Automatic Ink Refilling Machine for Ball Point Pen- A Vending Machine Concept

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Abstract: While plastic has many valuable uses, we have become addicted to single-use or disposable plastic which results in severe environmental consequences. In total, half of all plastic produced is designed to be used only once and then thrown away. In all of the single-use plastic wastage, there is also a significant contribution of plastic pens, disposable or not. This adds up to a result where we decisively take up instant disposal instead of recycle or reuse.

Pens, which are globally used as instruments for writing, are generally made of plastic. When these are discarded, they have a negative impact on the environment since there are no known ways to recycle the discarded pens. The plastic wastage arising from pens alone was amounted to 600-630 tonnes between 2017 and 2018, worldwide.

This project aims at design and fabrication of an Automatic Ink Refilling Machine for used ball point pen refills to avoid the major wastage of plastic used in the manufacturing of the pens and making it reusable until the tip or ball wears out. The "Ink re-filler" machine is mechanically constructed with hydraulic actuation for the function and is interfaced via an electronically operated interface, enabling anybody to fill the ball point refills for reuse, under less than a minute and at low cost. This will also avoid the continual purchase of new refills and pens, since the cost of the ink of the pen is hardly lesser than 1% of total cost of the pen.

Keywords: Arduino Uno processor, Coin acceptor machine, Ink re-filler, Ink refilling machine

I. INTRODUCTION

The "Automatic Ink Refilling Machine for Ball Point Pen Refills" is aimed to design and fabricate a system for the reuse of the used ball point pen refills repeatedly until the tip or the ball at the nib wears out.
The project is to construct and model an Ink Refilling Machine similar to a conceptual vending machine, where users can make use of the system as per their requirement to renew their use of the pens.
The machine houses an electronically operated vending machine mechanism. The user feeds the machine with the designated currency into the Coin Acceptor/ Dispenser.
Once the currency is verified, the signal flows to the micro-controller, and permits the user to choose from the options of multiple colours available. The designated piston-cylinder mechanism with non return valve attached to the dispensing needle is then actuated by the controller to dispense the particular fluid into the refill of the pen, up to a certain quantity of 0.3ml or so.
Once the cycle is completed, the user is intimated through a display screen and interactive LEDs.

II. OBJECTIVE

The primary objective to achieve the success of the project is to design and fabrication of an Automatic Ink Refilling Machine for used ball point pen refills. By achieving this, we aim to reduce the use of the multiple usage of plastic waste generated by pens alone, which amount significantly for the deterioration of the environment. The machine works without a manual need for the user using multiple mechanism interface which is done electronically to actuate a piston-cylinder mechanism with non return valve, after a user inputs a coin and chooses the preferential colour of the ink for refill. It allows the usage of the same ball point pen refills until the tip of the ball wears out which is estimated to three or four uses, which cuts down the wastage by 70% due to reuse.

III. PROBLEM DEFINITION

With the existential system, it is a manually operated mechanical system where the user places the used ball point pen refill to a designated holder and the needle is inserted into the used ball point pen refill. A lever is then operated upon which the piston-cylinder mechanism in hand with the ink container thrusts down the ink into the refill for reuse.
With the operation of a user manually, there is a chance for the machine to be misapplied and an unprecedented error to take place.
The size of the ink reservoir was also considerably small and the refilling cycles were very limited. Due to certain misapplications, there was a chance for the machine not to work meeting the requirement. Hence the need for an electronically actuated alternative which is to be user friendly and operated without any prior knowledge for mechanics.

IV. PROPOSED SOLUTION

A conceptual solution to the above mentioned problem is to make the "Ink re-filling" machine an electronically automated system with a provision to dispense multiple colors of ink, when the user inserts a specified form of currency into the machine.
The machine is also designed with larger and multiple ink reservoirs for the storage of more ink with multiple colors for option, and multiple refilling cycles.
With the conceptual vending machine proposal, the machine can be accommodated at offices, colleges and public buildings, which in turn becomes an investment to pay back.

V. PROPOSED BLOCK DIAGRAM

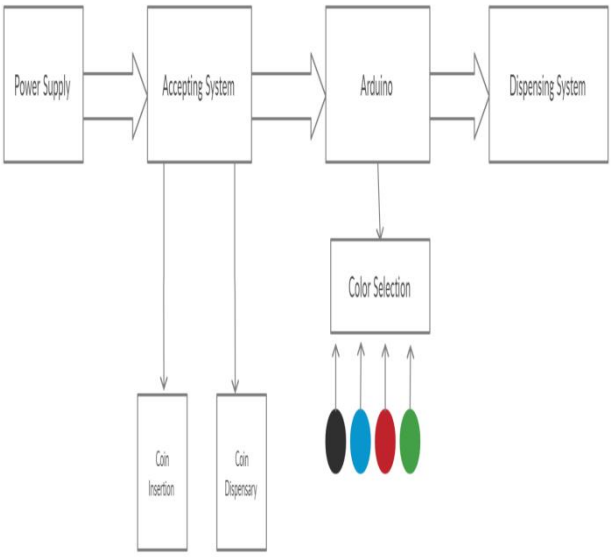

Figure 1

A. Block diagram for the sequence of operations in the ink-refilling machine-
The Figure 1 above depicts the flowchart of the operational passage of the machine. In Figure 1, the flowchart indicates the flow of operation from the power supply to the coin acceptor machine which validates the sequence to operate and sends appropriate signal to the microcontroller, which in this case is the Arduino UNO R3 microcontroller. The microcontroller then sends the particular signal with respect to the color chosen by the user to validate the particular piston-cylinder mechanism and relevant circuit to dispense the ink through the needle into the refill.

B. Block diagram for the operational flow of the validation in coin acceptor machine-

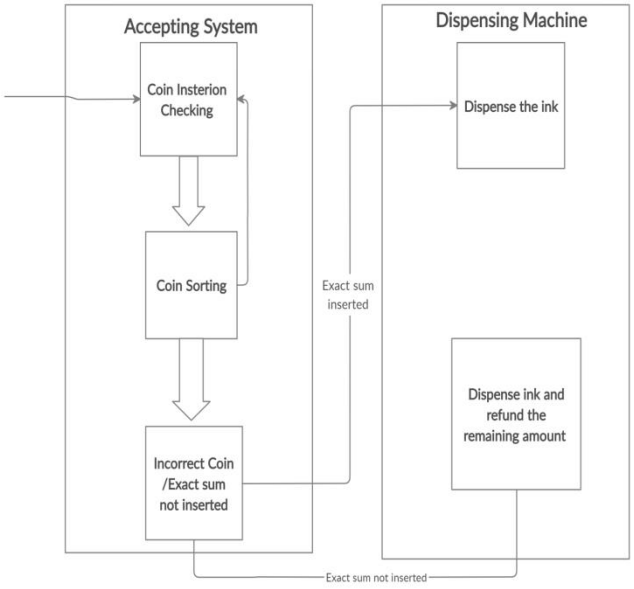

Figure 2

The Fig. 2 represents the sequential flow of the coin acceptor machine for our application. We opt for the use of coin acceptor in our machine to promote the use of the machine for various applications and for its use in educational institutions, public and private offices, libraries, where extensive use of pens is required.
With this, there is also a sense of ownership and responsibility towards the maintenance and use of the machine, which acts like a return on the investment.

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PROPOSED MACHINE DESIGN

- **Skeletal design**

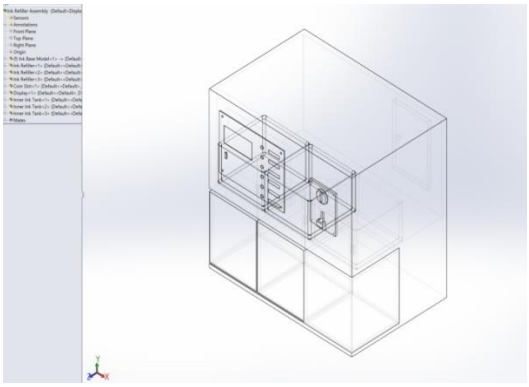

Figure 3

- **Isometric View (3-Dimensional)**

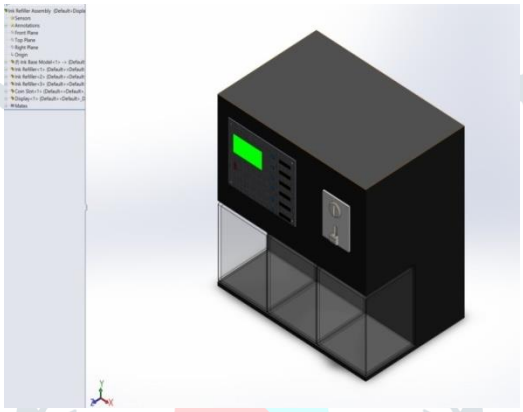

Figure 4

- **Frame diagram sketch**

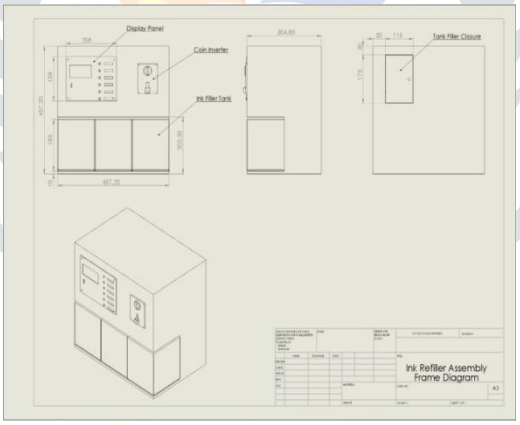

Figure 5

The proposed design consists of the following parts-

- The skeletal frame of the machine is made up of 10X10mm, 2 gauge mild steel pipes. The sides are enclosed by sheet metal plates of mild steel, fastened by spot welding and screws.
- The coin acceptor machine is present on the front face of the machine which enables easy interaction with the user for usage.
- The LED signage with buttons (display panel) is also present alongside of the coin acceptor allowing the user with the choice of the ink to be dispensed.
- The bottom half of the machine has room for the user to insert the empty refill in the machine below the injection needle.
- The dispenser mechanism consisting of piston-cylinder and NRV are present inside the sheet metal body, just above the needle.
- There are slots on the top and sides of the machine for maintenance and the top-up of the ink container.

VI. COMPONENT REQUIREMENT

1. Controller (Arduino Uno R3):
   The Arduino Uno microcontroller is a suitable device to act as a microprocessor for this application. The open-source board is easily programmable according to our requirement and suitably used.
   The microcontroller is used to receive the validated signal from the coin acceptor machine and process it.
   The processed signal is then sent to the motor input which then helps to actuate the required piston-cylinder mechanism on the basis of the selected colour and the ink is dispensed into the refill through the needle.
   Fig. 6 depicts the microcontroller configuration.

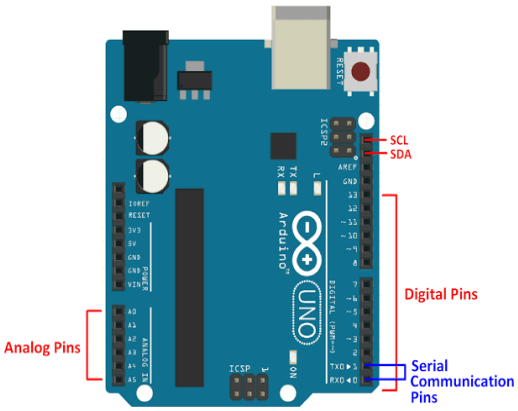

Figure 6

2. Coin acceptor machine-
   The coin acceptor machine analyses the currency on the basis of its mass, size, diameter, thickness, metal composition and magnetism, and then sends an appropriate electrical signal through the output connection to the microcontroller.

Figure 7

Fig. 7 shows the coin acceptor machine used in the Ink-Re filler Machine. It is a programmable device with in-built ability to validate the coin and send an appropriate signal accordingly.

1. Cylinder-
   It is a cylindrical aluminium rod which was machined to the dimensions of 16 mm diameter and 70 mm long. A hole of 6.5 mm was then drilled through the axis of the cylinder and a threaded hole was made on the bottom side of the cylinder from one side to the center axis which is perpendicular to the axis of the cylinder for fastening the threaded smaller end of the tap.

2. Piston-
A proper piston was required to pump the ink since plastic piston tends to bend during lever motion. A cylindrically shaped

Figure 8

steel rod of 3 mm diameter is machined by hand using smooth files to obtain a projection on the end of the rod that is similar to the plastic piston used in the vaccine syringe in order to fix the rubber head as the ram of the piston. This rubber ram provides a good seal with no leakage and smooth pumping action.

3. Needle-
As we discussed earlier, the stainless steel made 16 gauge needles were chosen best for this system. The needle is cut of at the end to avoid the sharp edge in the end and to have a length of 135 mm which is enough to go till the bottom of the refill.

Fig. 9 shows the 16 gauge Stainless Steel needle.

Figure 9

4. Stepper Motor-
A Stepper Motor or a step motor is a brushless, synchronous motor, which divides a full rotation into a number of steps. For this application, we use 5.5kg-cm stepper motor for the actuation of the piston-cylinder mechanism.

Figure 10

Fig. 10 shows the stepper motor used in the Ink Re-filler machine.

5. Check Valve-
Non-return valve or check valve is a valve which allows a fluid to flow through it in only one direction.
Check valves are two-port valves, meaning they have two openings in the body, one for fluid to enter and the other for fluid to leave.

VII. RESULTS AND DISCUSSION

The Ink refilling machine is operated electronically and the Ink injecting work is done by a piston-cylinder mechanism. The operation is simple and the working is smooth.

First of all, the refill which needs to be filled is placed concentrically with the needle in such a way that the end of the needle touches the bottom of the refill or the top of the nib.

During this operation, the piston move up relatively by the motor inside the cylinder creating a vacuum inside the chamber which draws 0.3ml of ink into the cylinder, which is the required quantity for a typical ball point pen refill. The Ink necessary to fill a refill has been sucked into the chamber of the pumping cylinder and the tap is closed to make sure no reverse flow of ink back to the Ink container through Non-return valves. The piston then comes down relatively inside the cylinder in turn pumping the ink downwards. The pressure buildup by the motor and piston in the cylinder makes the ink to flow through the needle which injects the ink at the bottom of the refill. The high pressure of ink presses the refill downwards gradually filling it from bottom to top almost around 100 mm of length.
The refill is then removed from the needle and should be swirled between our hands few times to make sure that there are no air gaps and the ink has flown into the nib of the refill. Now the pen is ready for another use and also the machine is ready for the next cycle.

VIII. CONCLUSION

- The ink re-filling machine for used ball point pen refills has shown substantial performance. The refills were filled with ink repeatedly. Possibly, it can be used until the tip or ball totally wears out. Operation takes less than a minute to fill up an empty pen.
- The ink does not drip out or leak from the back of the refill even though it is held or kept vertically upside down for a long time. Hence no fear of ink leakage when handling the pen. This is due to the air tight epoxy sealing for the container.
- This has the potential to save the environment and the eco system by reducing the thousands of kilograms of plastic waste by discarded pens.
- The ink filling machine is compact, almost portable and can be commissioned in places like schools, colleges, offices and etc. An individual reservoir in the system can store up to 30ml of ink which is well enough to refill around 100 refills.
- This will also eliminate the cost of buying new pens repeatedly by cutting the cost by a tenth of the cost of a pen.

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