DisKURSO INTERNATIONAL MULTIDISCIPLINARY RESEARCH JOURNAL
E-ISSN: 3116-3106 | P-ISSN: 3116-3084

Small Engine Fuel Pump Breakdown Detection Device

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DOI: 10.63941/DisKURSO.2025.1.1.9

Article Information

Received: July 22, 2025

Accepted: September 26, 2025

Published: November 12, 2025

Keywords

Accuracy; Reliability; Portability; Fuel Pump; Cost-Effectiveness

ABSTRACT

Fuel pump detection systems play a crucial role in modern vehicles by monitoring the operation and performance of fuel pumps to ensure optimal efficiency and reliability. This abstract explores recent advancements in fuel pump detection technology, focusing on key aspects such as accuracy, reliability, portability, and cost-effectiveness. The accuracy of these systems is essential for detecting anomalies in fuel pump operation, preventing potential failures, and optimizing fuel consumption. Recent developments in sensor technology and data analysis techniques have improved the accuracy of fuel pump detection systems, enabling real-time monitoring and diagnostics. Reliability is another critical factor in fuel pump detection systems, as vehicle safety and performance depend on their continuous operation. Evaluating the reliability of these systems involves rigorous testing under various conditions, including long-term durability testing and fault tolerance evaluation. Portability is increasingly important in fuel pump detection systems, particularly for applications such as field diagnostics and mobile repair services. Portable systems must be compact, lightweight, and easy to install, ensuring flexibility and convenience for users in diverse environments. Cost-effectiveness is a key consideration for deploying fuel pump detection systems in commercial fleets and automotive maintenance facilities. Evaluating the total cost of ownership, including initial investment, maintenance costs, and operational efficiency gains, helps determine the overall value proposition of these systems.

INTRODUCTION

The automotive industry is fundamentally changing toward innovative technologies, prioritizing performance and safety. The fuel pump is vital to the effective running of internal combustion engines. The fuel pump's smooth operation is essential for vehicle performance. Still, it's prone to many irregularities that, if left unchecked, can result in severe consequences such as unexpected failures, lower fuel pressure, and decreased safety. Despite the significance of the fuel pump in vehicle operation, there exists a gap in current automotive technology concerning the early detection of fuel pump anomalies. The absence of a dedicated early warning system may result in unforeseen breakdowns, safety hazards, and increased repair costs. Bridging this gap is crucial for advancing automotive reliability and ensuring a safer and more efficient driving experience. The fuel pump, an unseen, crucial component of the vehicle, needs help to identify the problems due to its installed location inside the fuel tank; it may face several issues that might disrupt its smooth performance. Examples are Wear and tear, contamination, and lousy operating conditions, which can seriously threaten fuel distribution.

The Current automobile technology lacks an exclusive technique or device for detecting irregularities inside the fuel pump, resulting in a crucial gap in our capacity to deal with issues before they worsen. In response to this need, we are focusing our research on the development and importance of an innovative device known as the Small Engine Fuel Pump Breakdown

Detection Device. This device shows a crucial improvement in automotive fuel systems, aiming to effectively discover abnormalities within the gasoline pump and provide timely Warnings to drivers and maintenance personnel. The detection system provides vital, easy warning of dangerous anomalies in the fuel pump. Some gases and vapors also pose a fire risk, and another risk arises when anomalies such as losses of pressure and fuel pump failure create severe damage to the engine. Example: leaking due to a drop in pressure of the fuel injected became lean; not achieving the atomized form of fuel injected by the injector, which will result in an engine power loss or irregular RPM (revolution per minute); and fuel pump breakdown caused by clogging up the fuel filter. Due to its old age, the fuel became weak, resulting in losses of pressure and fuel pump failure; the engine will cut off, and sometimes you will be stranded on the road. The condition of the fuel pump is quite difficult to notice because it is inside the fuel tank. Sometimes, the technician misdiagnoses and replaces it, even though it is not the main problem. The fuel pump is expensive and will cost the vehicle owners a lot of money. The fuel pump, a fundamental component in a vehicle's fuel delivery system, is pivotal in maintaining optimal engine performance. However, factors such as Wear and tear, contamination, and suboptimal operating conditions can compromise the health of the fuel pump, leading to inefficiencies and potential failures. Recognizing the need for an innovative solution beyond reactive maintenance, our research delves into developing a Small Engine Fuel Pump Detection Device. (Wuling, 2023). As Muhammad (2021) mentioned, "Gas leakage detection systems are essential components of safety systems, serving as the primary defense against potential gas leakage disasters. The device detects the presence of gas leaks and initiates an alert system to activate safety measures." As Delphiblog (2023) mentioned, "In the fuel delivery- the detection device, they measure both the pressure and volume of the fuel being delivered through the system under standard testing conditions. In addition to testing for pressure and volume, measuring the amperage of the fuel pump circuit can assist in identifying the underlying reason for the issue." Some leaks are too small to smell or unnoticeable, and you can't tell at first glance if your fuel pressure is dropping, so it's a worthwhile investment to install a detection device to ensure the safety of the vehicle and motorcycles. The timeframe of the research project is around 43 weeks or about 10 months.

MATERIALS AND METHODS

Project Design

This project-based research focuses on the general application, implementation advantages, and performance of a Small Engine Fuel Pump Breakdown Detection Device. It includes the research method, project design, development, testing, operating procedures, and project evaluation. The study was conducted in the Engineering Department.

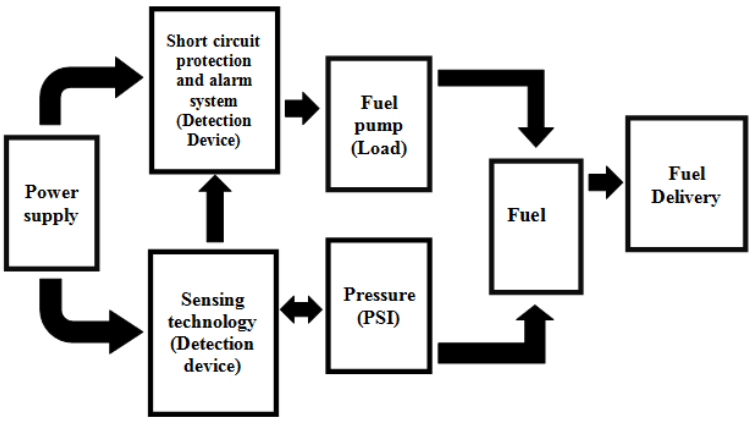

Figure 1. *Block diagram of Small Engine Fuel Pump Breakdown Detection Device.*

In Figure 1. The fuel delivery system is complex and relies on a reliable power supply, short circuit protection, and an alarm system to ensure smooth operation. The power supply provides the necessary energy for the system, while the short-circuit protection and alarm system safeguard against potential hazards. Advanced detection devices and sensing technologies enhance the system's efficiency by monitoring parameters such as fuel pressure.

The fuel pump, a dynamic component, operates under the directives of these devices, adjusting its performance to meet demand. The sensing technology continuously monitors and communicates with the fuel pump to regulate its output, ensuring optimal fuel pressure for combustion. Integrating these components with intelligent monitoring and control systems creates a robust infrastructure for efficient and secure fuel transportation in the automotive or industrial environment.

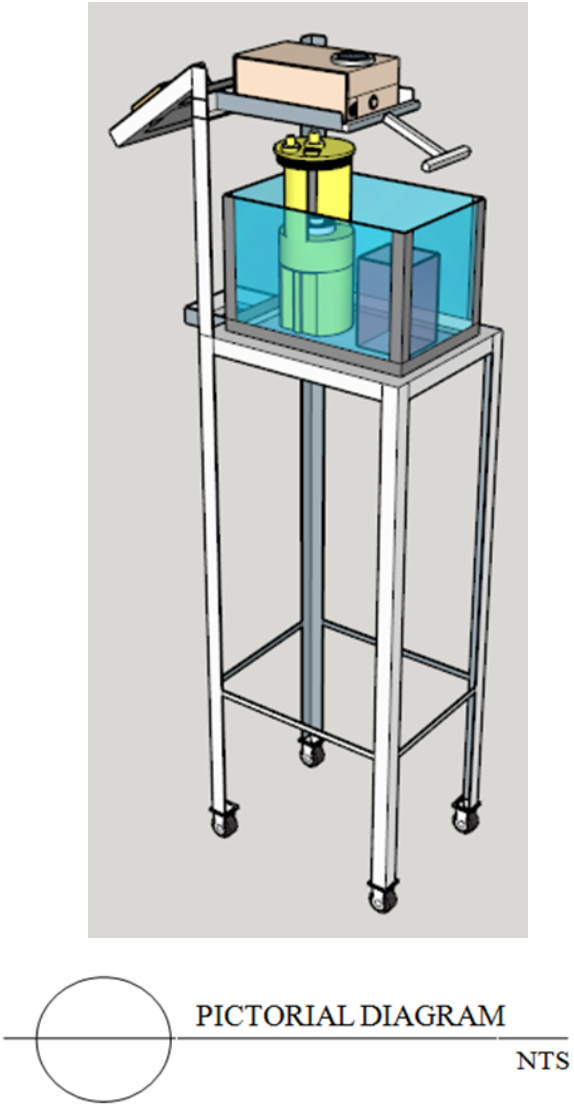

Figure 2. Pictorial diagram of the proposed project

The diagram in Figure 2 depicts the design of the proposed research project. The frame is constructed from 1”x1” angular steel, providing support for the mock-up. At the top, there is a main control unit connected to a gauge meter. Casters will be installed to facilitate easy transportation.

Project Development Procedure

The project development showed how the researchers planned the construction of the Small Engine Fuel Pump Breakdown Detection Device. Procedures were presented in a flowchart illustrating the project's development phases.

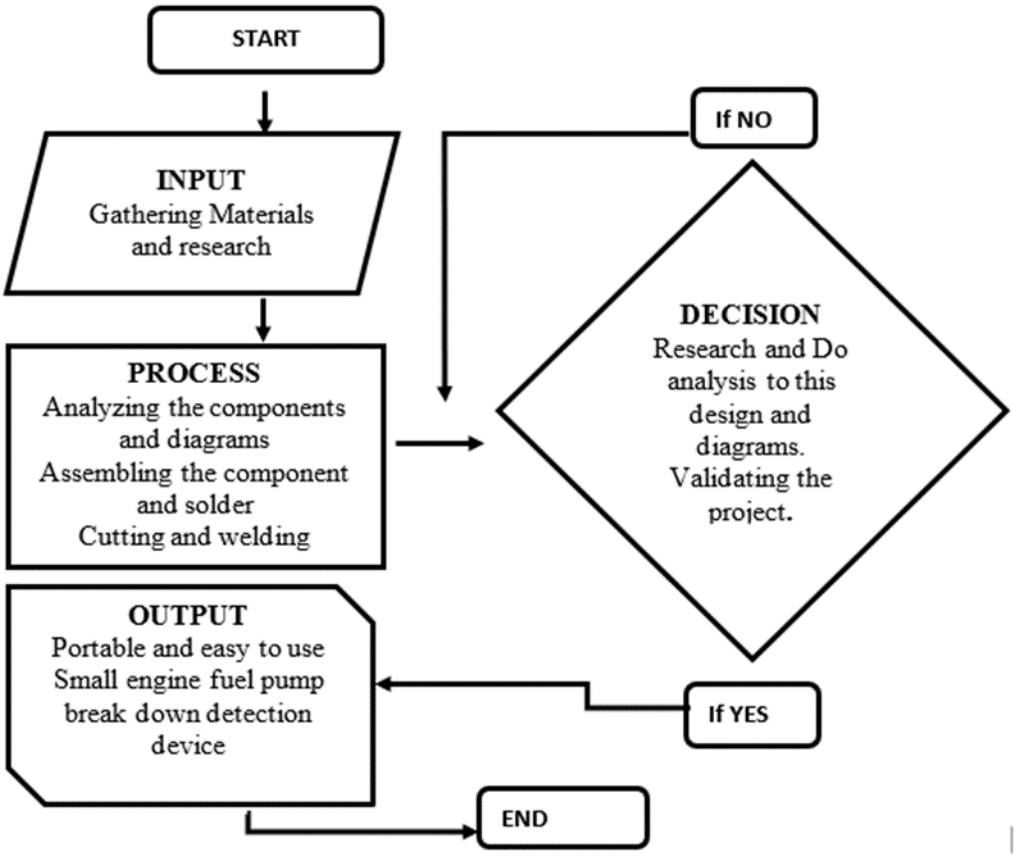

Figure 3. Fuel Pump Detection Device Flow Chart

Figure 3.3 shows the study's flow chart. The first objective is to determine how the researcher gathers data for the chosen study. Input: gathering materials such as a sensor, a 12V relay, a 100k multi-turn potentiometer, a BC547 transistor, a 1k ohm resistor, a bicolor (dual color, red/green) LED 1.5v, and a momentary switch. Process: gathering data and determining research on how to make an effective power/short circuit protection system, an applicable sensor device, and a flexible diagram design. Analyze this design through wiring diagrams, validate the project design, construct the final design using suitable steps, and apply it to the detection device, test and evaluate, and validate the final output and decision; all the materials and research are being evaluated, finalized, and agreed upon by the researchers and evaluator. Output: small engine fuel pump breakdown detection device.

Testing and Operating Procedures

In this stage, the researcher conducted testing and operating procedures to test the general functionality, including reliability, accuracy, portability, and cost-effectiveness of the components and operation. The problem is that revisions are made once the project has reached a reasonable and acceptable level of performance.

Testing Procedure

In this procedure, the researcher used a Voltmeter Ammeter and Pressure Gauge as testing instruments to check the performance of the Small Engine Fuel Pump Breakdown Detection device.

Phase 1: Simulation and Experimentation Project Research, Short circuit detection system.

Step 1: Log in to the 12V power supply
Step 2: Test the fuel pump short-circuit protection and alarm-detection system input voltage presence using a Voltmeter tester.
Step 3: Test the output voltage and amperage present using an Ammeter tester.
Step 4: We are activating the fuel pump.
Step 5: By creating a short circuit in the output terminals, the detection device becomes active and sends an alarm signal.
Step 6: Testing the input and output voltage again to ensure no issues happened.
Step 7: Activate the fuel pump again for 1 hour, create a short circuit, and test whether the detection system responds well.
Step 8: The test runs well consecutively and lasts a duration of 12 hours.

Phase 2: Simulation and Experimentation Project Research, sensor or sensing system.

Step 1: Activating the fuel pump to suck the fuel goes to the fuel line to create fuel pressure.
Step 2: Test the sensor input voltage present.
Step 3: The sensor will respond well if there's pressure in the fuel line.
Step 4: Measure the Pressure (PSI) present using a Pressure Gauge.
Step 5: Record the time when the signal responds using a Timer.
Step 6: They are intentionally dropping the fuel pressure or creating leaks.
Step 7: The pressure drops and the sensor sends an alarm signal.
Step 8: The pressure-dropping test records the time duration of the pressure drop of every signal indicator.

Operating Procedure

Step 1: Prepare the materials needed.
Step 2: Prepare the necessary testing Instruments, such as a voltage and ammeter, a pressure gauge, and a time watch.
Step 3: Construct a suitable diagram for a Small Engine Fuel Pump Breakdown Detection Device.
Step 4: Connect the input and output terminals to their designated terminals.
Step 5: Connect the hose to the designated connection.
Step 6: Make sure the researcher follows what's on the diagram.
Step 7: Review the wire connection on its designated terminal
Step 8: And activation
Step 9: Log in to the 12V power supply.
Step 10: The current flow from the 12V power supply is distributed to the fuel pump and sensors.
Step 11: Test the voltage present.
Step 12: Test the breakdown response.
Step 13: If everything is functional without any issues, the researcher can conclude that the research project performs appropriately.

Project Evaluating Procedure

This study used the descriptive method. The descriptive study design entails systematically collecting data on a particular subject matter without attempting to deduce cause-and-effect correlations. Furthermore, descriptive research encompasses surveys, observational studies, and case studies, with the potential to gather qualitative or quantitative data (Sirisilla, 2023).

Evaluation Instrument

This research project uses surveys to acquire information about small engine fuel pump breakdown detection devices. The first begins with the distribution of a survey questionnaire to the study's participants, and it ends with the collection and analysis of the gathered data. The statements are answerable using a point rating scale.

Criteria for Evaluation

The project evaluation for a fuel pump detection device should cover various aspects, including project planning for diagram design, technical aspects, risk management, testing, quality assurance, user interface, performance metrics, and future development. The lessons learned can be applied to future projects. The following are the testing procedures for the said components using the testing instruments, such as a voltage meter, an ammeter, a pressure gauge, and a timer. The research project is evaluated in terms of the functions of each component accordingly, such as: The reliability of a fuel pump detection device is assessed based on factors like detection reliability, downtime, response time, environmental resilience, durability, component reliability, emergency response, longevity, and testing. The accuracy of a fuel pump detection device can be assessed through benchmark comparison, false positives, detection sensitivity, precision, calibration, environmental influences, and user feedback. Regular calibration and validation are crucial for ensuring accuracy under different conditions. The portability of a fuel pump detection device is assessed based on factors such as size, weight, mobility, power consumption, durability, and resilience. It also considers compatibility with vehicles, communication, user interface accessibility, and remote monitoring. The cost-effectiveness evaluation of a fuel pump detection device considers the initial investment, reduces maintenance cost, enhances fuel economy, and impacts energy efficiency compared to alternatives. The study involves respondents choosing a number (1 to 5) to express their opinion on the cost-effectiveness of a fuel pump detection system.

Rating Scale

According to Likert (1932). The Likert scale is a quantitative measurement tool commonly employed to assess individuals' opinions, attitudes, or behaviors. This structure consists of a statement or a question, followed by a sequence of five or seven answer statements. Participants select the choice most accurately aligns with their sentiments towards the statement or query. A 5-point Likert scale is a psychometric tool that allows respondents to quickly express their level of agreement with questions using a scale of five points. This study was patterned with the Likert-type scale.

Statistical Tools

This research aims to explore the application and efficacy of two fundamental statistical tools weighted mean and percentage formula in data analysis. The study will investigate these tools' theoretical underpinnings, practical applications, and comparative advantages in handling real-world data sets. The weighted mean and percentage formulas are particularly noteworthy for

their versatility and precision among various statistical tools. This research seeks to clarify how these tools enhance data analysis processes, ensuring accurate and meaningful interpretations.

RESULTS AND DISCUSSION

Project Description

The efficient operation of fuel systems is essential in all types of vehicles. However, it faces obstacles such as pump failures and safety measures. This research project focuses on developing an advanced fuel pump detection device. The device aims to identify irregularities in gasoline pumps and fuel distribution, thereby enhancing security and efficiency. The project aims to improve fuel control methods in various operating conditions by giving early warnings and safety measures.

Evaluation Results

Fuel pump detection systems are critical for monitoring fuel pump performance in vehicles. They utilize sensors to measure parameters like fuel pressure and flow rate, enabling real-time monitoring and diagnostics. Advancements in sensor technology have led to enhanced precision and dependability of systems, which are subjected to thorough assessments to ensure accuracy and long-lasting performance. Portable designs allow for field diagnostics, enhancing convenience. Cost-effectiveness considerations are crucial, balancing initial investment with maintenance costs and operational efficiency gains.

Project Design

1.1. The design is light, flexible, and reasonably portable for its size.

1.2. Due to its design, the device can be applied to any environment.

1.3. The device has an easy wiring connection, which is standard for motorcycles.

Project Development

1.1. The development of the study was challenging. Some difficulties were experienced when finding suitable materials for the project. Since this was a new venture, every step was upside down, and the researcher experienced failures, purchasing the wrong materials, and more.

1.2. The researchers needed some help with the measurements of the project design.

1.3. When putting the components together, the researchers overcome problems like destroyed parts.

Project Functionality Test

1.1. **Sensor Performance**. Testing the accuracy and responsiveness of sensors, such as oil pressure sensors and pressure transducers, to detect varying fuel pump conditions accurately.

1.2. **Assembly and Integration**. Assessing the assembly process to ensure components are securely mounted within the project box, with proper wiring connections and effective integration to prevent damage or operational issues.

1.3. **User Interface**. Evaluating the user interface for simplicity and effectiveness, ensuring that it provides intuitive controls and clear feedback to operators during monitoring and troubleshooting.

1.4. **Safety Measures**. Validating the device's ability to activate safety measures promptly in response to detected anomalies, such as fuel leaks or pump failures, to prevent potential hazards

Project Evaluation

1.1. The reliability of the device has very positive reviews, with an average mean of 4.46

1.2. The device's accuracy has been very positive, and they are delighted with its performance. With an average mean of 4.45

1.3. The portability and user interface of the project were strongly agreed upon, which means evaluators have a very positive view of the fuel pump detection device's appearance, size, and flexibility, able to adapt to different environments and different platforms, and are delighted with its proficiency. With an average mean of 4.38

The project's cost-effectiveness was strongly agreed upon, meaning evaluators have a favorable view of the fuel pump detection system; they likely see it as reliable and effective. With an average mean of 4.42

DISCUSSION

The researchers examined and reviewed the study results and came up with the following conclusion.

Project Design

1.1. The fuel pump breakdown detection device boasts a design that is light, flexible, and reasonably portable, making it convenient to handle and install.

1.2. Its versatile design allows it to be applied in various environments, enhancing its adaptability and broad usability.

1.3. The device features easy wiring connections that are standardized for motorcycles, ensuring straightforward and efficient integration into existing systems. This combination of portability, versatility, and user-friendly installation makes the detection device an excellent solution for improving fuel pump management and security across diverse settings.

Project Development

1.1. The development of this project presented significant challenges and learning opportunities throughout its journey. Finding suitable materials posed initial difficulties, compounded by the exploratory nature of the venture, which led to setbacks such as purchasing incorrect components and encountering unexpected failures.

1.2. Collaborative efforts were crucial, particularly in obtaining accurate measurements and overcoming assembly challenges, including the unfortunate occurrence of damaged parts.

1.3. Despite these obstacles, the project's progression underscored the resilience and adaptability of the research team, culminating in valuable lessons learned and a refined understanding of project management and component integration. These experiences have not only enriched the development process but also paved the way for future innovations in similar endeavors.

Project Functionality Test

1.1. Through rigorous testing of sensors, electrical components, assembly integrity, user interface effectiveness, environmental adaptability, and safety measures, the device has proven its capability to accurately detect fuel pump anomalies and activate timely responses.

1.2. These results validate the device's readiness for deployment, ensuring enhanced fuel management efficiency and operational safety in diverse industrial and automotive applications.

1.3. Users can rely on its accurate sensor readings, seamless integration into different environments, and intuitive user interface for efficient monitoring and troubleshooting.

1.4. The functionality test of the fuel pump breakdown detection device has demonstrated its robust performance and reliability across various critical parameters.

Project Evaluation

1.1. The fuel pump breakdown detection systems are essential to modern vehicle technology and offer efficiency, performance optimization, and increased reliability. Due to developments in sensor technology and project design, these detection systems have developed to deliver more precise and reliable fuel pump operation monitoring.

1.2. The research findings highlight the importance of accuracy in detecting fuel pump anomalies, which can prevent potential failures and optimize fuel consumption. Additionally, evaluating reliability through rigorous testing under various conditions ensures continuous operation and enhances vehicle safety.

1.3. Fuel pump detection systems' portability allows them to be utilized in various settings, including field diagnostics and repair services, which increases operator flexibility and convenience.

1.4. Evaluating these systems' total value proposition requires careful evaluation of cost-effectiveness factors, such as initial investment, maintenance expenses, and effectiveness enhancements.

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