American Journal of Smart Technology and Solutions (AJSTS)

ISSN: 2837-0295 (ONLINE)

VOLUME 5 ISSUE 2 (2026)

PUBLISHED BY
E-PALLI PUBLISHERS, DELAWARE, USA

American Journal of Smart Technology and Solutions (AJSTS)

Volume 5 Issue 2, Year 2026
ISSN: 2837-0295 (Online)
DOI: https://doi.org/10.54536/ajsts.v5i2.7814
https://journals.e-palli.com/home/index.php/ajsts

Development of Portable Farm Equipment Starter

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Article Information

Received: March 08, 2026

Accepted: May 20, 2026

Published: July 21, 2026

Keywords

Capacity, Development, Equipment, Farm, Portable, Starter

ABSTRACT

The study aimed to develop a portable farm equipment trick starter. Specifically, it sought to: describe the technical features in terms of design, technical specification, and functionality; measure the operating performance of the device in terms of starting operation of different farm equipment, discharge process of different engine capacity, and the number of equipment operated when full charge; and determine the acceptability of the portable farm equipment starter in terms of composition, safety features, portability, and functionality. This used a developmental method, and the evaluation was conducted using a validated researcher-made questionnaire. Sixty evaluators assessed the developed device, providing valuable insights for its proper utilization in farming and farm equipment suppliers. The device is powered by a rechargeable battery that provides enough electrical energy to operate the starter mechanism. It features a push-button control built into the handle, making it easy for the operator to start the engine with minimal physical effort. Its compact and lightweight design makes the unit easy to carry and handle in the field, which is especially helpful for users who need to move between different farm machines frequently. The findings revealed that the device demonstrated reliable performance, predictable battery discharge behavior, and a practical number of engine starts per full charge. The acceptability of the device in terms of composition, safety features, portability, and functionality was very acceptable. These results highlight its potential as a convenient, labor-saving tool for starting agricultural engines efficiently.

INTRODUCTION

With the continuous rise in labor shortages and the high cost of machinery, particularly in developing countries, many farmers are compelled to rely on manual methods that are often inefficient and physically strenuous (Mohanraj *et al.*, 2020). Although large-scale farm equipment is widely used to enhance efficiency and ease of work in agricultural operations, access to such technologies remains limited for many small- and medium-scale farmers. These machines are designed to reduce labor demands, save time, improve operational efficiency, minimize maintenance requirements, and support sustained productivity throughout the agricultural production cycle.

This study aligns with the United Nations Sustainable Development Goals (SDG), particularly Goal 4: Quality Education, which promotes inclusive and equitable quality education and lifelong learning opportunities, and Goal 9: Industry, Innovation, and Infrastructure, which emphasizes building resilient infrastructure, fostering innovation, and promoting sustainable industrialization. Moreover, it supports the provisions of Republic Act No. 10601, also known as the Agricultural and Fisheries Mechanization (AFMech) Law, which ensures the quality and safety of agricultural machinery through strengthened regulation, testing, and accreditation, and promotes support services such as research, training, extension programs, and infrastructure development.

Traditional farming implements, although widely used and reliable, are often limited to single functions such as planting, digging, or soil covering, requiring multiple tools and repeated efforts to complete a single planting cycle. This process is time-consuming and can negatively affect overall productivity and sustainability. In response, there is a growing need for innovative agricultural tools that integrate multiple functions into a single device. The developed Portable Farm Equipment Starter (PFES) is designed to address this need by providing a convenient means of starting farm equipment engines efficiently, thereby reducing physical strain and improving operational efficiency. It is especially beneficial for small to medium-scale farmers who have limited access to expensive mechanized systems. By reducing time, labor, and operational effort, the device contributes to more efficient and less physically demanding farming practices. Additionally, it supports the global movement toward sustainable and climate-smart agriculture, which aims to enhance food production while conserving energy and resources (Food and Agriculture Organization [FAO], 2021).

Recognizing these challenges and opportunities, the researchers developed the Portable Farm Equipment Starter (PFES) as a practical contribution to modernizing farming practices. This innovation is envisioned as a cost-effective and accessible solution that enhances labor efficiency and supports agricultural productivity. Ultimately, the development and evaluation of this device aim to address gaps in labor efficiency, resource utilization,

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and technological innovation, thereby contributing to more sustainable and productive farming systems in the long term.

Generally, this study aimed to develop a Portable Farm Equipment Starter (PFES). Specifically, it sought to: describe the technical features of the PFES in terms of design, technical specifications, and functionality; evaluate the operating performance of the PFES in terms of its ability to start different types of farm equipment, its battery discharge behavior across varying engine capacities, and the number of equipment units it can operate on a full charge; determine the acceptability of the PFES in terms of composition, safety features, portability, and functionality.

LITERATURE REVIEW

A recoil starter, also known as a pull starter or rewind starter, is a mechanical device used to manually start small internal combustion engines, such as those found in lawnmowers, chainsaws, generators, and other portable equipment. It operates by converting human pulling force into rotational motion, which turns the engine's crankshaft and initiates the combustion process.

A typical recoil starter consists of several essential components that function as an integrated system, including the pull cord (starter rope), handle (grip), recoil spring, pulley or spool, pawl (dog) mechanism or clutch, and starter housing. These components work together to transmit motion from the user to the engine (Antanker Parts, 2023).

The primary function of a recoil starter is to manually initiate engine operation. When the user pulls the cord, the rope unwinds from the pulley, causing it to rotate and engage the crankshaft through the pawl mechanism. This action turns the engine over, creating the necessary compression and ignition for startup. Once the engine starts, the pawls automatically disengage, and the recoil spring rewinds the rope into its original position. This process allows the engine to operate without the need for electricity or a battery (Engineer Fix, 2025; Antanker Parts, 2023).

Recoil starters offer several advantages, including a simple and reliable design, independence from electrical power, lightweight construction, portability, and low cost with minimal maintenance requirements. These features make them widely used in portable equipment and in remote locations. However, they also have limitations, such as requiring physical effort, difficulty in starting engines under cold or worn conditions, susceptibility to component wear and failure, and the need for multiple pulls to achieve ignition. These disadvantages can make recoil starters less convenient compared to electric starting systems, particularly in larger or more demanding applications (Engineer Fix, 2025; Turner, 2026).

Agriculture has long been a fundamental sector for economic development, food security, and rural livelihoods. Over time, the shift from traditional farming practices to mechanized agriculture has significantly transformed the way agricultural activities are carried out. Farm equipment, ranging from simple hand tools to advanced machinery such as tractors, harvesters, and irrigation systems, plays a vital role in enhancing efficiency, productivity, and sustainability within agricultural production systems. Agricultural mechanization, defined as the application of tools, implements, and machinery in farming operations, is widely recognized as a key driver of modern agricultural development. The utilization of farm equipment spans various agricultural processes, including land preparation, planting, irrigation, harvesting, and post-harvest handling. Mechanization applies engineering technologies to improve labor productivity and operational efficiency, ultimately increasing agricultural output (Emami *et al.*, 2018). Likewise, Sarkar (2020) emphasized that the adoption of farm machinery reduces labor and time requirements while significantly enhancing productivity in crop production systems. These findings underscore the importance of integrating appropriate technologies to meet the growing global demand for food.

In developing countries, the adoption of farm equipment is especially critical due to challenges such as labor shortages, climate variability, and limited access to resources. Paul and Régis (2024) noted that mechanization helps address labor scarcity, reduce post-harvest losses, and strengthen food security by improving efficiency in farm operations. Additionally, mechanization enables farmers to perform tasks more accurately and on time, which is essential for maximizing yields and minimizing losses. It also reduces the physical burden on farmers, thereby improving working conditions and overall productivity.

Despite these benefits, the adoption of farm equipment also presents several challenges. High initial investment costs, limited access to credit, insufficient technical knowledge, and inadequate infrastructure often hinder the use of modern machinery, particularly among smallholder farmers. Furthermore, unequal access to mechanization technologies may contribute to disparities in agricultural development across regions (Sarkar, 2020; Ranabhat *et al.*, 2025). These issues emphasize the need for supportive government policies, capacity-building programs, and improved access to financing to ensure equitable adoption of farm technologies.

The utilization of farm equipment is essential for improving agricultural productivity, ensuring food security, and promoting sustainable development. While mechanization offers substantial advantages, addressing its associated challenges is crucial to maximizing its potential. A comprehensive understanding of farm equipment utilization provides a strong foundation for enhancing agricultural practices and supporting rural development initiatives.

Recent studies have emphasized the significant role of farm equipment utilization in enhancing agricultural productivity, efficiency, and sustainability. Ariyanto (2026), through a systematic literature review and bibliometric analysis of global trends in agricultural mechanization, found that mechanization substantially improves cultivation efficiency, reduces harvesting costs, and increases farmers' income by approximately 15–36%. The study further underscores that farm equipment utilization extends beyond mere economic optimization; it serves as a catalyst for broader social transformation and the strengthening of institutional frameworks within rural agrarian communities.

Similarly, Paul and Régis (2024) examined the drivers of agricultural mechanization among smallholder farmers in Haiti and found that the use of farm equipment plays a crucial role in addressing labor shortages, minimizing post-harvest losses, and increasing overall productivity. However, their findings also revealed that the level of utilization varies according to farmers' socio-economic conditions, indicating the need for targeted and context-specific mechanization strategies.

In the Philippine context, Romallosa *et al.* (2022) investigated the technical performance and utilization of agricultural technologies in Iloilo. The results showed that the use of appropriate farm equipment significantly enhances operational efficiency and supports sustainable mechanization. Moreover, the study reported that locally developed technologies met national standards and demonstrated strong potential for improving productivity when adopted by farming communities.

Furthermore, Ahiakwo and Isirima (2023) explored the utilization and maintenance of farm machinery in educational farm settings. Their findings revealed that proper use and maintenance of agricultural equipment contribute to sustainable farm development while also enhancing learning outcomes in agricultural education. Access to machinery was found to improve both productivity and the technical skills of users.

In addition, Maghfiroh *et al.* (2025) analyzed the impact of agricultural machinery utilization on production efficiency among rice and maize farmers in Indonesia. The study found that mechanization significantly reduces labor costs and increases production efficiency, thereby improving economic returns and helping farmers cope with rising production costs and labor shortages.

Moreover, Li *et al.* (2023) investigated the utilization of small agricultural machinery in mountainous regions of China. Their findings indicated that factors such as farm size, terrain, and access to resources significantly influence equipment utilization. The study concluded that improving access to machinery and optimizing its use are essential for enhancing agricultural productivity and ensuring food security.

These studies consistently demonstrate that farm equipment utilization plays a vital role in improving agricultural efficiency, reducing labor demands, and promoting sustainable farming practices. However, they also highlight that effective utilization depends on various factors such as socio-economic conditions, accessibility, and proper management of equipment, emphasizing the need for context-specific approaches to agricultural mechanization.

Prior Art

Figure 1: Recoil Starter (Antanker Parts, 2023).

MATERIALS AND METHODS

Design Criteria

The primary goal of the developed Portable Farm Equipment Starter (PFES) was to describe the technical features of the PFES in terms of design, technical specifications, and functionality. The fabrication of the starter and battery assembly followed a systematic and methodical procedure, ensuring proper use of tools and materials. Initially, all necessary tools and components were prepared to facilitate a smooth workflow. Precise measurements of the starter and battery were taken to ensure accurate fitting within the assembly. An angle bar was then welded into a square base using a welding machine, in accordance with the design specifications.

Subsequently, the starter motor and battery were carefully positioned and aligned within the fabricated base. The design bracket was secured using bolts and nuts to stabilize the starter unit. The battery was strategically placed behind the starter to optimize space and maintain balance. Handles were then installed to improve portability and ease of handling. A starter switch was attached to the handle to allow convenient operation, while a starter relay and battery fuse were integrated to ensure safety and proper functionality. Electrical wiring was meticulously installed to complete the circuit, ensuring efficient power transmission. Finally, a socket wrench extension was connected to the starter shaft to enable effective engagement with the engine.

Through these procedures, a well-constructed and functional starter and battery assembly was developed, making it suitable for its intended application in improving the starting mechanism of farm equipment.

Design Plan, Preparation, and Fabrication

Gathering and preparation of materials

↓

Measuring and cutting of metals as body framing

↓

Welding fabrication of its body framing

↓

Sanding and painting of metal parts of the device

↓

Attachment and connection of electrical/electronics parts

↓

Testing of the device for operation

↓

Packaging of finished product

Figure 2: Flow chart of the development of Portable Farm Equipment Starter (PFES).

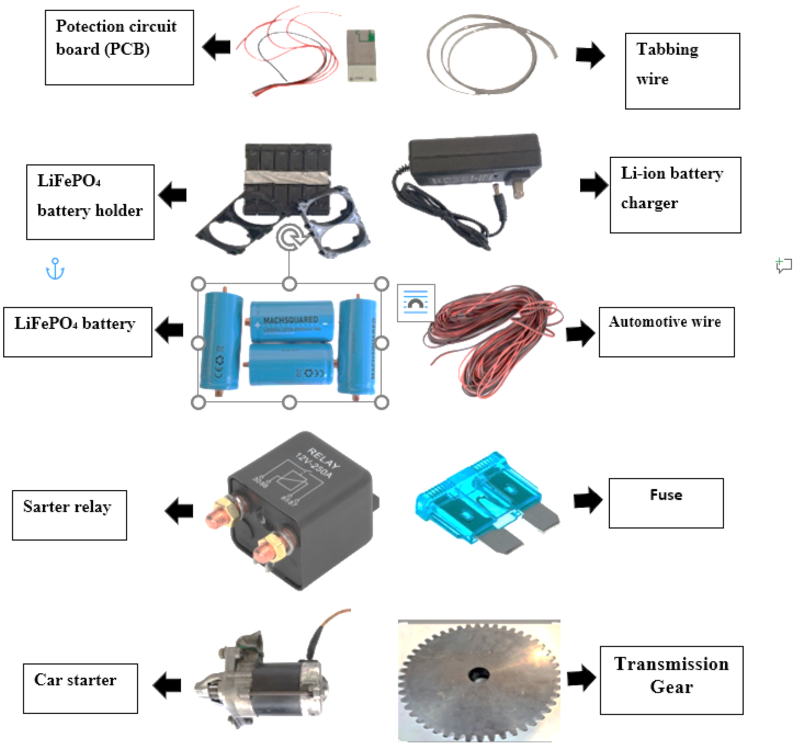

Figure 3: Parts and components of the development of the Portable Farm Equipment Starter

Fabrication/Development Procedure

The development of the Portable Farm Equipment Starter (PFES) followed a sequential process designed to ensure structural integrity, functional efficiency, and operational safety.

The initial stage focused on constructing a durable and stable structural frame, which serves as the foundation of the device. Angle bars were carefully measured, cut, and welded to form a rigid base capable of withstanding operational stress in field conditions. This structural stability minimizes vibration and misalignment, which are common causes of mechanical inefficiency and failure in small farm machinery.

Following frame fabrication, pillow blocks were installed to support the rotating shaft and ensure smooth rotational movement while reducing friction losses. The transmission gear was then precisely mounted onto the shaft to facilitate efficient transfer of rotational force to the starter system. Proper alignment at this stage is critical, as it directly influences the efficiency, durability, and reliability of the starting mechanism.

The starter unit was then securely mounted onto the frame in a position that ensures proper engagement with the transmission gear. This configuration provides a mechanized alternative to conventional recoil or manual starting systems, reducing physical effort and improving ease of operation for users. A handlebar was also incorporated to enhance ergonomics, user control, and portability during operation.

In the electrical integration phase, a $LiFePO_4$ battery was installed within a protective battery box and firmly secured to the frame. This choice supports the study's emphasis on safety, energy efficiency, and durability, as $LiFePO_4$ batteries are known for their thermal stability, long cycle life, and reduced risk of overheating. Automotive-grade wiring was used to interconnect all electrical components, ensuring proper insulation, organized routing, and protection against short circuits.

To enhance system safety, a fuse was installed near the battery to protect against overcurrent conditions. A main switch was incorporated to provide centralized control of power distribution, improving operational safety and convenience. A starter relay was integrated to handle the high current required by the starter motor, thereby protecting lower-capacity components. In addition, a momentary switch was used to activate the relay only during engine starting, ensuring controlled and efficient operation.

For monitoring and maintenance purposes, a voltmeter was connected across the battery terminals to provide real-time voltage readings. This allows users to assess battery status and prevent unexpected system failure. Finally, a charging port was installed to enable convenient recharging without disassembling the unit, further enhancing usability and practicality in agricultural field applications.

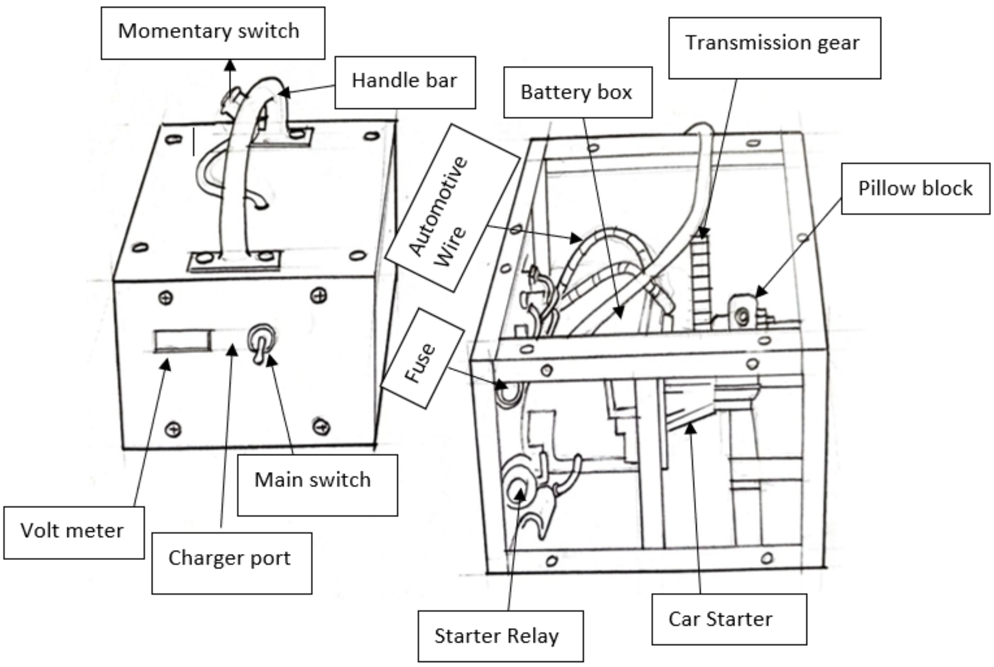

Figure 4: Graphical sketch of the development of Portable Farm Equipment Trick Starter

Parts and Functions of the Portable Farm Equipment Starter (PFES)

A protection circuit board in a $LiFePO_4$ BMS acts like a built-in safety guard that constantly checks the battery's voltage, current, and temperature, and automatically stops charging or discharging to prevent overcharge, deep discharge, short circuits, and overheating, helping the battery work safely and last longer.

Tabbing wire or a nickel-plated strip battery connector is a thin metal connector made of nickel or nickel-plated steel that is used to link individual battery cells together in a battery pack, providing a low-resistance electrical path between cells and enabling reliable current flow during charging and discharging.

A $LiFePO_4$ battery holder is a device or compartment designed to securely house one or more lithium iron phosphate ($LiFePO_4$) cells, keeping them in proper alignment, maintaining electrical contact, and protecting them from movement, vibration, short circuits, and mechanical damage during use.

A $LiFePO_4$ battery (lithium iron phosphate battery) is a type of rechargeable lithium ion battery that uses lithium iron phosphate ($LiFePO_4$) as the cathode material, offering high safety, long cycle life, and stable performance for applications such as energy storage, electric vehicles, and backup power.

Li ion battery charger is an electronic device designed to safely recharge lithium ion batteries by regulating the charging voltage and current through a controlled constant current/constant voltage (CC CV) profile, preventing overcharge and ensuring the battery reaches its full capacity without damage.

Automotive wire is a type of electrical wire designed specifically for use in vehicles to carry power and electrical signals between components while withstanding harsh conditions such as heat, vibration, moisture, oils, and chemicals.

A starter relay is an electrical switch in a vehicle's starting system that uses a small current from the ignition switch to control a much larger current going to the starter motor. When you turn the key or press the start button, the relay closes its internal contacts, allowing the battery's high current to flow to the starter motor, which cranks the engine.

A fuse is an electrical safety device that protects a circuit from too much current. It contains a thin metal wire or strip that melts (or "blows") when the current exceeds a safe level, interrupting the flow of electricity and preventing damage to wiring, devices, or even fire hazards.

A car starter is an electric motor in a vehicle that cranks the engine to start it. When you turn the ignition key or press the start button, the starter motor receives electrical power from the battery, which spins the engine's flywheel or crankshaft. This initial rotation allows the engine to begin its own internal combustion process, after which the starter disengages.

Instrumentation

The developed Portable Farm Equipment Starter (PFES) was tested and evaluated by farmers, farm owners, laborers, electrical/electronics professors, and welding fabricators. The testing phase was conducted to assess the functionality of the device. Manual operation was initially applied, and inputs from experts were consolidated to improve the design. Comments and suggestions were also gathered and incorporated for further enhancement of the device.

To evaluate the technical features of the device in terms of design, technical specifications, and functionality, a researcher-made evaluation sheet was developed and subjected to content validation and reliability testing.

In terms of validity, the items assessing composition, safety features, portability, and functionality were reviewed and refined based on the ratings and recommendations of experts. The collected data were tabulated, computed, and interpreted using a predetermined scale for evaluating the validity of the instrument.

For reliability testing, the validated evaluation sheet was administered to respondents from the academe, industry experts, and end users. The researcher-made instrument was used to gather quantitative data in this study, employing a 5-Point Likert Scale. Each item in the questionnaire was provided with five response options. Responses rated as Very Acceptable and Acceptable were considered positive, indicating agreement with the statements presented. Meanwhile, Less Acceptable and Not Acceptable were considered negative responses, corresponding to lower levels of agreement with scale values of 2 and 1, respectively.

Scoring Variables

The evaluation of the acceptability used a 5-Point Likert Scale, wherein 5 was the highest, and 1 was the lowest. The evaluation was done in the automotive laboratory room; however, other evaluators, such as farmers, farm owners, and laborers who have more experience with farm equipment, were done in their place where they really work to show them the real physical object and instruct them how to start and how to utilize the device.

The evaluators are the following: (5) Farmers, (5) farm equipment suppliers, (20) professional/academe (automotive, electronics, electrical, mechanical major). They were selected using a purposive sampling method, taking into consideration that their judgment is based on their prior information and knowledge regarding the device under study (Fraenkel & Wallen, 2012).

The mean was computed to answer the level of acceptability of the developed Portable Farm Equipment Trick Starter from a varied group of evaluators. The evaluators were asked to assess each item in the questionnaire in terms of its level of acceptability with regard to composition, safety features, portability, and functionality.

In ensuring that the study meets its intended purpose, operates correctly under various conditions, and provides accurate and reliable performance, the instruments were submitted for proofreading to the advisory committee, examining committee, statistician, and English critic for comments, suggestions, and possible changes and necessary revisions.

Data Gathered

The data gathering was done through the actual observation and manipulation of the development of the Portable Farm Equipment Starter (PFES).

The acceptability of the PFES was determined in terms of composition, safety features, and portability. The accomplished evaluation sheets were gathered and consolidated for scientific analysis and interpretation purposes.

Parameters for Analysis

To analyze the effectiveness and performance of the PFES, several parameters were considered to ensure a comprehensive evaluation of the device. These include the assessment of its technical features in terms of design, technical specifications, and functionality. The researcher presented a graphical sketch with appropriate labeling, illustrating the arrangement of components and their interrelationships within the system. Each part of the device was thoroughly described to provide a clear understanding of its structure, operational procedures, and intended use, thereby enhancing users' comprehension of its practical applications in agricultural settings.

In assessing the operating performance of the device, specific parameters were evaluated, including the number of engines activated or started using different types of farm equipment, the discharge process across varying engine capacities, and the number of equipment that can be operated per full battery charge. This evaluation was carried out through actual testing, manipulation, and systematic observation with the assistance of expert farmers to ensure accuracy and relevance to real farming conditions.

Furthermore, the acceptability of the PFES was determined in terms of composition, safety features, portability, and functionality. This was based not only on the actual performance of the device during testing but also on the responses gathered through a researcher-made evaluation questionnaire. The combined quantitative and qualitative feedback from evaluators provided a reliable basis for determining the overall effectiveness and usability of the developed innovation.

Statistical Tools

A 5-Point Likert Scale was employed to measure the acceptability of the product. Evaluators assessed the four key factors, namely composition, safety feature, portability, and functionality. The mean scores were interpreted using a verbal rating scale ranging from Least Acceptable to Very Acceptable. This allowed for a systematic and quantitative evaluation of the device based on the perception of the respondents Formula for mean (Downie and Heath, 1984)

RESULTS AND DISCUSSION

Technical Features of the Development of Portable Farm Equipment Starter

This section presents the technical features of the developed Portable Farm Equipment Starter. The device was designed to enhance the ability of farmers to start farm equipment engines more efficiently and with reduced physical effort. The system consists of electronic and electrical mechanisms that control the starting process when connected to the engine of farm equipment (Figure 5).

The technical features of the device are composed of several key components. A protection circuit board within the $LiFePO_4$ Battery Management System (BMS) serves as a built-in safety mechanism that continuously monitors the battery's voltage and automatically regulates or stops charging and discharging to prevent damage. Tabbing wire, or a nickel-plated strip connector, is a thin metal conductor made of nickel-plated steel that provides a low-resistance electrical pathway between cells, ensuring reliable current flow during both charging and discharging. A $LiFePO_4$ battery holder is a compartment designed to securely house lithium iron phosphate cells, maintaining proper alignment, ensuring stable electrical contact, and protecting them from movement, vibration, short circuits, and mechanical damage.

The $LiFePO_4$ battery (lithium iron phosphate battery) is a rechargeable lithium-ion battery that uses lithium iron phosphate as its cathode material, offering high safety, long cycle life, and stable performance. In addition, a lithium-ion battery charger is an electronic device designed to safely recharge batteries by regulating voltage and current, preventing overcharging, and ensuring full capacity without damaging the battery.

Automotive wire is specifically designed for vehicle applications to transmit power and electrical signals between components while withstanding harsh environmental conditions such as heat, vibration, moisture, oils, and chemicals. A starter relay functions as an electrically controlled switch that uses a small current from the ignition system to control a larger current supplied to the starter motor. Meanwhile, a fuse is a safety device containing a thin metal element that melts when excessive current flows through the circuit, thereby preventing damage to wiring and reducing the risk of fire. Lastly, the car starter is an electric motor that initiates engine operation by cranking the engine until the combustion process becomes self-sustaining

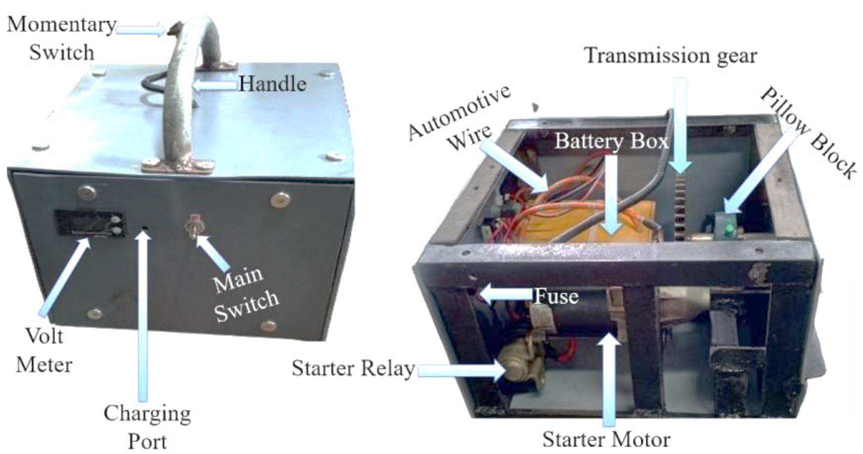

Figure 5: Technical features of the development of Portable Farm Equipment Trick Starter

Operating Performance of a Developed Portable Farm Equipment Starter in terms of the Starting Operation of Different Farm Equipment

Table 1 presents the evaluation of the device's operating performance in terms of the starting operation of different farm equipment. The results were determined through actual trials and observations conducted during the evaluation by experts and users. Findings revealed that 37 units of both hand tractors and threshers were successfully started, while 42 blower engines were also successfully operated. These results indicate that the device is effective in facilitating the start-up of various farm equipment under practical conditions.

This implies that the initial starting operation of farm equipment is crucial to overall farm efficiency, particularly in small to medium-scale agricultural settings. In real field conditions, farmers rely on engines that start quickly and reliably, whether for hand tractors, water pumps, or other agricultural machinery. Efficient engine starting minimizes downtime, reduces fuel consumption, and enhances productivity during time-sensitive farming activities. In many rural areas, ease of starting is as important as engine power, as operators often work under time constraints and varying environmental conditions (Smith, 2021). Moreover, operators frequently resort to practices such as preheating, fuel priming, and routine maintenance checks, as environmental factors like cold weather, high humidity, and prolonged storage periods can make engine starting more difficult. Poor starting performance and harsh operating conditions may gradually damage engine components, leading to increased maintenance costs and reduced equipment lifespan. In contrast, reliable starting systems improve workflow efficiency, reduce mechanical stress, and contribute to better fuel efficiency in agricultural operations (Garcia & Torres, 2022).

Table 1: Operating Performance of a developed Portable Farm Equipment Starter in terms of the starting operation of different farm equipment.

Different Farm Equipment	Number of Engine Activated/Started
1. Hand Tractor/ Thresher	37 started/activated
2. Blower	42 started/activated

Operating performance in terms of the Discharge Process Across Different Engine Capacities

Table 2 presents the evaluation of the device's operating performance in terms of the discharge process across different engine capacities. The discharge process is a critical factor in the design and performance of a farm engine starter, as it directly influences the smooth transition from engine cranking to full combustion. The primary objective of developing the PFES is to minimize the effort required to start the engine while ensuring efficient expulsion of exhaust gases during the initial firing cycles. This is particularly important for small agricultural engines, where starting resistance significantly affects operator convenience and overall equipment reliability (Villanueva, 2022).

The battery voltage behavior was also identified as an important finding during the testing phase. Results showed that with every engine start, the battery voltage decreased by approximately 0.4 volts. For instance, a slight voltage drop was observed after starting a 10-horsepower engine, and this reduction accumulated progressively with subsequent starts. It was also noted that fewer 12-horsepower engines could be started on a single full charge compared to 10-horsepower engines, due to the higher energy demand of larger engines, which resulted in a more significant voltage drop per operation (Delos Santos, 2022; Garcia, 2020).

Table 2: Operating performance in terms of the discharge process across different engine capacities.

Different Engine Capacity	Discharge process
1. 10 HP	0.4 volts every engine
2. 12 HP	

Operating Performance in terms of the Number of Equipment that can be Operated Under a Full Battery Charge

Table 3 presents the evaluation of the device's operating performance in terms of the number of equipment that can be operated under a full battery charge. In addition, the specifications of the equipment were considered and observed as part of the analysis of performance outcomes.

The typical specifications of a 10-horsepower (HP) farm engine, commonly used in water pumps, tillers, and other small agricultural machinery, are also presented. Although exact values may vary depending on the manufacturer and model, the data provided represent standard ranges for small-scale agricultural engines used in practical field applications.

A 10-horsepower farm engine is commonly used in agricultural and small-scale industrial applications because of its reliable performance, durability, and fuel efficiency. This type of engine is generally designed as a single-cylinder, four-stroke, air-cooled engine that can operate continuously under demanding working conditions. It typically produces a rated power output of approximately 10 horsepower or about 7.5 kilowatts, with an operating speed commonly reaching 3,600 revolutions per minute (rpm), although some models are designed to run at 3,000 rpm depending on the intended application and load requirement.

The engine usually has a displacement ranging from 270 to 300 cubic centimeters (cc), allowing it to generate sufficient torque and power for agricultural machinery such as water pumps, blowers, power tillers, threshers, and other farm equipment. Most units use gasoline as fuel, although diesel-powered variants are also available for users who require higher fuel economy and longer operational life. To provide convenient operation, the engine may be equipped with either a recoil starter or an electric starting system.

For temperature regulation during prolonged operation, the engine commonly utilizes a forced air-cooling system, which helps prevent overheating and ensures stable performance even under heavy workloads. Fuel storage capacity generally ranges from 5 to 6.5 liters, enabling the machine to operate for several hours before refueling. In terms of lubrication, the engine commonly uses a splash lubrication system with an oil capacity of approximately 0.9 to 1.1 liters, which helps reduce friction and wear among moving components.

The engine's internal dimensions, particularly the bore and stroke, are typically around 77 millimeters by 58 millimeters, although these measurements may vary slightly depending on the manufacturer. It also operates with a compression ratio ranging from 8.0:1 to 8.5:1 for gasoline models, contributing to efficient combustion and dependable engine performance. Despite its power capability, the engine remains relatively portable, having a dry weight of approximately 25 to 30 kilograms.

In terms of performance characteristics, a 10 HP farm engine can produce an estimated torque output of about 18 to 22 Newton-meters at rated speed, making it suitable for operating equipment that requires consistent rotational force. Fuel consumption is generally around 2.0 to 2.5 liters per hour when running at full load, reflecting its efficiency for agricultural operations. Because of these specifications, the engine iA 12-horsepower farm engine. is a single-cylinder, 4-stroke engine commonly used in agricultural machinery because of its durability, fuel efficiency, and strong low-speed performance. It produces approximately 12 HP or 8.8–9 kW and operates within a speed range of about 2,400–3,600 rpm. The engine usually has a displacement of around 420–624 cc and may use either diesel or gasoline as fuel. Depending on the model, it can be air-cooled or water-cooled and may be equipped with a recoil or electric starting system.

In terms of performance, the engine can generate approximately 26–45 N•m of torque, making it suitable for heavy farm work. Gasoline engines commonly have a compression ratio of about 8:1, while diesel variants range from 18:1 to 21:1 for improved efficiency and power output. Fuel consumption is typically around 210–286 g/kWh at rated load, with an idle speed of about 1450 rpm.

The engine generally has a fuel tank capacity of 5–11 liters and an oil capacity of about 1.1–2.8 liters. Water-cooled models may require approximately 2.1 liters of cooling water. Its dry weight ranges from 30–110 kilograms depending on the design and construction. A 12 HP farm engine is widely used for operating power tillers, irrigation water pumps, rice threshers, hand tractors, and corn shellers because it delivers reliable power while remaining practical and serviceable in rural agricultural conditions is highly recommended for use in water pumps, blowers, and various farm machinery that require stable and dependable mechanical power.

The PFES's performance was evaluated based on the number of engines it could start under a full battery charge, focusing on two common engine capacities: 10 horsepower (hp) and 12 horsepower (hp). Results of the testing showed that a fully charged device was able to start 42 units of 10 hp engines and 37 units of 12 hp engines consecutively. This indicates the device's reliability and efficiency in reducing the physical effort required to initiate engine operation across multiple farm machines.

Furthermore, the ability of the device to start multiple engines on a single full charge was used as a key measure of performance. Field test results demonstrated strong dependability and operational efficiency, particularly for farmers who utilize multiple pieces of equipment in succession. These findings suggest that the device performs more efficiently with lower-capacity engines, as reflected in its higher number of successful starts for 10 hp units compared to 12 hp units (Lopez & Cruz, 2021).

Table 3: Operating performance in terms of the number of equipment that can be operated under a full battery charge.

Farm Equipment	Number of equipment operated when full charged
1. 10 hp for Blower	42 engine
2. 12 hp for Thresher and Hand Tractor	37 engine

General Acceptability of the development of Portable Farm Equipment Starter in terms of Composition, Safety Feature, Portability, and Functionality

The mean scores across these categories reflect the extent to which the device meets or exceeds user expectations, with each aspect assessed based on key criteria relevant to farm equipment. The composition dimension received the highest mean score of 4.71, interpreted as very acceptable. This indicates that respondents were highly satisfied with the materials used, construction quality, and overall design of the device. The composition of farm equipment is crucial for ensuring long-term durability, particularly in environments exposed to harsh weather conditions and continuous use. The strong rating suggests that the device is perceived as robust and reliable, providing confidence in its ability to withstand the demands of agricultural operations (Dias & Cunha, 2018). The use of quality materials and solid construction directly contributes to the overall performance and longevity of the equipment, making it a key factor in its acceptability.

The safety features dimension obtained a mean score of 4.69, also interpreted as Very Acceptable. This result indicates that respondents strongly agreed with the effectiveness of the device's safety mechanisms, which are essential in preventing accidents and ensuring safe operation. In agricultural machinery, safety is critical due to the inherent risks associated with mechanical and electrical components. The high rating reflects the device's ability to minimize hazards such as electrical overloads, mechanical failure, and environmental risks that may compromise user safety or equipment reliability (Zheng *et al.*, 2021). Safety features such as overload protection and proper insulation significantly enhance the device's usability and promote user confidence.

For portability, the device also received a mean score of 4.69, indicating that respondents found it easy to transport and handle across different work areas. Portability is a vital attribute of farm equipment, as it directly affects usability and operational efficiency in the field. Equipment that can be easily moved between locations enhances productivity by reducing setup time and improving workflow efficiency. The positive evaluation suggests that the device is well-suited for dynamic farming environments where frequent relocation of equipment is required. Additionally, ease of transport helps reduce user fatigue and supports more efficient field operations (Gao *et al.*, 2016).

The functionality dimension obtained a mean score of 4.61, likewise interpreted as Very Acceptable. This indicates that respondents were highly satisfied with the device's ability to perform its intended functions effectively. Functionality in agricultural tools is directly linked to performance consistency, ease of use, and reliability under various field conditions. The high rating suggests that the device operates efficiently and consistently, fulfilling its intended purpose without significant difficulty or failure, thereby supporting its practical application in agricultural operations (Majumder *et al.*, 2017).

The grand mean score of 4.67, interpreted as very acceptable, reflects a high level of general acceptability across all evaluated dimensions. This indicates that respondents are highly satisfied with the PFES in terms of composition, safety features, portability, and functionality. The consistently high ratings suggest that the device is well-suited for practical agricultural use, offering a reliable, durable, and safe solution for farm operations. The overall positive evaluation confirms that the device meets the essential needs of users and demonstrates strong potential for real-world application (Preece *et al.*, 2022).

The PFES has a high level of general acceptability, with strong ratings across all key dimensions. These findings suggest that the device is perceived as a reliable, efficient, and safe tool for agricultural operations, with features that support its durability and ease of use. The high level of acceptability further indicates its strong potential for adoption and integration into farming practices, addressing operational challenges commonly encountered by farmers (Dias & Cunha, 2018; Zheng *et al.*, 2021).

Acceptability of the Developed Portable Farm Equipment

Starter in terms of Composition

Among the evaluated features, the presence of a protection circuit board in the $LiFePO_4$ battery management system, which automatically regulates charging and discharging to prevent overcharge, deep discharge, short circuits, and overheating, obtained a mean score of 4.46, interpreted as Very Acceptable. This indicates that respondents placed high importance on the safe operation of the device, particularly in terms of electrical protection. The inclusion of such safety mechanisms enhances user confidence by minimizing potential hazards that may compromise both device performance and user safety (Chen, 2018).

The use of tabbing wire or nickel-plated strip connectors, which provide a low-resistance electrical pathway and ensure reliable current flow during charging and discharging, received a mean score of 4.70, also interpreted as very acceptable. This result indicates that respondents valued the stability and reliability of the device's electrical connections, which contribute to consistent performance and improved system durability (Aitken, 2023).

The starter relay, which enables the control of high current flow to the starter motor, obtained a mean score of 4.80, interpreted as Very Acceptable. This finding suggests that respondents recognized its importance in ensuring reliable engine ignition, making it a critical component in the overall functionality of the device (Dixit *et al.*, 2021).

The fuse, which protects the system from excessive current and electrical overload, received the highest mean score of 4.83, also interpreted as Very Acceptable. This indicates that respondents highly appreciated its role in safeguarding the device from potential electrical damage, thereby enhancing safety and operational reliability (Lee & Lee, 2020; Zheng *et al.*, 2021).

Lastly, the car starter, which initiates the engine's internal combustion process before disengaging, obtained a mean score of 4.80, interpreted as Very Acceptable. This suggests that respondents viewed it as an essential component for ensuring smooth and efficient engine operation, thereby contributing significantly to the overall effectiveness of the device (Islam *et al.*, 2019; Naranjo *et al.*, 2025).

Overall, the grand mean score of 4.71, interpreted as Very Acceptable, indicates a high level of acceptability of the composition of the PFES. This suggests that the device's electrical protection systems, functional components, and safety features are well-received by the respondents, highlighting its potential for reliable, safe, and efficient operation under real-world agricultural conditions (Majumder *et al.*, 2017; Lee & Lee, 2020).

These findings imply that the technical features of the PFES are sufficiently refined to support its potential application in real-world agricultural settings. The high level of acceptability in terms of safety features, portability, and functionality suggests that the device can be operated reliably without compromising user safety or causing operational discomfort. Since these technical features are directly associated with durability, ease of use, and operational efficiency, the results further indicate that the device has strong potential for adoption as a practical and dependable tool for agricultural applications.

The consistently high ratings across all evaluated features demonstrate that the PFES is well-suited for use in demanding farm environments. It provides essential protection against electrical hazards, offers ease of transport across different field conditions, and ensures efficient functionality under varying operational demands. The strong acceptance of these features suggests that the device may significantly enhance operational productivity in agricultural settings while promoting safety, convenience, and user efficiency.

Acceptability of the Development of Portable Farm Equipment

Starter in terms of Safety Feature

Product composition plays a critical role in the acceptability and long-term usability of farm equipment. For the PFES, factors such as material quality, structural integrity, weight, and mechanical connectivity directly influence its durability, ease of use, and operational reliability. Table 6.2 presents the respondents' evaluation of the developed device in terms of safety features, focusing on materials used, workmanship, weight suitability, mechanical linkage, and overall product durability (Majumder *et al.*, 2017; Gao *et al.*, 2016).

The highest mean score of 4.80, interpreted as Very Acceptable, was obtained by the automotive wire, which is designed to withstand harsh conditions such as heat, vibration, moisture, oils, and chemicals. This result suggests that respondents highly valued the wire's durability and reliability in demanding environments. In farm equipment applications, components exposed to extreme conditions must maintain stable performance, and this high rating reflects confidence in the system's ability to function effectively under such conditions. Durable wiring is essential for the safe and efficient operation of farm equipment, as electrical failures may result in malfunctions or safety hazards in agricultural settings (Kim *et al.*, 2017; Preece *et al.*, 2022).

Closely following this result, the safety switch, which allows controlled and secure operation of the device, obtained a mean score of 4.73, also interpreted as Very Acceptable. This indicates that respondents highly appreciated the ability to regulate device activation and deactivation, which is essential in preventing accidental or unintended operation. In agricultural environments where safety is a major concern, such control mechanisms are critical in ensuring user protection and operational safety (Lee & Lee, 2020; Zheng *et al.*, 2021).

The battery enclosure, designed to protect the battery from contact with metal surfaces and prevent sparking, received a mean score of 4.63, also interpreted as Very Acceptable. This suggests that respondents recognized the importance of this protective feature, although it was perceived as slightly less critical compared to other components. Nevertheless, the rating indicates confidence in the device's ability to protect the battery system, which is essential in preventing electrical hazards and potential fire risks (Islam *et al.*, 2019; Naranjo *et al.*, 2025).

The protective casing made from polyvinyl chloride (PVC) obtained the lowest mean score of 4.60, still interpreted as Very Acceptable. This indicates that respondents found the casing suitable for protecting internal components from external elements such as moisture, dust, and physical impact. The use of PVC reflects an emphasis on durability and environmental resistance, which are essential for equipment intended for agricultural field conditions (He *et al.*, 2016; Majumder *et al.*, 2017).

The grand mean score of 4.69, interpreted as Very Acceptable, indicates that respondents are highly satisfied with the safety features of the PFES. The results suggest that the materials used, quality of workmanship, and safety mechanisms contribute to a durable, reliable, and safe device that is well-suited for agricultural environments (Preece *et al.*, 2022; Zheng *et al.*, 2021).

Overall, the computed grand mean of 4.69, interpreted as very acceptable, indicates a high level of acceptability in terms of safety features for the PFES. These results demonstrate that the device's physical construction, including its materials, safety mechanisms, and durability, meets the standards expected for farm equipment used in harsh environments.

This implies that careful attention to material selection, structural integrity, and the incorporation of protective features significantly enhances the acceptability of farm equipment. High acceptability in terms of safety features suggests that users are more likely to trust and consistently use devices that are perceived as secure, well-constructed, and resistant to environmental stressors. Consequently, the strong evaluation of the safety features supports the device's readiness for real-world application and suggests its potential for long-term use with minimal risk of malfunction or failure, even under challenging conditions.

Acceptability of the development of the Portable Farm

Equipment Starter in terms of Portability

The highest mean score of 4.83, interpreted as very acceptable, was obtained for the device's lightweight nature, indicating that respondents found it easy to lift and handle. This suggests that the device is sufficiently light for frequent movement across different farm locations, which is an essential characteristic of portable agricultural equipment. Portability is a key factor in improving operational efficiency, as equipment that is easy to carry and maneuver is more likely to be adopted and effectively integrated into daily farming activities. Studies on farm mechanization emphasize that lightweight and portable designs reduce physical strain and enhance user satisfaction (He *et al.*, 2016; Majumder *et al.*, 2017).

The statement assessing the ease of transferring the device from one location to another obtained a mean score of 4.63, also interpreted as Very Acceptable. This indicates that respondents considered the device convenient to relocate during farm operations. The ability to move equipment quickly between work areas is particularly important in agricultural settings where time efficiency directly affects productivity.

The device's design, including the GI pipe holder and integrated switch for ease of operation, received a mean score of 4.66, likewise interpreted as Very Acceptable. This reflects the respondents' appreciation of the device's user-friendly design, which enhances handling and operational convenience. An ergonomic and intuitive design is essential in agricultural tools, as it reduces user effort and supports efficient task execution in demanding field conditions.

The protective cover made of polyvinyl chloride (PVC), which was flattened using a heat gun, obtained a mean score of 4.70, interpreted as very acceptable. This suggests that respondents viewed the cover as both durable and sufficiently lightweight, contributing to the device's portability while providing adequate protection for its internal components. The use of durable and weather-resistant materials is essential in agricultural environments where equipment is exposed to moisture, dust, and physical impact.

Overall, the grand mean of 4.70, interpreted as very acceptable, reflects a high level of acceptability in terms of portability. The findings demonstrate that the PFES is easy to transport, handle, and operate, making it a practical tool for agricultural use. The consistently high ratings indicate that the device is well-suited for farm environments where mobility, convenience, and ease of use are essential, further supporting its potential for real-world application.

This implies that careful attention to weight, user-friendly design, and portability features significantly enhances the acceptability of farm equipment. High acceptability in terms of portability suggests that users are more likely to trust and consistently use devices that are perceived as easy to handle, transport, and operate, especially in environments where mobility and efficiency are crucial. Consequently, the strong evaluation of portability supports the device's readiness for real-world application and suggests its potential to improve productivity and convenience in farming operations with minimal strain or difficulty for the user.

Acceptability of the development of the Portable Farm

Equipment Starter in terms of Functionality

Safety is a critical component in the design and implementation of farm equipment, particularly for devices that integrate electrical and mechanical systems and are exposed to harsh environmental conditions. The respondents' assessments reflect key safety aspects, including protection against electrical hazards, insulation quality, overload protection, and overall design suitability for safe and efficient operation in farming environments.

The highest mean score of 4.86, interpreted as Very Acceptable, was obtained by the fuse, which functions to interrupt electrical flow in cases of excessive current, thereby preventing damage to wiring and components and reducing the risk of fire hazards. This result indicates that respondents highly valued the fuse's role in ensuring safe device operation, particularly in agricultural applications where electrical loads may fluctuate. Overload protection is essential in electrically powered equipment used in variable and demanding field conditions. The strong rating suggests a high level of confidence in the device's reliability and its capacity to mitigate electrical risks, thereby enhancing long-term usability (Dias & Cunha, 2018; Zheng *et al.*, 2021).

Following this, the protection circuit board, which automatically stops charging or discharging to prevent overcharging, deep discharge, and overheating, obtained a mean score of 4.80, also interpreted as Very Acceptable. This indicates that respondents recognized the importance of this component as a critical safety mechanism that ensures stable and efficient device operation over time. In agricultural environments where equipment is often used continuously and under variable power conditions, thermal and electrical protection is essential. The inclusion of this system enhances device longevity and provides users with assurance of operational stability, thereby minimizing downtime during critical farming activities (Majumder *et al.*, 2017; Lee & Lee, 2020).

The battery enclosure, designed to prevent sparks from occurring through metal contact, received a mean score of 4.63, still interpreted as very acceptable. Although slightly lower than the previous components, this result indicates that respondents still recognized its importance in protecting the battery system from electrical faults. The enclosure is particularly significant in farm environments where exposure to dust, moisture, and mechanical stress is common. By preventing sparks and electrical short circuits, it contributes to overall device safety and reduces the risk of fire and equipment failure (Islam *et al.*, 2019).

Lastly, design suitability, which evaluates whether the device's structure supports safe and convenient operation, obtained a mean score of 4.70, interpreted as very acceptable. This suggests that respondents found the device ergonomically designed and easy to operate without compromising user safety. In farm equipment, where both efficiency and operator safety are essential, a well-designed structure enhances usability and ensures that the device can be operated effectively under real field conditions (Gao *et al.*, 2016; Kim *et al.*, 2017).

Overall, the grand mean of 4.74, interpreted as very acceptable, demonstrates that the PFES is perceived as safe for use under typical agricultural conditions. The consistently high ratings across all safety-related indicators suggest that the device has been designed with careful attention to minimizing risks associated with electrical malfunctions, environmental exposure, and user operation. The positive evaluations indicate that the device is well-suited for deployment in real-world farming environments, where safety and equipment reliability are essential (Majumder *et al.*, 2017; Lee & Lee, 2020).

This implies that the PFES meets the critical safety requirements necessary for its intended field application, with features specifically designed to enhance user confidence and reduce operational hazards. The strong ratings for overload protection, electrical insulation, and protective casing further suggest that the device is not only functional and reliable but also safe for sustained use under diverse and demanding conditions. Such integrated safety mechanisms support its potential for confident use in agricultural operations and strengthen its suitability for broader adoption in farming communities (Preece *et al.*, 2022; Zheng *et al.*, 2021).

CONCLUSIONS

The PFES proved to be an effective and practical solution for starting small farm engines. The device shows reliable performance throughout testing and consistently cranks engines within the targeted horsepower range. Its portable, ergonomic design made it easy to use in field conditions, significantly reducing the physical effort typically needed with traditional recoil starters. The evaluation also reveals that battery discharge occurred gradually and predictably with repeated use. While the voltage drops slightly after each engine start, the device maintains reliable functionality throughout the test cycle. This demonstrates that the PFES can support multiple engine starts on a single full charge without compromising its starting power. The PFES effectively achieves its goals of improving starting efficiency, reducing operator fatigue, and increasing convenience in agricultural engine operation. With further improvements, especially in battery capacity and durability, the device holds strong potential for broader use and adoption in supporting modern farm equipment.

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