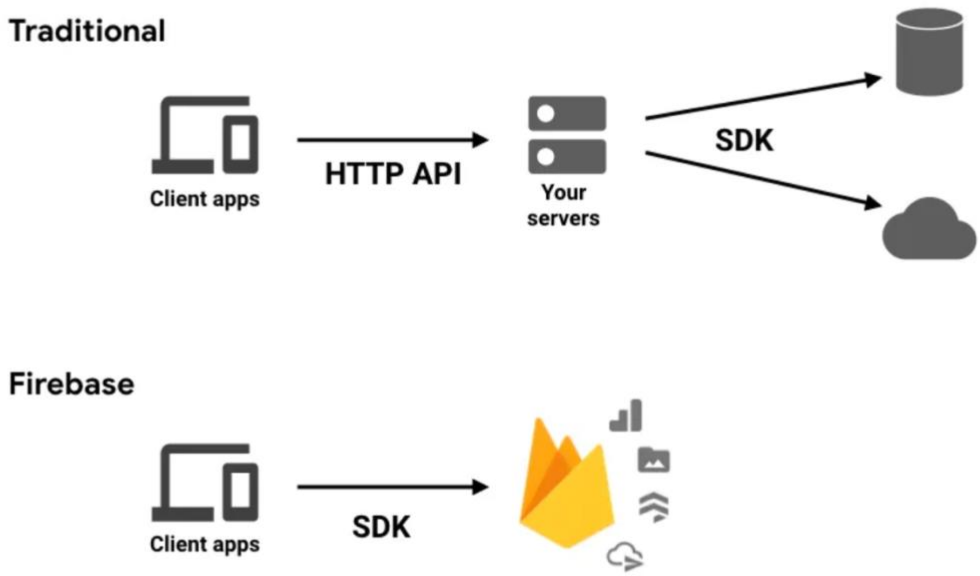

Figure 9. Firebase hierarchy (Firebase)

5.2 Connecting the Firebase to the project

In integrating Firebase with the project, a series of steps were followed to seamlessly connect the application to the Firebase platform.

Firstly, the integration process was initiated by navigating to firebase.google.com through a web browser and clicking on 'Add a project', as depicted in Figure 10.

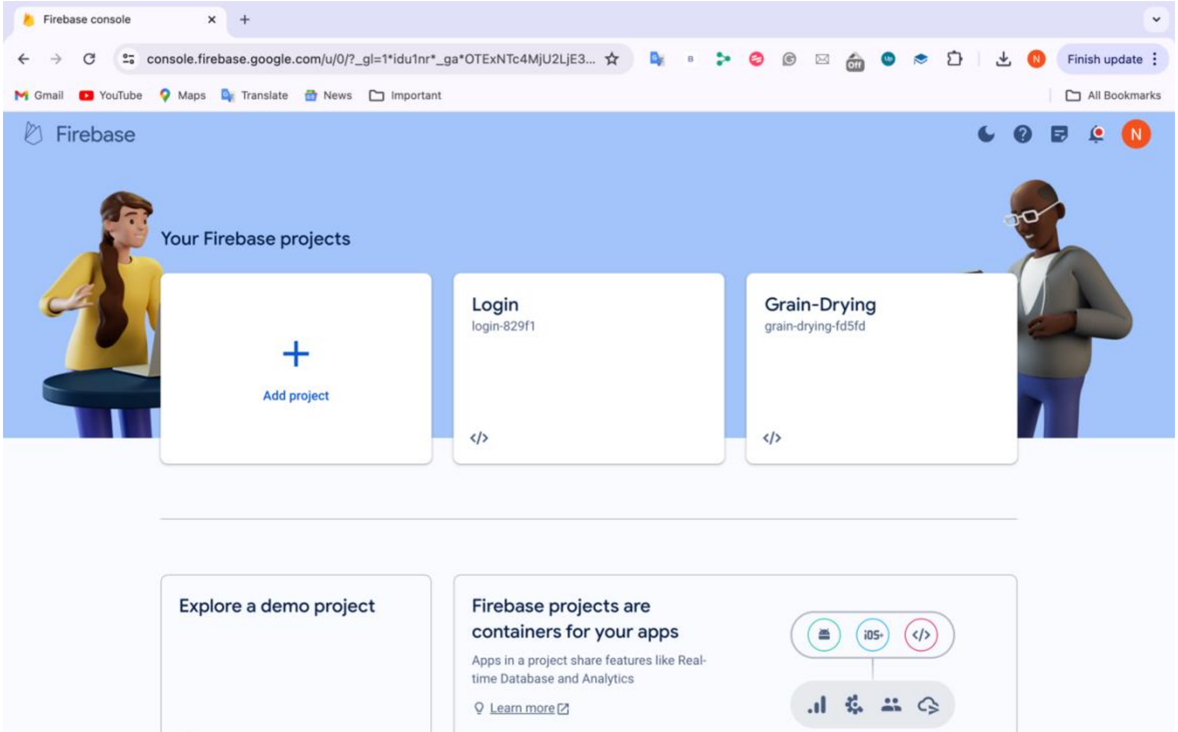

Figure 10. Firebase projects

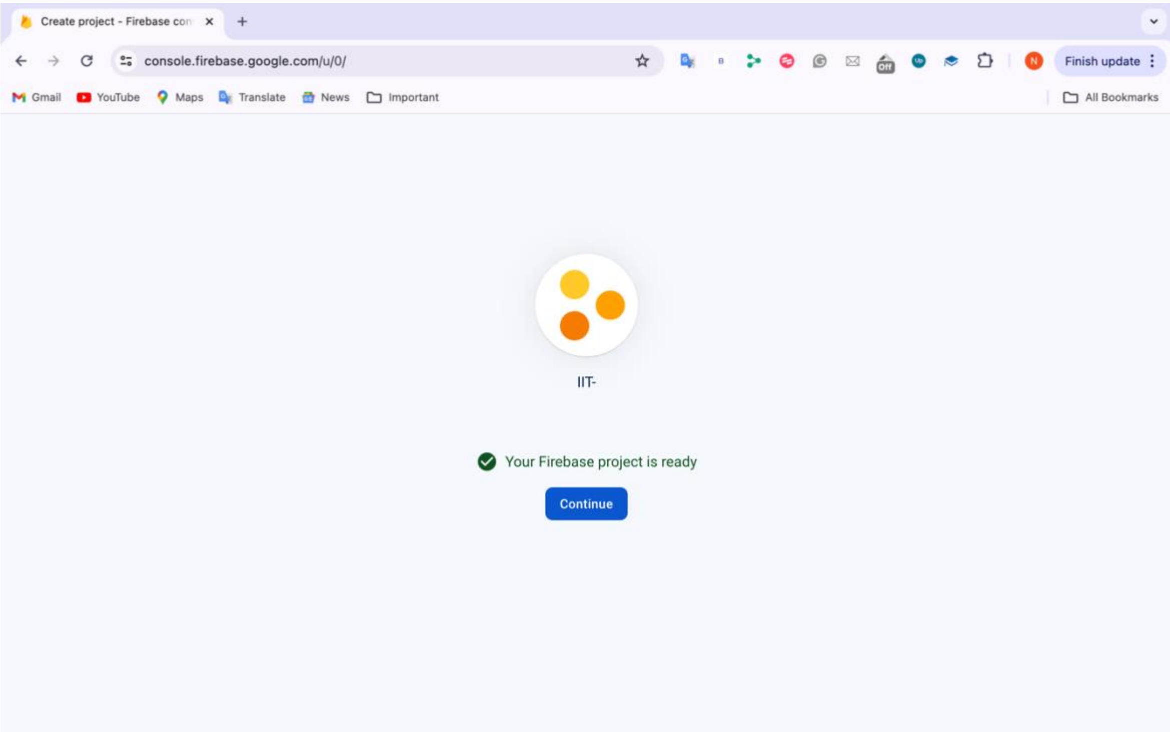

Figure 11. The Firebase project is ready

Subsequently, the ‘Web’ was specified as the target platform for the application, a pivotal choice illustrated in Figure 12.

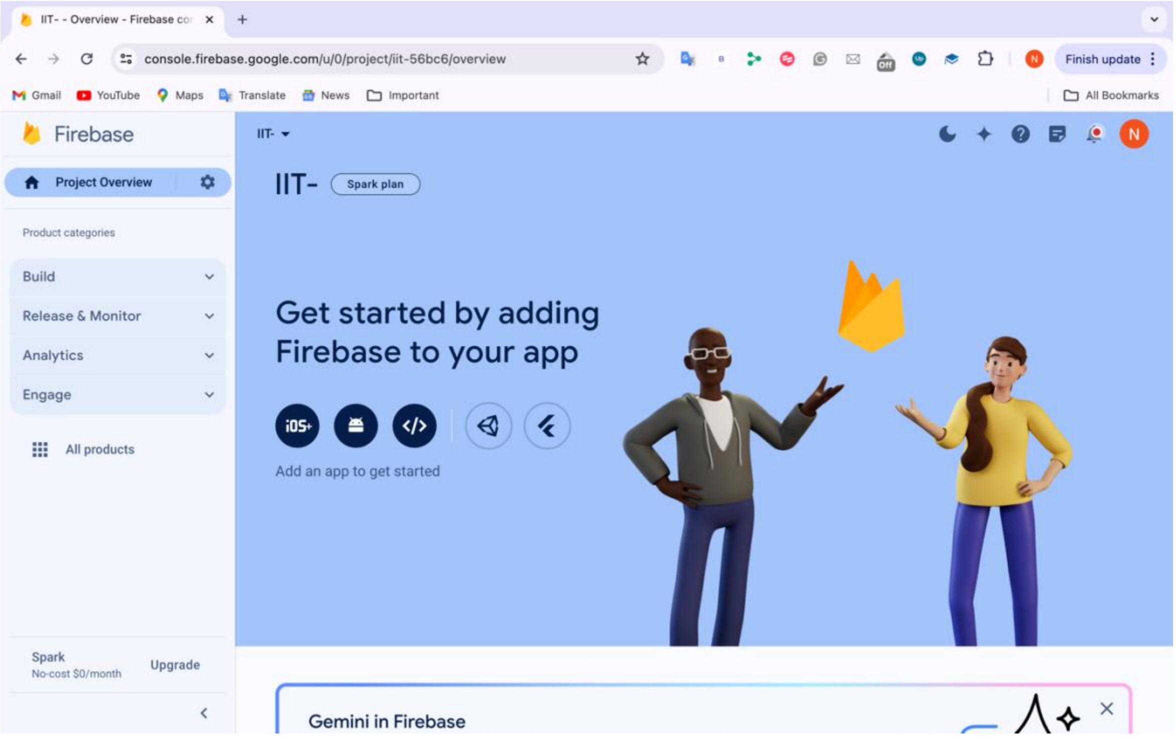

Figure 12. WEB selection

Continuing forward, Figure 14 depicts the application ID retrieval, a vital element that was then carefully copied and pasted into the 'Package name' field of the WEB environment, as shown below.

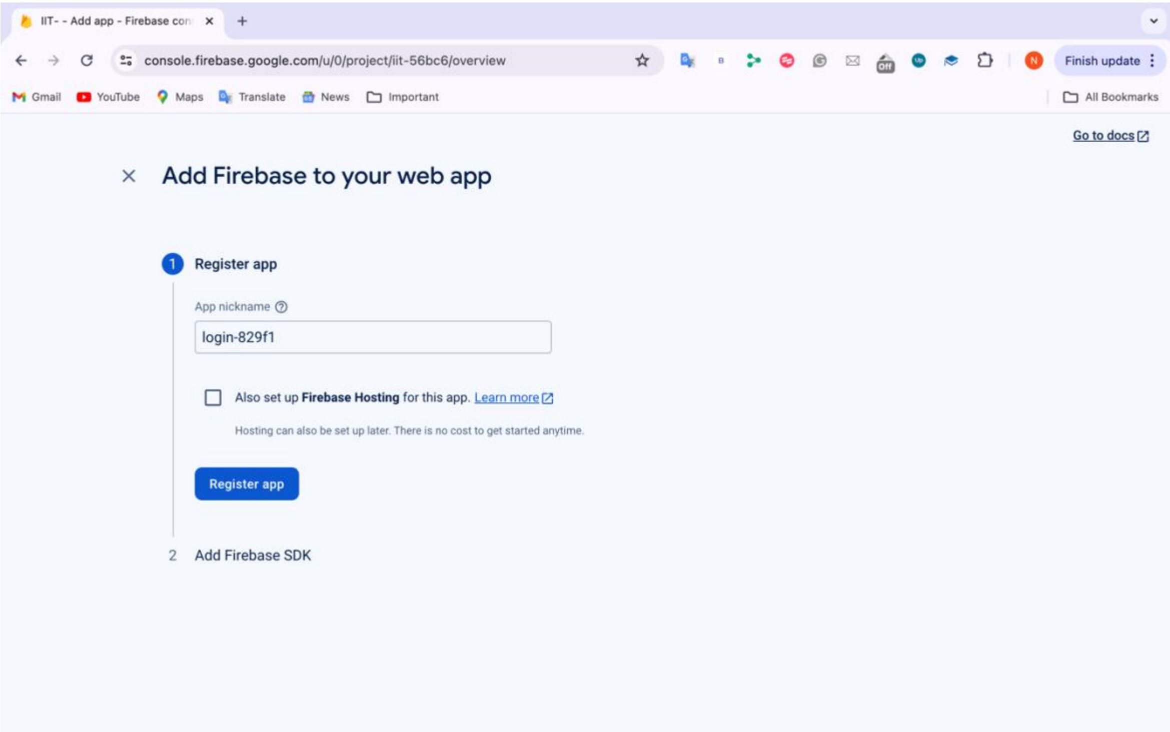

Figure 13. Firebase Package name

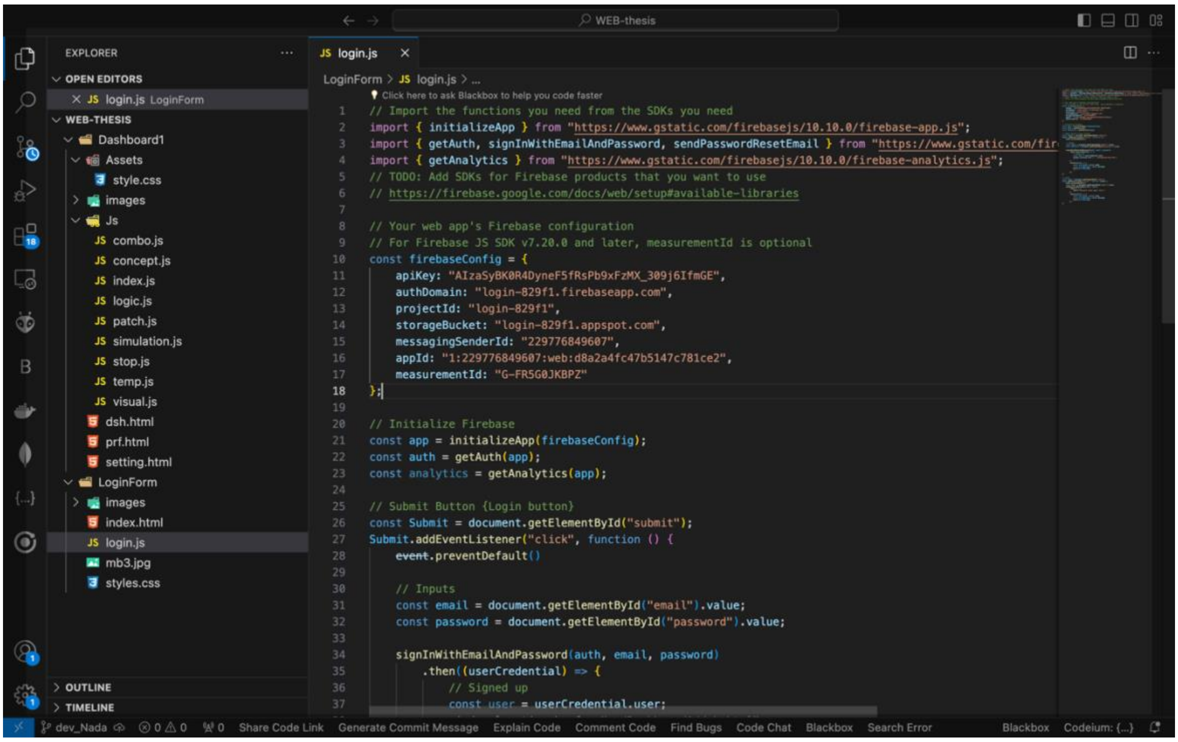

Figure 14. Application ID

Lastly, in Figure 15, the web setup that the integration used was thoroughly added.

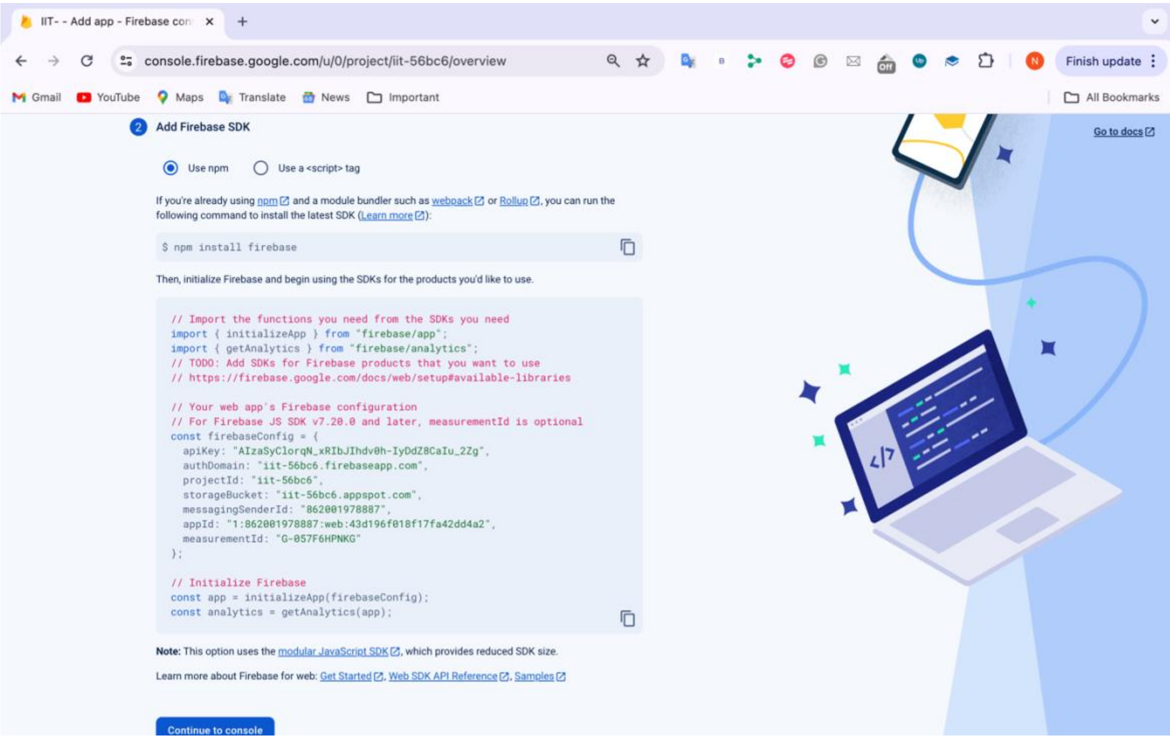

Figure 15. Firebase SDK

6 The application

6.1 Modelisation of the application

The modelisation of the application is centered on establishing an efficient and straightforward approach to enabling users to manage the process of grain drying. The application is fundamentally built on a dashboard that incorporates analysis, performance indicators, and setting management. These aspects are in a model initialized through a clear interface to enable the user to see and summaries the pillars with ease. The dashboard will manage the dryer aspects such as the inlet temperature, the air temperature, and the moisture content, thereby the user can have valuable information and decide in real-time. The start and stop patch permits the user to differentiate between the start and the termination of a drying process. The type of grain, the kilograms, and the date details aid the user track the patch successfully. The drying process is defined through dynamic simulation in which the application indicates the grains' loss of moisture over the stages. Additionally, the In-Storage section dynamically updates grain quantities based on user inputs and process completions, ensuring accurate inventory management.

6.2 Login page

A login page is displayed upon launching the application for the first time, as shown in Figure 16.

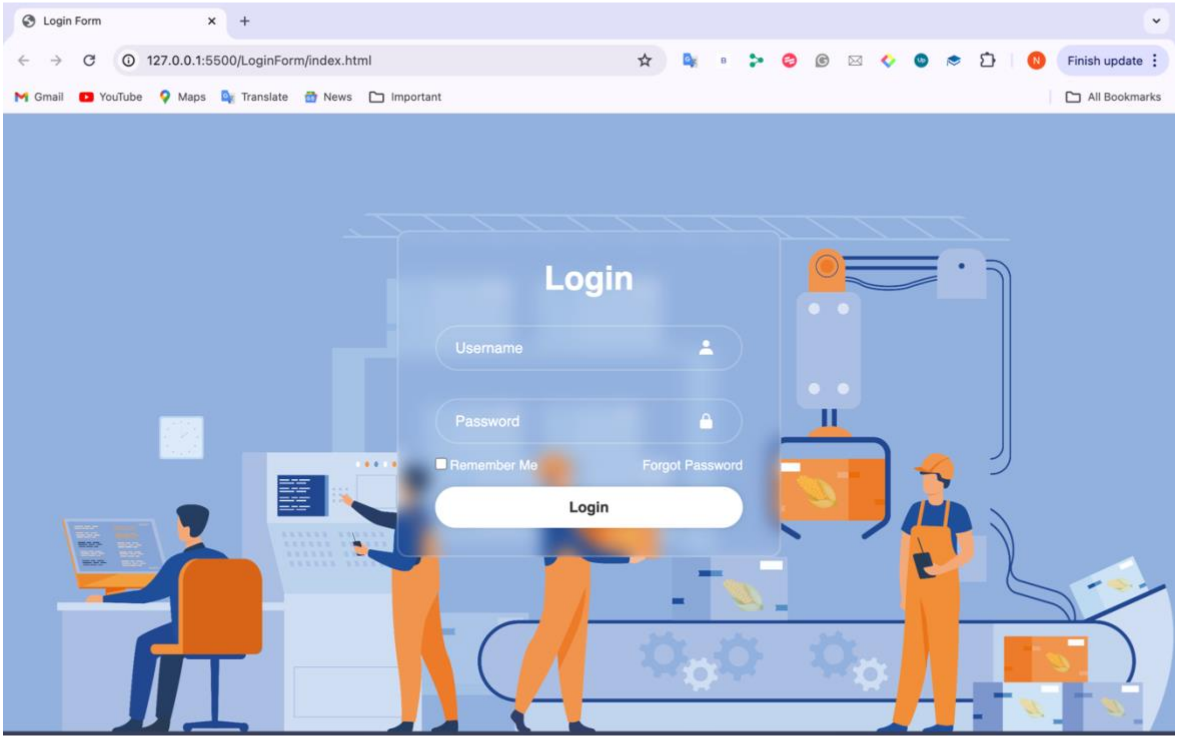

Figure 16. Login Page

In Firebase, the authentication function is implemented through the FirebaseAuth class. The class provides a set of methods that enable developers to handle user authentication such as createUserWithEmailAndPassword(), signInWithEmailAndPassword(), and signOut(). Once a user is authenticated, Firebase generates a token that can be used to validate the user's identity and access Firebase services such as Realtime Database or Cloud Firestore.

As shown in Figure 17, the signInWithEmailAndPassword () was used in this case.

```
const firebaseConfig = {
    apiKey: "AIzaSyBK0R4DyneF5fRsPb9xFzMX_309j6IfmGE",
    authDomain: "login-829f1.firebaseapp.com",
    projectId: "login-829f1",
    storageBucket: "login-829f1.appspot.com",
    messagingSenderId: "229776849607",
    appId: "1:229776849607:web:d8a2a4fc47b5147c781ce2",
    measurementId: "G-FR5G0JKBPZ"
};

// Initialize Firebase
const app = initializeApp(firebaseConfig);
const auth = getAuth(app);
const analytics = getAnalytics(app);

// Submit Button {Login button}
const Submit = document.getElementById("submit");
Submit.addEventListener("click", function () {
    event.preventDefault()

    // Inputs
    const email = document.getElementById("email").value;
    const password = document.getElementById("password").value;

    signInWithEmailAndPassword(auth, email, password)
        .then((userCredential) => {
            // Signed up
            const user = userCredential.user;
            window.location.href = "../Dashboard1/dsh.html";
            // ...
        })
        .catch((error) => {
            const errorCode = error.code;
            const errorMessage = error.message;
            alert(errorMessage)
            // ..
        });
})
```

Figure 17. Firebase code

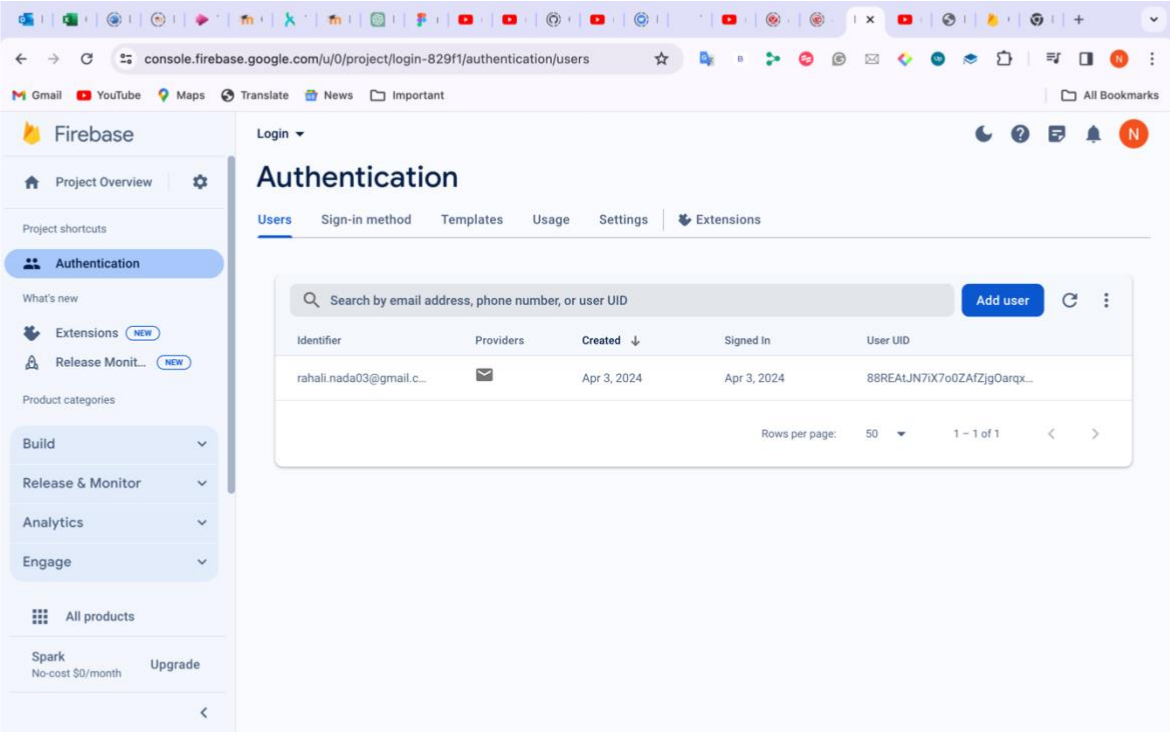

Figure 18. Firebase authentication

6.3 User Interface

Upon logging in, the system checks the user's role to determine if they are eligible. Based on this role, the user is directed to the appropriate page – the dashboard page.

The screen for several dashboards is displayed in the figures below.

The dashboard is the interface that shows crucial information about the drying process that is going on now. The user will be able to easily check the main indicators like the dryer inlet temperature, air temperature, and the level of moisture. Besides that, it encourages the creation of new drying patches, thus, the user can determine the important parameters which are the type of grain, the number of grains, and the measuring interval. The latest drying patches have been exquisitely presented, showing their evaluation date, final moisture level, and number of patches. Moreover, the dashboard delivers a quick scan of the grains presently kept, therefore, information is given about the kind and number of grains in the storage.

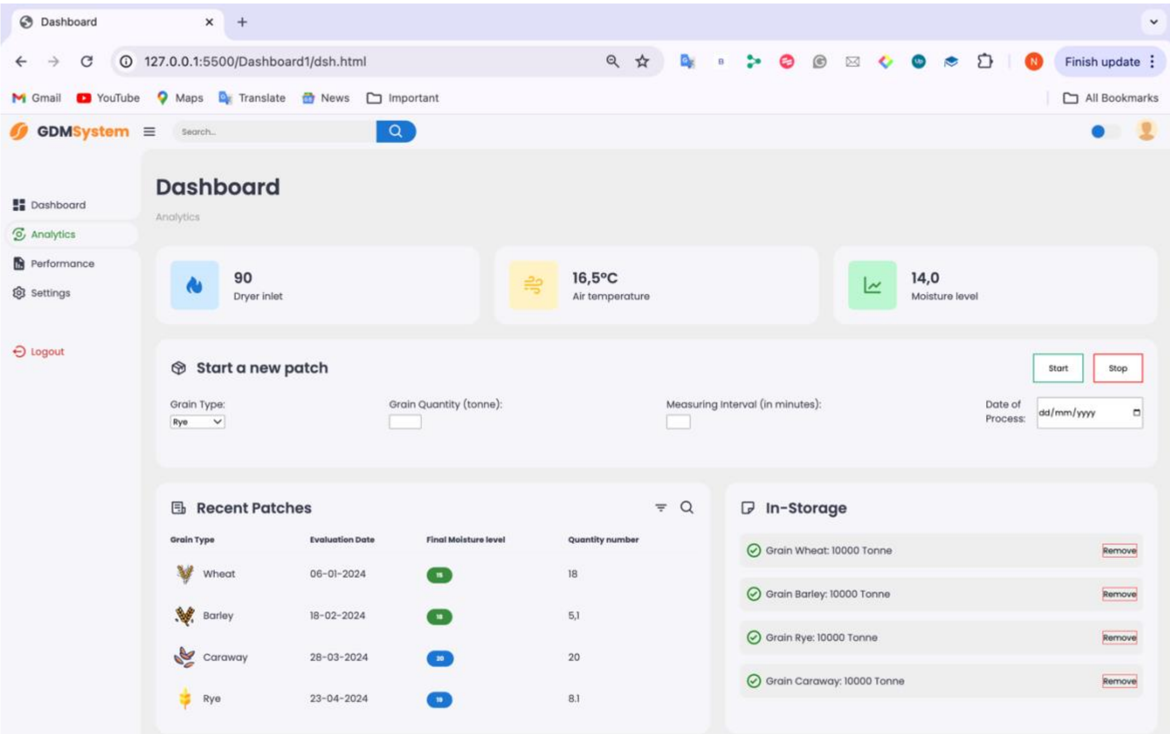

Figure 19. Main Dashboard

The performance page gives an in-depth description of the operational efficiency and status of the drying system. The main indicators such as the dryer inlet temperature, air temperature, and moisture level are shown prominently for easy monitoring. Besides, the page has interactive charts that display important data such as temperature trends, moisture levels, and readiness of drying patches. Through the use of intuitive visualizations and informative graphs, users can obtain valuable insights into the performance of the drying process, which in turn will help the users to make the right decision and effectively manage the resources.

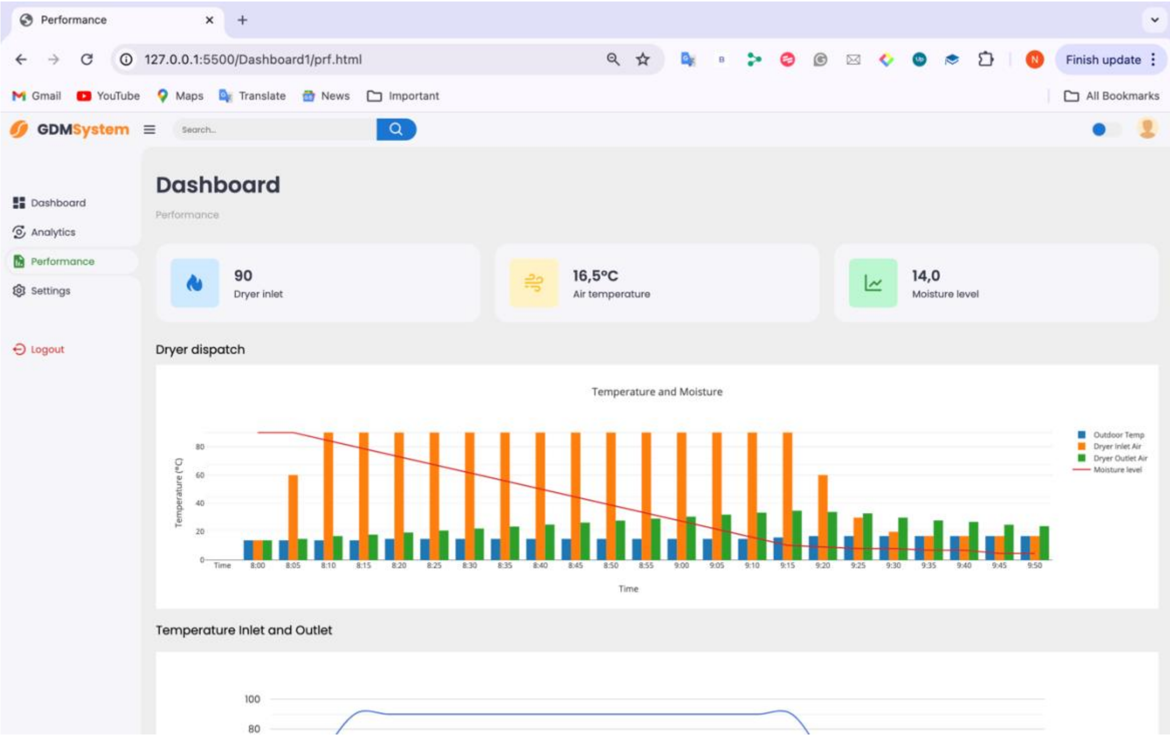

Figure 20. Performance page

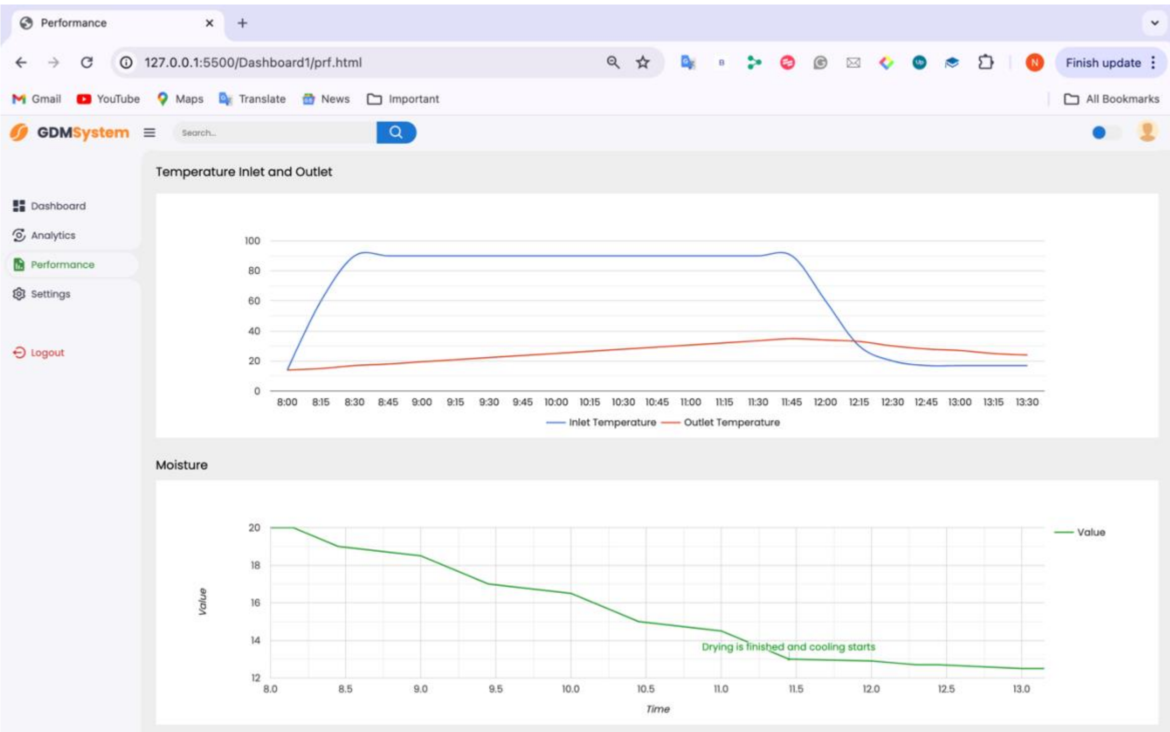

Figure 21. Performance page

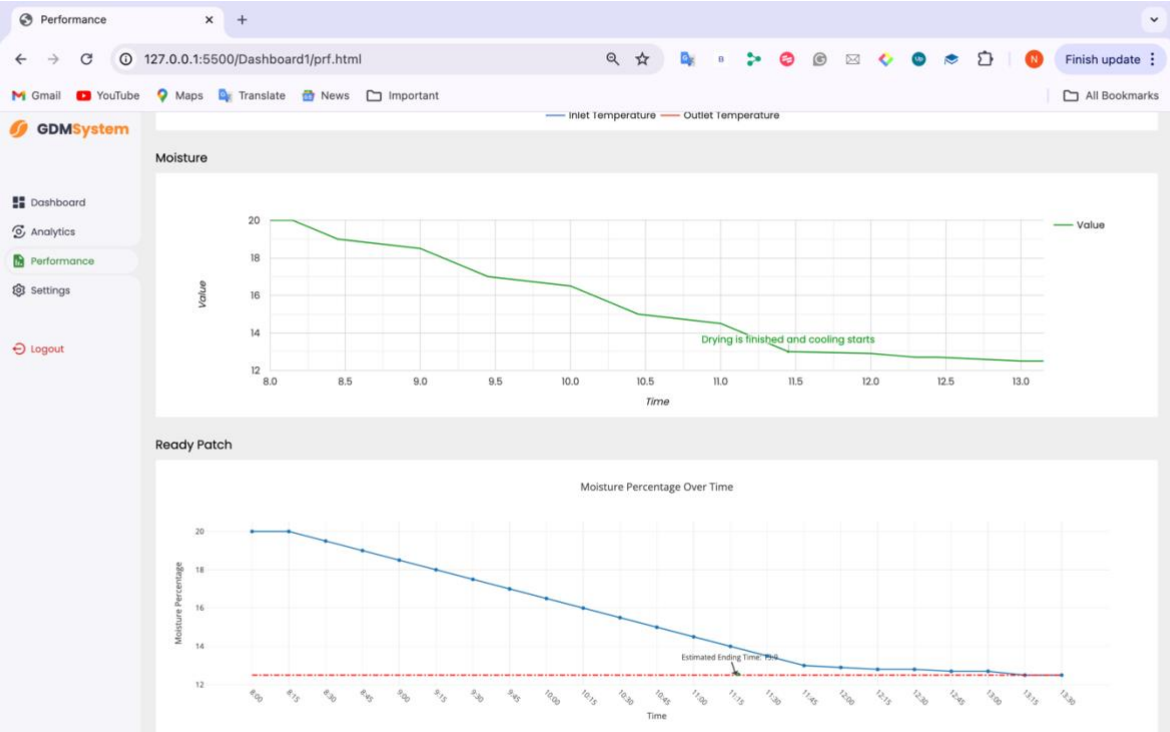

Figure 22. Performance page

The settings page allows user to choose and adjust the different parameters of the drying system as they please and as they need, thus making the system more user-friendly and efficient. The interface enables the users to regulate the time interval for the drying process thus making it easier to control the time of each cycle. Moreover, the customization of the settings is possible by the users through the choice and setting of certain parameters via the dropdown menus and text areas, thus, flexibility in the definition of the operational settings is obtained. The use of interactive elements, such as sliders and drop-down menus, improves the user experience better and the customization process is easily done. Through the settings page, the user can modify the drying system to suit their particular needs and increase efficiency.

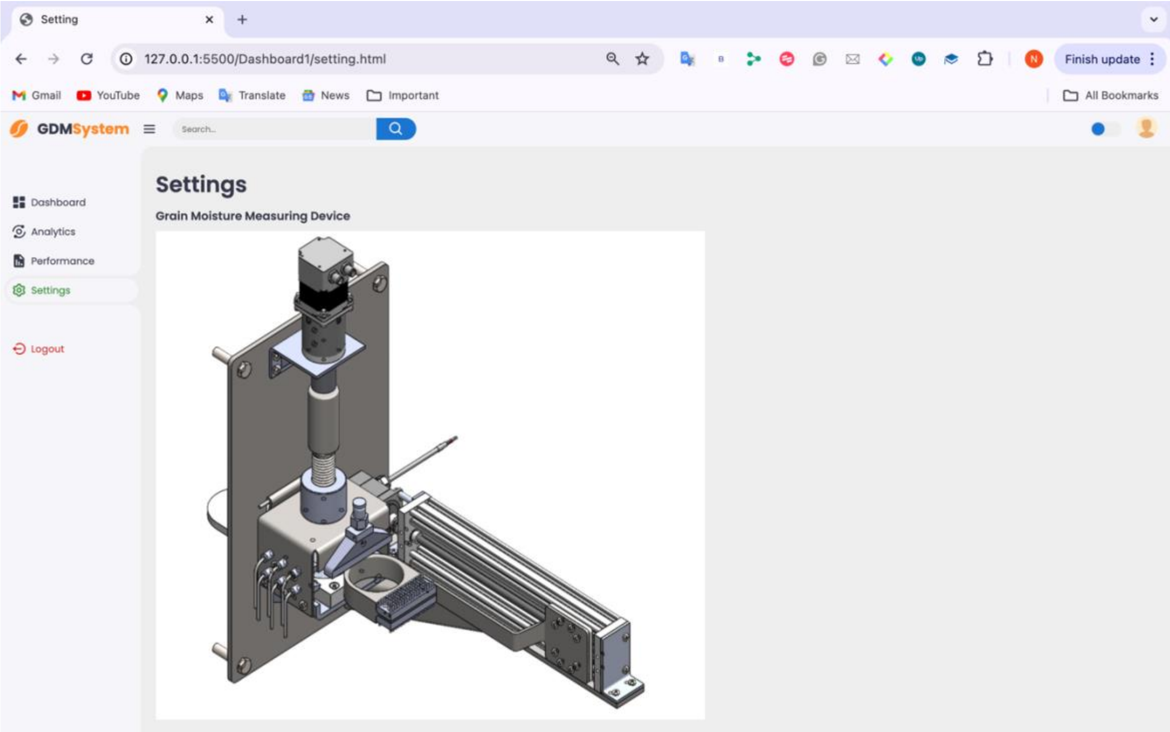

Figure 23. Setting page

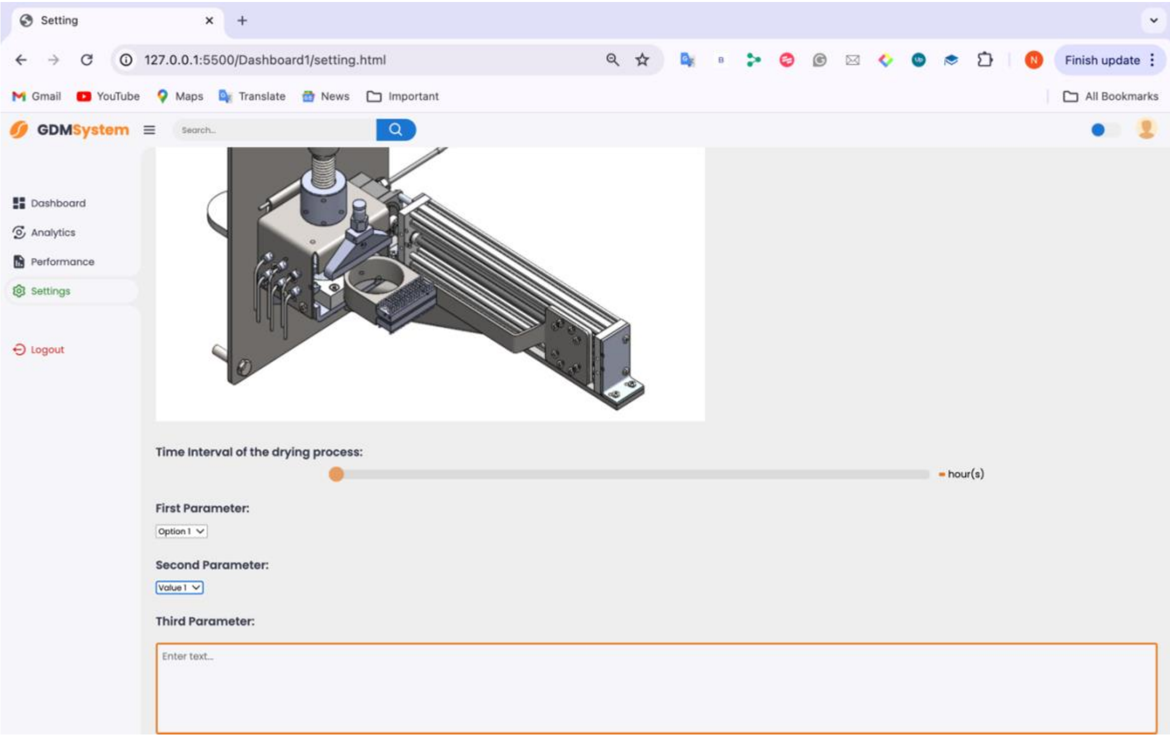

Figure 24. Setting page

6.4 Simulation

The simulation was carried out to examine the properness and efficiency of the dashboard system. The simulation was designed to simulate real-world situations that are usually encountered in the agricultural drying processes, which is a way to show the system's capability and effectiveness.

Through the simulation, the dashboard gave the user a clear view of the important points like the dryer inlet temperature, air temperature, and moisture levels. These insights were the main topic of the 'Insights' section of the dashboard, thereby, users could see the critical parameters in real-time.

In addition, the dashboard made the process of starting new drying patches easier through the 'Start a new patch' function (Figure 25). The users could set the parameters like the kind of grain, the amount, the measuring interval, and the process date thus, they will be able to manage the drying processes at the same time and that will be a good method to do it.

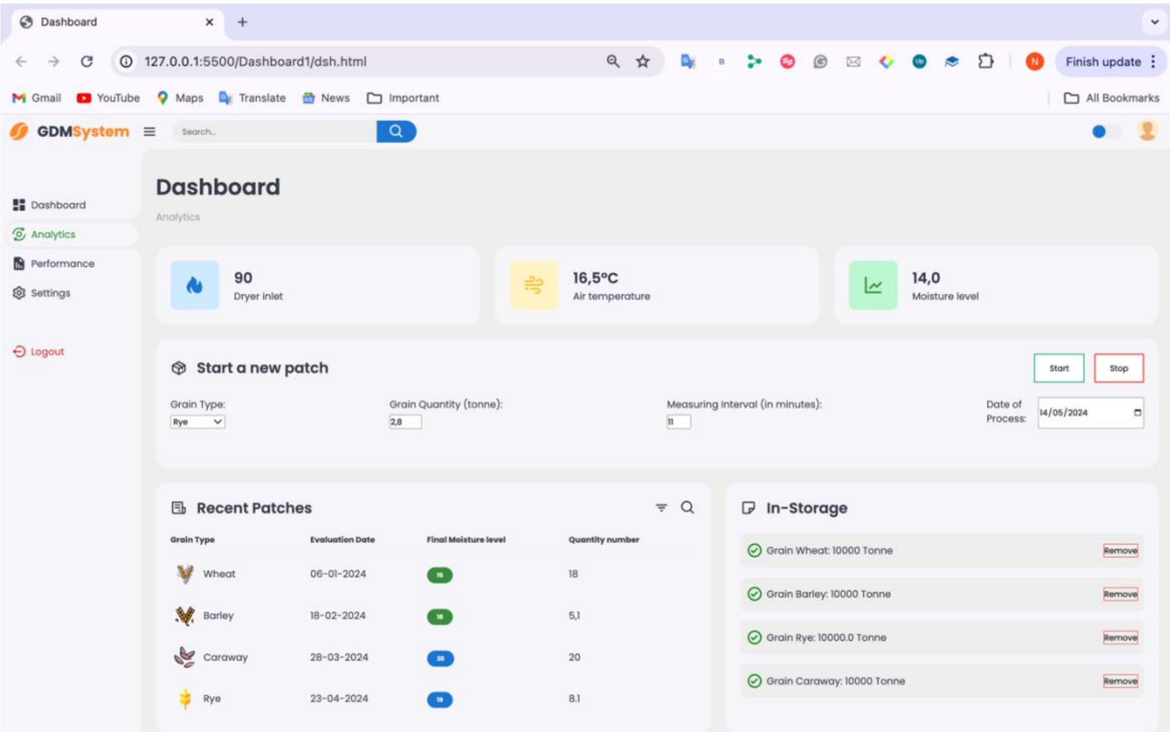

Figure 25. 'Start a new patch' function.

Moreover, the dashboard displayed the latest drying patches in the 'Recent Patches' table, and it was very helpful as it contained the grain type, the evaluation date, the final moisture level, and the quantity of the spots (Figure 26). This enabled users to monitor the status of the ongoing drying processes and at the same time to evaluate the results of these processes.

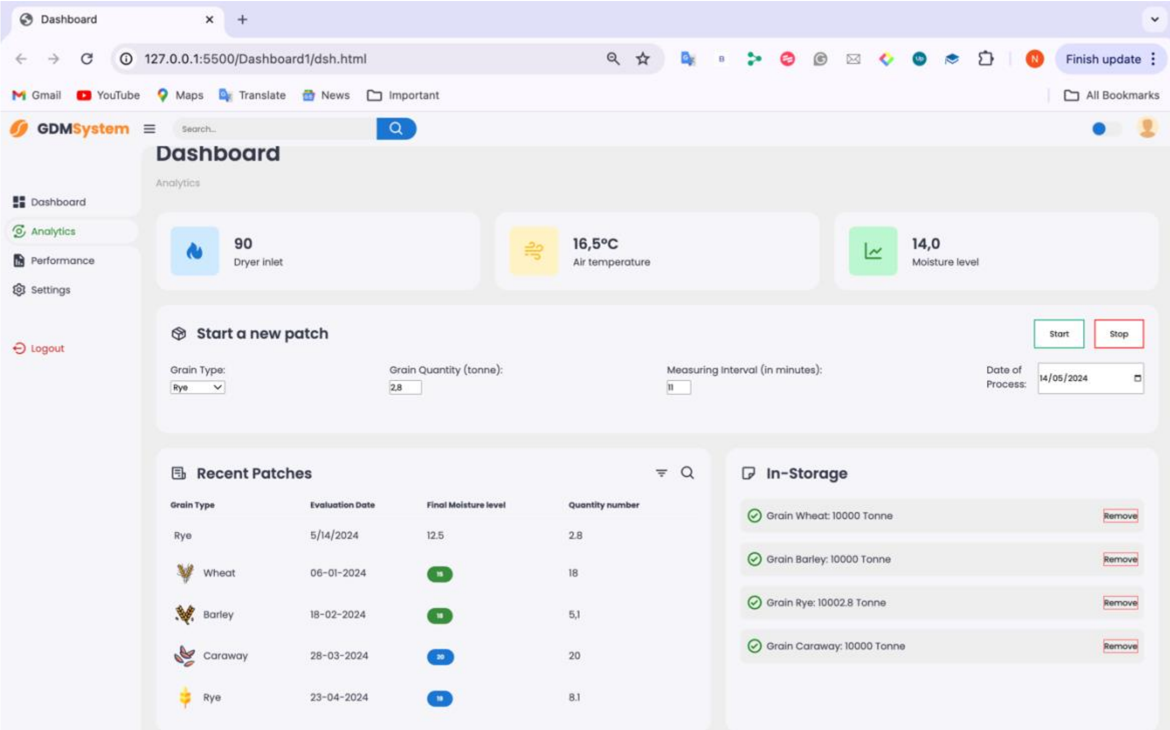

Figure 26. Dashboard after the simulation

Besides, the 'In-Storage' section of the dashboard presented information about the capacity of grains in storage, thus, user could monitor the amount of grains and manage the inventory in the best way possible. The users could also eliminate the grains from the storage by typing the number of sold grains, which would keep the available quantity updated in real-time (Figure 27).

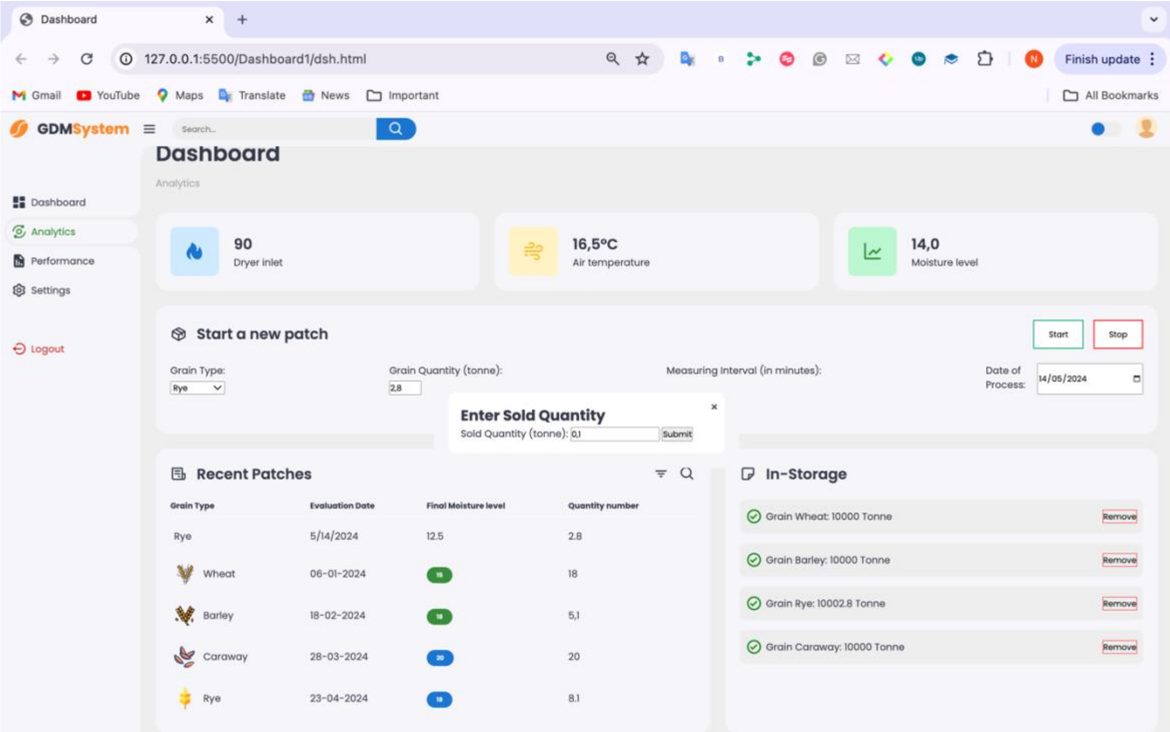

Figure 27. Sold quantity pop-up window

In general, the simulation was a solid confirmation of the dashboard system's working and the ability of the users to use it. This was the system's capacity to offer real-time data, the drying operations, and the decision-making processes in the agricultural environment.

7 Summary and discussion

To sum up, this thesis presented thorough research on the drying processes in agriculture, which is a sector of Finnish agriculture that is very resilient and innovative. The research process involved a multi-faceted approach addressing different goals that were to be accomplished by improving the operational efficiency and sustainability of grain management.

Finnish agriculture, characterized by a blend of traditional practices and technological innovation, provided an excellent backdrop for this project. Despite the challenges posed by the Nordic climate, Finnish farmers have consistently demonstrated adaptability and ingenuity, advancing the farming sector with their unique and determined efforts.

The thesis started with a comprehensive analysis of the state-of-the-art in agricultural drying processes, identifying major problems and areas for improvement. Based on the views of stakeholders and the experts in the industry, the research aimed to overcome these challenges through technological innovation and process optimization

A key component of this thesis was the development of a web application dashboard which was designed for monitoring and analyzing the processes of drying in real-time. The dashboard has become a powerful tool for the stakeholders in the drying cycle to visualize and manage the critical data points by using modern web development frameworks and intuitive design principles.

The dashboard was accompanied by simulation exercises and real-world testing, which proved the efficiency of the different methods and technologies in enhancing the drying process and improving the grain quality. As well, the inventory management functionalities were integrated into the system and thus, another layer of utility was added. Thus, grain stocks could be tracked, demand forecasted, and logistics could be streamlined with precision and foresight.

Apart from the technological side, this thesis also explored the socio-economic impact of better grain management.

The implementation of a thesis implies collaborative work across different sectors. My role was geared toward the creation of software, specifically the web-based dashboard. The mechanical part of the drying process as well as the automation part will be handled by other team members.

While the project was successful on many counts, there are always areas that need to be worked on. The possibility of an earlier assembly of the mechanical and software components could be one of the improvements. Such an approach would have made the process more iterative and enabled us to identify and resolve integration issues early enough. Furthermore, real-time feedback from end-users during the development process would have played an important role in developing a friendly interface and more practical functionalities.

However, there are various directions that research and development can be taken in the future. The next step would be to fully automate the process, which would hasten the drying process and improve efficiency. Future work should also consider advanced data analytics and machine learning, which can give predictive insights and further improve the efficiency of the drying system. Furthermore, expanding the web application to feature other farming operations could make it more versatile.

This thesis spotlights the significance of interdisciplinary cooperation. The mechanic engineering essentials were the basis of the provided drying systems. The newly developed software will provide a friendly user interface for monitoring and management with the upcoming automation working smoothly to bring everything together. Although each part is independent, they are all interdependent and the teamwork aims to find better ways to dry agricultural produce. This project demonstrates how mechanical engineering, software, and automation create innovative agricultural solutions.

In a nutshell, this thesis is a holistic analysis of agricultural drying processes that covers technology development, process optimization, and socio-economic considerations. The cooperative activity and the teamwork throughout the whole work are of great value to the development of agriculture and to the farmers in Finland and abroad.

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