Design modification and advancement in vending machine

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Abstract **- The paper aims to improve vending machines by introducing new modifications and advancements. Historically, vending machines have dispensed various items in exchange for coins or tokens. With advanced electronic components, the mechanical vending machine has been modernized, enabling seamless transactions through cashless payments using QR code scanning. This innovation enhances the overall user experience by ensuring customers receive their selected items with precision and reliability. A motor shield has been incorporated to efficiently control the vending mechanisms, enhancing user experience and operational reliability. The core controller of the machine, an Arduino Mega 2560, orchestrates the functionalities of QR code scanning and communication with the SIM800L module for processing cashless transactions. Users can easily make purchases by simply scanning a QR code generated by their mobile devices, eliminating the need for physical currency. Additionally, an Arduino UNO is employed to display advertising content, providing relevant information and promotional offers that enrich the user experience. This additional feature not only serves as a means of revenue generation but also showcases the potential of Arduino-based solutions in revolutionizing traditional vending systems and meeting the demands of modern consumers in an increasingly digital world. The advanced vending machine prototype also enhances hygiene standards through touchless transactions, minimizing physical contact with vending machine surfaces. The implementation of this technology demonstrates a significant advancement in vending technology, offering increased convenience, efficiency, and adaptability to evolving consumer preferences. The creators of this technology are proud to introduce it to the market, and they are confident that it will transform the way people interact with vending machines.**

Keywords **- Arduino Mega 2560, SIM 800L, Motor Shield, Cashless payments, QR code scanning, User experience.**

I. INTRODUCTION

Vending machines are a form of automated machines that have evolved with the addition of new features. These machines allow customers to pay for a product using coins, tokens, or cards and dispense the product once payment has been received. The products dispensed by these machines can range from beverages and snacks to tickets, receipts, and even change. In Western countries, vending machines that rely on coin intake with currency recognition techniques like image subtraction techniques are common. However, they are not as popular in India, and current vending machines are often inconvenient and insecure. To address these issues, a new model for a vending machine has been developed that accepts paper currency, detects it using less expensive techniques, and is more secure. This vending machine is controlled by a system that includes a main module, a payment system, a user interface system, a product extraction system, and a communication system. With advancements in technology, vending machines are moving away from coins and towards plastic money. They are also referred to as machines that provide service at an unattended point of sale with monetarily driven equipment. Vending machines have a long history of automated control. Over time, they've evolved with technological advancements and various features. These machines accept payment in coins, tokens, or cards and dispense products like drinks, snacks, tickets, receipts, or change. While prevalent in Western countries, vending machines are less common in India and other parts of the world, providing opportunities for innovation.

Traditional vending machines face a major challenge due to their reliance on coin-based payment systems and rudimentary currency recognition techniques. These methods have served their purpose, but they lack the convenience and security that modern consumers expect. Hence, there is a pressing need for a new model of vending machine that can accept cashless payment and detect it using more reliable techniques, ultimately enhancing security for both operators and users. The modern vending machine is a sophisticated piece of technology controlled by an intricate system comprising various components. This system includes a central main module, a payment system, a user interface system, a product extraction system, and a communication system. These components work together seamlessly to ensure that the vending machine operates smoothly, delivering products or services to customers while handling transactions securely. With the rapid advances in technology, vending machines are transitioning from coin-based systems to accommodating cashless payment, marking a shift towards becoming unattended points of sale with monetarily driven equipment.

Vending machines can also serve as advertising platforms, providing a unique customer experience while promoting products. This research aims to design a vending machine that can dispense a diverse range of products to increase profitability and appeal to a broader audience. It will investigate the challenges and opportunities present in the industry and discuss the methodology and design considerations for an innovative

model. The goal is to enhance the convenience, security, and adaptability of vending machines in the digital age.

Murnea, E. et al., [1] Three concepts for designing a vending machine control system are suggested, Concept A uses an IoT Gateway Device powered by an Intel Atom processor, Concept B uses an 8-bit Nuvoton W78E052DDG microcontroller with a PID controller and Concept C uses a PLC with ladder logic instructions. Krischer, J. [2] The paper introduces a low-cost package advancement system for vending machines with X-Y picker assemblies. This system facilitates package movement on the vending machine's shelf and outlines potential methods for loading, securing, and dispensing packages. Ratansi, N. and Sharmilan,T. [3] discusses non-IoT and IoT-based vending machine technologies. Non-IoT machines use sensors and cameras to detect fluid levels and accept various forms of payment. It also includes a brief overview of IoT-based vending machine technologies. Bhodale, A. and Kulkarni, J. [4] studied various vending machines, focusing on smart coffee and soda vending systems. The proposed state machine design for a soda vending machine ensures that change is provided as needed. Smart vending machines offer customizable options for coffee or tea preparation, potentially leading to increased user satisfaction. These systems have communication interfaces for real-time monitoring and management, enhancing user experiences while optimizing operational efficiency. Plaha, B. and Singh, B. [5] literature presents the design of a vending machine that accepts paper currency and uses IR sensors to differentiate between genuine currency and ordinary paper. The hardware implementation includes the AVR ATmega8515 microcontroller, power supply regulation, push-button switches, LCD interfacing, solenoid valve activation, IR sensors, and ADC for currency detection. Desai, S. et al., [6] This project focuses on developing an Automatic Chocolate Vending Machine using Arduino Uno. The vending machine offers a cashless payment system using Radio Frequency Identification (RFID). The system has three main components: RFID card scanning, Arduino programming, and product display and delivery. Users can select their desired products and pay without physical currency by scanning their RFID card. Kim, K. et al. [7] introduced a smart coffee vending machine that uses IoT technology, smartphone apps, and sensor networks. It features magnetic sensors to detect cleaning status and controllers to adjust coffee customization. Chadha, A. et al., [8] The literature talks about the introduction of a chocolate vending machine and how it operates using Finite State Machines (FSMs) in its design. It also discusses other related works in the field of vending machines and FSM-based digital design, including a vending machine for steaming frozen food using conceptual modeling, research on automatic mobile payment using FSM-based digital design, and passenger requirements for public transport ticketing system, which may be relevant to user interface design in vending machines. Sibanda, V. et al., [9] This document discusses the use of Arduino-based control software for a high-tech vending machine. It includes components like the H-bridge, Arduino board, breadboard, pushbuttons, LED, and connectors to facilitate product dispensing and customer interactions. Jianbo, Z. et al. [10] This literature provides an overview of the development, hardware, and software design of a vending machine control system, emphasizing the integration of PLC technology. A clever solution for modern transportation systems is a smart automatic ticket vending machine embedded in a system studied by Sukumar, S. et al., [11]. This machine uses RFID and Zigbee for ticketing. Passengers can choose their destination using Zigbee and get a ticket via RFID using a smart card. The bus has safety features and opens and closes automatically. This innovation can reduce manual ticketing and personnel on buses, ensuring a safe journey for passengers. Kadam, M. et al., [12] studied a cash-counting machine and a navigation system. The machine has modular blocks and a spring action mechanism to dispense paper faster. This shift in technology is making vending machines even more convenient and accessible, reflecting the changing preferences and needs of consumers in our modern world by Susanne, G. et al., [13]. Ahmed, I. et al.,[14] Developed a clever microcontroller-based paper vending machine with embedded software. This machine is designed to accept coins as payment and, in return, dispense paper sheets. Kumar, S. and Pandey, R. [15] suggest a Real-time vending machine for regular customers using RFID technology, Arduino UNO R3 microcontroller, and a prompt for RFID code and product quantity. Offers tailored and efficient shopping experiences for everyday necessities in various locations. The study by Ramkumar, R. et al., [16] made a machine that simplifies the purchasing process by enabling cashless payments through RFID card scanning. It can dispense a variety of products, including A4 sheets, pencils, pens, and more. Additionally, it offers the convenience of canceling a transaction. The algorithm for this machine is implemented in Verilog Hardware Description Language (HDL), and the design is executed on the Xilinx Spartan-3 XC3S400 FPGA platform. Krishna, K. et al., [17]. Abhishek, S. [18] Introduced an innovative touchscreen-based automated medical vending machine. This machine utilizes infrared (IR) touch technology as input, allowing users to select various medical services, including first-aid, ambulance assistance, and direct communication via GSM. It also incorporates dynamic GPS, smart card functionality, and an alert system for restocking medicines. The software behind this machine is developed using Visual Basic and is designed so that when a patient chooses a specific service, it is promptly provided to them. Mohd, S. and Beg, S. [19] developed a Finite State Machine (FSM) in VHDL using Xilinx ISE 14.2. It accepts money and verifies the product expiry date before dispensing. If the product is expired, it returns money. This innovative solution ensures product quality and regulatory compliance, enhancing vending machine technology.

II. METHODOLOGY

A. Geometry

The vending machine is diligently designed using creo parametric, to ensure precise dimensions and functionality.Here are the geometric specifications

- Overall Dimensions:
  Height: 0.61 m
  Length: 0.47 m
  Depth: 0.31 m

- Product Compartments:

  Product Size:
  Length: 0.05 m
  Height: 0.015m

  Dispense Area:
  Height: 0.175 m
  Length: 0.135 m

  Slope:A slope is incorporated to facilitate the smooth descent of products towards the dispense area, ensuring efficient product dispensing.

- LCD screen Frame:

  Frame size:
  Length: 0.08 m
  Height: 0.055m

- Product Storage area:
  Two hollow rectangle shapes are provided for two flavors of Tic Tac, with a maximum capacity of 6 Tic Tac in each.
  Shape of Hollow Rectangle
  Height: 0.17 m
  length: 0.035 m
  Depth: 0.06 m

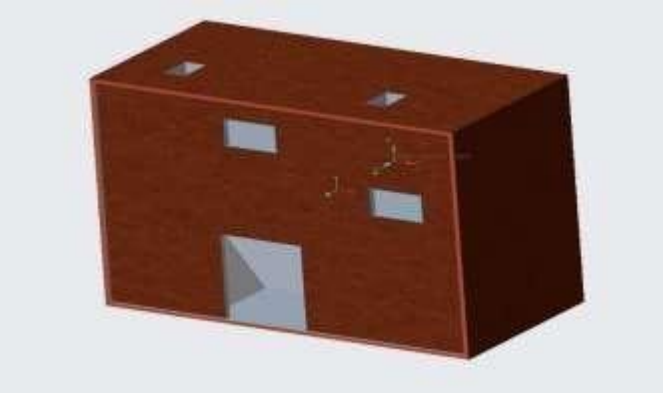

Fig.1 Shows the CAD model of vending machine with TFT display.

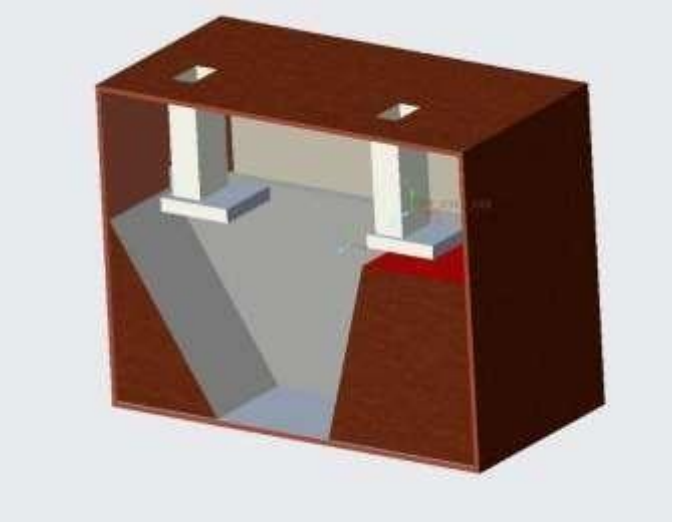

Fig.2 Shows CAD model of interior of vending machine.

The geometric design of the vending machine is optimized to accommodate products of specified dimensions, provide a clear interface through the LCD screen frame, ensure seamless product dispensing through the designated area with the help of the integrated slope, and offer efficient storage for Tic Tac products within the specified hollow rectangle shapes. CAD model of the vending machine could be seen in Fig. 1 and Fig. 2

TABLE I. Shows voltage and current for electronic components

Components	Voltage	Electric Current
Sim 800l	3.6 – 5.20 Volts	1 – 2.5 Amp
L298N motor shield	5 – 35 Volts	2 Amp
Arduino UNO	5 Volts	0.02 Amp
Arduino Mega	5 Volts	0.04 Amp
DC Motors	6 Volts	0.2 – 7 Amp

B. Components used

- Arduino Mega 2560

A Microcontroller (MCU) is a compact computer integrated circuit designed to manage specific tasks within electronic systems. It integrates the functions of a central processing unit (CPU), memory, and input/output interfaces onto a single chip. Arduino Mega 2560, stands out as a versatile development board within the Arduino lineup, offering extensive capabilities for diverse applications.

Powered by the ATmega2560 microcontroller running at 16 MHz, the board boasts 54 digital input/output pins, 16 analog inputs, 4 UARTs, USB connectivity, a power jack, an ICSP header, and a reset button. The Arduino Mega. plays a pivotal role. Specifically, it read and process SMS through the SIM module 800L, extracts the amount, and presents a user interface for selecting Tic Tac flavors. Upon selection, the corresponding motor initiates rotation, facilitating product dispensation. This functionality is integral to the vending machine's operation, ensuring smooth and efficient performance throughout the process. The voltage and electric current requisites are outlined in Table 1, offering crucial details for system operation. Actual image of components used in vending machine are shown in Fig.4

- Ardunino UNO

The Arduino Uno integrates a central processing unit (CPU), memory, and an array of input/output connections onto a single board. With a total of 20 digital input/output (I/O) pins, including 6 designated for pulse width modulation (PWM) outputs, along with 6 analog input pins, the Uno boasts versatility that knows no bounds. In vending machine , we utilize the Arduino Uno for advertising Tic Tac products. It displays information about Tic Tac flavors, promotions, and other related content to attract customers. The Uno serves as the platform for managing and presenting these advertisements effectively. Table 1 delineates the necessary voltage and electric current, essential for the system's functionality

- TFT touchscreen display

Touchscreen technology has revolutionized vending machines, offering intuitive selection methods. Capacitive touchscreens, like those shown in Fig 3, detect electrical changes upon contact, enhancing user interaction. Meanwhile, TFT displays, known for vibrant colors and sharp images, further enrich the vending experience with clear visuals at resolutions of 480x320 pixels . Together, they redefine vending, making it user-friendly, engaging, and visually captivating, while streamlining the purchasing process for consumers. With dual screens, one for the touch panel and the other for advertisements, vending machines become versatile platforms for interaction and promotion, seamlessly blending convenience with marketing appeal.

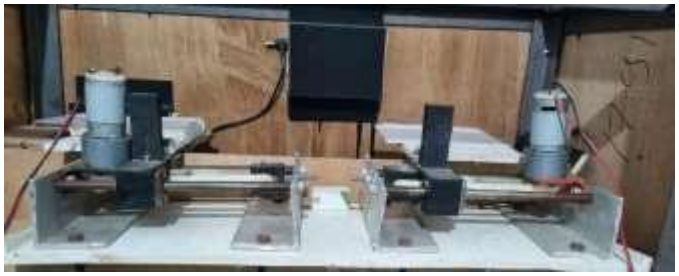

Fig.3 Shows motors and dispense mechanism used in vending machine.

- DC MOTOR and dispense mechanism

The DC motor (6V) is a versatile component widely used in various electronic applications. It operates using direct current and is known for its simplicity and efficiency in converting electrical energy into mechanical motion. Invending machine, we employ the DC motor to facilitate the dispensing of Tic Tac flavors selected by the consumer. Through a sliding mechanism, each motor rotates to dispense the corresponding Tic Tac flavor towards the designated dispense area. This integration of motors ensures precise and efficient dispensing, enhancing the functionality and user experience of the vending machine. The actual dispense mechanism and motors used in vending machine is given in Fig.3

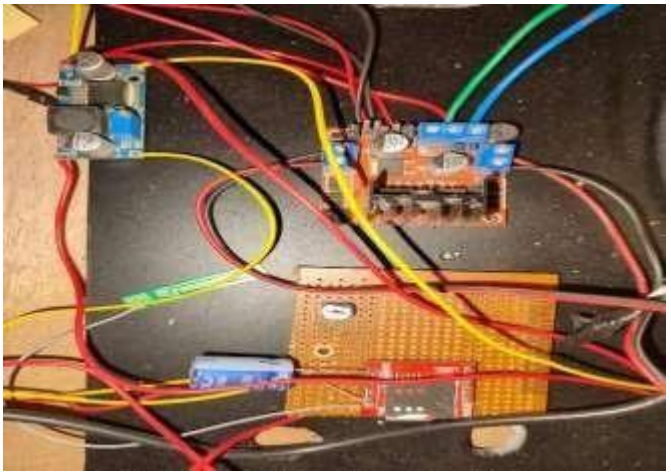

Fig.4 Shows components used in vending machine.

- Motor shield L298N

The Motor Shield L298N is a motor driver module commonly used in robotics and automation projects. It serves as an interface between microcontrollers and DC motors, providing control over motor speed and direction. In vending machine ,we utilize the Motor Shield L298N to regulate the required voltage and current supplied to the DC motors. This ensures optimal motor performance and efficiency, enabling precise control over the motor's rotation and speed. The Motor Shield L298N enhances the functionality of vending machine by providing a reliable and convenient means of powering and controlling DC motors. Within Table 1, the required voltage and electric current specifications are clearly defined for system operation.

- Sim 800L module

The SIM800L module is a compact and versatile GSM/GPRS modem designed for communication over mobile networks. Its small form factor and low power consumption make it ideal for various embedded applications. With capabilities for SMS, voice, and data transmission, the SIM800L facilitates wireless connectivity, particularly in projects needing remote communication. The SIM module plays a crucial role as once payment is completed, the SIM

module receives an SMS, triggering the Arduino to initiate further processing. This integration enables seamless communication and transaction handling, enhancing the efficiency and functionality of the system. Essential parameters for system operation, including required voltage and electric current, are detailed in Table 1.

- DC to DC buck converter

A DC-to-DC buck converter is a type of power supply circuit that efficiently reduces a higher input voltage to a lower output voltage. It works by controlling the duty cycle of a switch to regulate the voltage across the load. Buck converters are commonly used in electronic devices to step down voltage levels for various components. They offer high efficiency and compact size, making them suitable for a wide range of applications where power conversion is required.

C. Circuit Diagram and working

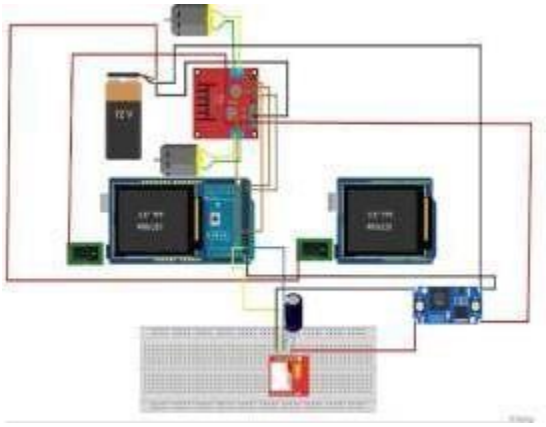

Fig.5 Shows Circuit diagram of Vending machine(*sketch)*

The most important part of this vending machine is the Arduino Mega 2560, a versatile microcontroller capable of managing various tasks simultaneously. Its role extends to controlling motors, managing communication with the SIM module, and orchestrating the user interface through the TFT display. Powering the system is a 12V 5A DC adapter, ensuring sufficient energy to drive the components effectively. For motor control, the L298N motor shield is seamlessly integrated with the Arduino Mega 2560. As shown in the above Fig.5 The motor shield's connections, with IN1 through IN4, are mapped to digital pins 25, 44, 23, and 45 of Arduino Mega respectively. This setup enables precise motor manipulation, crucial for vending machine operations. Facilitating communication is the SIM800L module, interfaced with the Arduino Mega 2560. The SIM module's Rx and Tx pins are linked to digital pins 52 and 53, allowing bidirectional data exchange with the Arduino. This communication enables functions like sending and receiving messages, facilitating remote management and monitoring capabilities. Adding to the user experience is a 3.5-inch TFT display, seamlessly integrated with the Arduino Mega 2560. This display serves as the interface through which users interact with the vending machine, displaying available items, prices, and transaction status. The Arduino's processing power efficiently manages the graphical interface, ensuring smooth user interactions. To ensure the SIM800L module receives the appropriate voltage, a LM2596 DC-to-DC buck converter is judiciously placed between the power source and the module. This converter steps down the voltage, optimizing it for the SIM module's operation, thus safeguarding against potential damage due to overvoltage. Additionally, an Arduino Uno, sharing the same power supply, is enlisted to manage another TFT display, serving as an advertising screen. This setup allows for dynamic content display, enhancing the vending machine's appeal and functionality. In summary, the intricate interplay between the Arduino Mega 2560, L298N motor shield, SIM800L module, TFT displays, and LM2596 converter forms the backbone of this vending machine, seamlessly orchestrating its operation and enhancing user engagement.

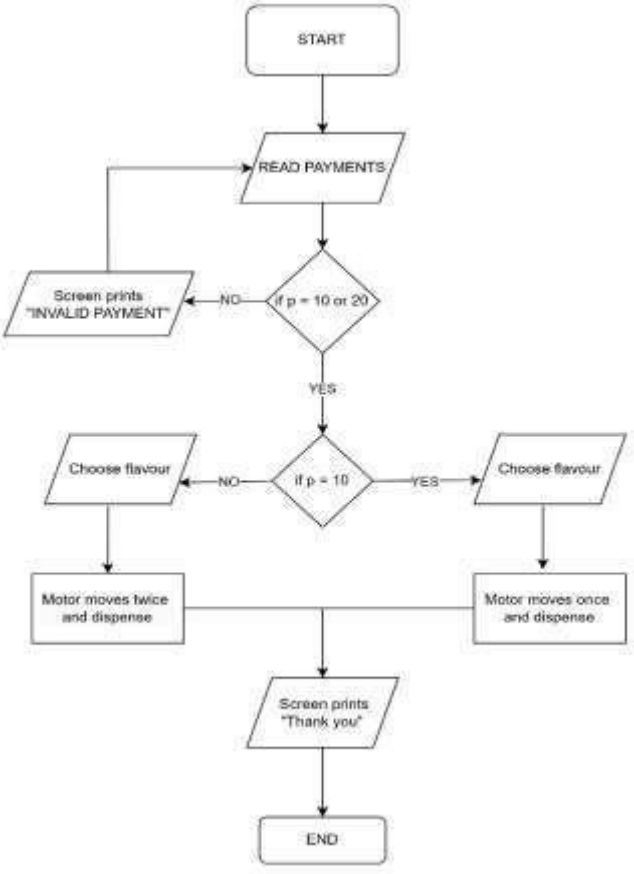

Fig.6 Shows Flowchart for working of Vending Machine.

The operational paradigm of the vending machine commences with the initiation of the payment mechanism, facilitated through the utilization of a QR code interface. Upon successful payment execution, the SIM800L module is engaged to receive an SMS confirmation generated by the banking institution, encapsulating pertinent transaction details. Leveraging the Arduino Mega microcontroller, the received SMS is parsed to extract the transaction amount, initiating the subsequent

validation process. This validation procedure meticulously scrutinizes the transaction amount to ascertain its adherence to predefined criteria, ensuring its appropriateness within the system. Upon validation, the graphical user interface (GUI) presented via the TFT screen dynamically showcases an array of flavour options, empowering the customer with the freedom to select their desired preference. Once the customer has made their flavour selection, the system seamlessly transitions into the execution phase, whereby a motor mechanism is activated in accordance with the validated transaction amount. In the event of a transaction amount corresponding to Rs. 10, the motor executes a singular rotation, thereby dispensing a single unit of the designated product. Conversely, for transactions amounting to Rs. 20, the motor undergoes two rotations, thereby dispensing two units of the selected product. Should the validation process identify the transaction as invalid, the TFT screen promptly communicates this status to the customer, indicating the nature of the discrepancy. Subsequently, the system intelligently resets, reinstating itself to a primed state for subsequent transactions. This meticulously orchestrated sequence of operations epitomizes the technical sophistication inherent within the vending machine framework, seamlessly integrating various components to deliver a seamless and intuitive user experience. The flowchart of working processes on vending machine is shown in Fig.6

III. RESULTS AND DISCUSSION

Fig. 7 Shows Touchscreen interface of vending machine.

1. User Interface and Payment System Integration

The vending machine successfully integrated a user-friendly touchscreen interface, allowing customers to easily navigate through available products and make selections. The implementation of an online payment system streamlined the purchasing process, enabling users to make payments conveniently using various digital payment methods such as credit/debit cards, mobile wallets, or other online payment platforms. An image of the actual touchscreen interface of vending machine used to select type of flavour is given in Fig.7

2. Increased Convenience and Accessibility

By incorporating online payment capabilities, the vending machine catered to the evolving consumer preferences towards cashless transactions, enhancing convenience and accessibility for users. This feature enabled customers to make purchases even if they did not have physical cash on hand, thereby expanding the target demographic to include individuals who prefer electronic payment methods.

Fig.8 Shows advertising display used in vending machine.

3. Enhanced User Experience

The touchscreen interface significantly improved the overall user experience by providing an intuitive and interactive platform for selecting products and completing transactions. Users could easily browse through product categories, view detailed descriptions and images, and make informed purchasing decisions, thereby enhancing customer satisfaction and engagement with the vending machine. Also another advertising display is used to advertise products which is shown in Fig.8

4. Hygiene

Touchscreen vending machines offer a myriad of hygiene benefits. Firstly, by utilizing touchscreen technology, users can interact without physical contact, effectively reducing the risk of germ transmission. Additionally, the ease of sanitization between uses ensures a consistently clean surface for each transaction, promoting a hygienic environment. Supporting contactless payment methods further minimizes the need for physical interaction, enhancing the overall safety for users. With an intuitive interface, navigating the vending process becomes simpler, reducing the time spent and minimizing potential contamination. Ultimately, the interactive nature of touchscreen vending machines not only prioritizes hygiene but also enhances the user experience, making transactions more convenient and enjoyable while maintaining a focus on cleanliness.

5. Future Improvements and Expansion

While the vending machine successfully integrated online payment capabilities and touchscreen interface, there is still room for further enhancements and future expansion. Potential improvements could include the integration of advanced biometric authentication for enhanced security, personalized recommendations based on user preferences, and the incorporation of contactless payment options such as NFC and QR code payments to cater to diverse consumer needs and preferences. Also, storage could be increased for better inventory management.

IV. CONCLUSION

The vending machine with online payment and touchscreen interface demonstrated significant advantages in terms of convenience, accessibility, user experience and hygiene. By leveraging the latest technologies and customer-centric design principles, the vending machine effectively addressed the evolving demands of modern consumers and paved the way for future innovations in the vending industry.

V. FUTURE SCOPE

1. Upgrade the dispensing mechanism to enhance efficiency and reliability, reducing instances of jams or malfunctions during product delivery.
2. Expand the storage capacity of the vending machine to accommodate a wider variety of products, catering to diverse consumer preferences and increasing convenience.
3. Integrate the capability to offer multiple product categories beyond snacks and beverages, such as electronics or personal care items, to broaden the machine's utility and appeal.
4. Implement robust security features including advanced locking systems, surveillance cameras, and remote monitoring capabilities to enhance protection against theft and vandalism.
5. Enhance the physical design of the vending machine to improve aesthetics and durability, ensuring a more attractive and resilient asset in various environments.

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