

Automated Stamp Pasting System for Industrial Applications

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Abstract: In stamping process is sometimes a painstaking task for a bulk process. The developed stamp pasting system is mainly designed for industrial applications. It is capable of handling any stamps in the range of (20-82×25-60) mm with any envelop sizes of (140-250×93-385) mm which cover the most common sizes worldwide. The system consist of ATmega328P microcontrollers and A4988 stepper motor driver modules with NEMA 17 and NEMA 23 stepper motors, MG 995 servo motors and a 2L glue tank. The main feature of this system is capable of picking and placed stamps automatically after applying a glue layer.

Keywords: Automated stamp, automated stamp pasting, industrial stamping, industrial stamp pasting, stamp pasting.

1. Introduction

According to world history, the first recorded handwritten letter was found in Persian Queen Atossa around 500 BC^{1,2}. After onwards people started their communication in the society using letters as the media and at the beginning the respective payment of the service made by after delivery by the receiver. This process continued till 1840 until Queen Victoria introduced the current stamping method to letter posting so that sender can bare the payment³. As of now all over the world, stamps are customized to a piece of paper with the value printed on it. The sender can buy stamps with a collective value equivalent to the respective service charges for the posting and should paste it on the top of the envelope. On the other hand, the most popular thing, as well as a convenient way, is to print some

symbol on the letter to represent payment with the help of such machines^{4,5}. However this process is having some drawbacks as these machines generally available at the post offices or large organizations. Henceforth people carrying their letters to the post office to print that symbol by paying the applicable total cost. Nowadays some countries and large scale companies used more advanced machines called “mailing stations” which do not belong to the property of the post office. Anyone can personally buy it and all the payments are paid by online using a credit card or any other online payment system.

In those machines instead of pasting stamps, it allows printing their postage. However, those machines are not suitable for most of the countries because stamp models, currency systems, and posting fees are different hence reprogram is required. Before using such a system it is required to create appropriate networking to collect postage together with the information about the processing. Since it takes extra cost together with fund allocation required for frequent monitoring and maintenance most of the developing and underdeveloped countries are not in favor of this new technology adaptation. However, some machines are also available to paste stamps on the letters instead of manually pasting but they are using stamps on sticker medium which is not suitable for standard stamps. In general, these machines available in the market are really expensive and should be customized case by case with specifically designed stamps to suit the machine vise. South Asian countries cannot afford this kind of technology just for stamping hence those are not suitable for developing countries for automating the stamp pasting process in bulk. In the stamping process, it is required to separate it from the stamp card and paste each stamp individually. For a limited number of letters, it can be processed manually but when we process hundreds to thousands of letters it is an extremely painstaking task and will take a lot of time and manpower. So in this project, we create a machine to paste several stamps for preprogrammed amounts. In this system, we insert pre-cut stamps.

In general, these countries have different size of stamps such as 20 mm x 25 mm, 20 mm x 30 mm, 30 mm x 30 mm, 30 mm x 41 mm, 20 mm x 50 mm, 25 mm x 60 mm, 30 mm x 60 mm, 82 mm x 30 mm, 35 mm x 35 mm⁶. This machine having the capability to handling all sizes of stamps as mentioned above. The developed machine uses the simplest functions to stamps the maximum number of envelopes in a unit time. This stamp pasting system is mainly designed for industrial applications. In a day, some companies send hundreds or thousands of letters to their customers.

Those letters are identical and the posting cost is also the same. Due to having a requirement of posting a large number of letters by the same company per day, the respective labour cost would be very high. If it is at a post office, people had to stay in long queue and spend a lot of time. Therefore authors believe that the developed system would be an ideal solution to accomplish the same task.

2. Methodology

When we need to give our services to a lot of letters we need mainly store stamps and envelopes. So we designed a storage area that can store several hundreds of letters in any size of envelopes and used a filtering system that helps us to control envelop flow by not ending multiple envelopes at the same time. That filtering system work at letter thickness so if your letter is less than or greater than the manufactured limit you can manually change that limit by yourself. When we need to send letters from the storage area to the stamping area we need some mechanism of conveyor system for that we designed a roller conveyor system with an IR sensor include that can give data about the availability of the letters, its position, and size of envelopes. To Store stamps, there is a specific box and used a stamp size filter system to hold stamps one top on another so every time system can grab and paste stamps on the same position. To handle stamps, we can use the high voltage vacuum addition method hence we need to design a vacuum pump to handle those stamps. Moreover, we need to apply glue to stamps. So next to the stamp holding section, we designed a glue sponge. Supplying glue to sponge there is a large glue holding tank on the system and pump that special design glue without contaminating it. Then if there is extra glue on the sponge we used the same pump that can pump glue back to the tank at the same time.

3. Design Stages

The developed Automated Stamp Pasting System consist of two design stages, namely; the Mechanical design section, and the Electronic circuit design section followed by a system validation process.

3.1 Mechanical Section Design: The designing of mechanical sections were mainly utilized a 3D printing approach using PLA polymer with the SOLIDWORKS software. The main body skeleton is constructed by using a 12 mm Aluminum box bar with pop rivet to connect each part and 3 mm plywood is used to cover the instrument body.

Figure 1 shows us the main part of the instrument; designed roller converter to move letters from storage area to area that used to paste stamps. That conveyor system includes several IR reflective sensors which are used to detect envelop size and the appropriate position in the system.



Figure 1. Designed roller converter



Figure 1. Vacuum pump

When the system switched-on, it detects the availability of the envelopes and starts the NEMA 23 stepper motor⁷. 3D printed pulley was connected to the motor and using timing belts it connects to the roller conveyor first roller and using several timing belts to transmit power to each roller. The conveyor system used stepper motors so we can control its movement very accurately. This system can hold 2 lts of glue in its build tank and used a Peristaltic pump to use to pump glue to the sponge that is located near the stamp holder. when the envelop trigger IR sensor belongs to stamp pasting area that NEMA 23 motor turn OFF and NEMA 17 motor that belongs to stamp moving system is turned ON⁸. It starts to move from its home position and used a limit switch to indicate its home position. To move stamps, as shown in Figure 2, a special vacuum pump has been designed to handle the smallest stamp to the largest stamp without changing any physical part of that system. The stamp moving head is moved appropriate stamp holding holder and move down the direction by using MG 995 servo motor and turn on motor which is used to create the vacuum and grab and hold the stamp⁹. After grabbing the stamp that vacuum system moves up and moves back to the home direction then alien

with glue soaked sponge again go down direction and applied glue on the stamp. Then stamp vacuum head move up and go again its default place and alien with envelope and move downward until stamp past on envelope and turn OFF vacuum pump. After that, the stamp head goes to its home position, and the envelope going forward through two rollers and permanently paste the stamp and moved out that envelope from the system and restart the process again.

3.2 Electronic Section Design: In the developed electronic circuit, as indicated in the respective block diagram in Figure 3, there are three Arduino mini pro microcontroller boards which include ATmega 328p IC and communication with each other by an I2C communication protocol¹⁰. Arduino board 1 control five input switches and an LCD unit. Arduino board 2 control five input switches and an LCD unit. Arduino board 3 control NEMA 23 stepper motor by using stepper motor driver

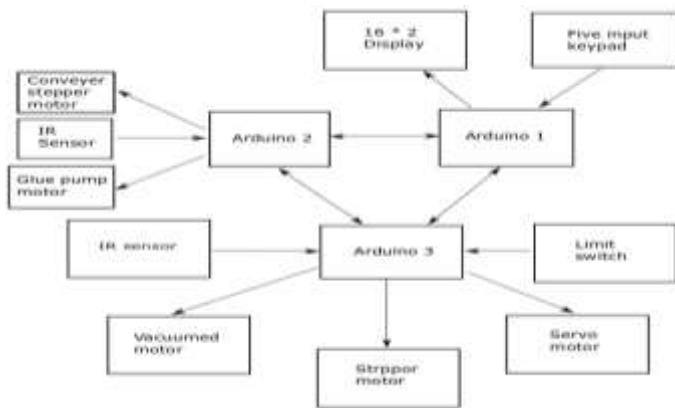


Figure 2. Block digram of the Electronic Curcuit

A4988, IR senor arrays in roller conveyer and glue pump by using power transistor as a switch. Arduino board 3 control limit switch, IR sensors, Vacuum motor by using a transistor as a switch, servo motor, and stepper motor by using controller circuit A4988¹¹.

Conveyor systems include several IR sensors and all are designing and developed using the same logical approach. There is an IR transmission LED which is in forward bias and light-up when the system is switched on. There is an IR receiver LED which is in reverse bias with a high resistive value and the signal pin connects to an operational amplifier circuit that operates in the comparator mode. So it can change the trigger value by changing the variable resistor value by rotating the respective variable knob¹².

3.3 System Validation Process: The validation process is carried out mainly in two steps. One is testing capability to handle stamp size range that available in the local market as well as for envelope sizes that available on the local market. Stamp pasting was also tested in several stages. For each success steps, we give 3.33 marks. Step one is to go and grab the stamp. Step two is to grab and applied glue to the stamp. Step three is to paste the glued stamp into the envelope. In this test, we used 10 stamps as samples and create samples for every available stamp size. To have more accurate results, every test had been repeated four times. A simple mathematical relationship had been used for the analysis and represented as percentages and results are tabulated in Table 1 and Table 2.

Success (in %) = (Total number of success tests)/(Total number of tests done) × 100%

Table 1. Stamp test data

Stamp size	Number of tests	Number of success tests	Success (in %)
20mm x 25mm	40	40	100%
20mm x 30mm	40	40	100%
30mm x 30mm	40	40	100%
30mm x 41mm	40	40	100%
20mm x 50mm	40	40	100%
25mm x 60mm	40	40	100%
30mm x 60mm	40	40	100%
82mm x 30mm	40	40	100%
35mm x 35mm	40	40	100%

Table 2. Envelope test data

Envelop size	Number of tests	Number of success tests	Success (in %)
140mm × 93mm	100	895	89.5%
227mm × 103mm	100	978	97.8%
256mm × 305mm	100	995	99.5%
250mm × 385mm	100	1000	100%
152mm × 230mm	100	1000	100%

4. Discussion

This stamp pasting system is mainly designed for industrial applications. This system can handle any size of envelopes used in ordinary posting. This can use for 1mm to 4mm thickness letters. If a thickness of more than 4mm is used, need to adjust the barrier which is created to stop

sending more than one letter at a time. As a conveyer roller PVC pipes are used but its surface condition is smooth so there is less friction and rubber skin can be used on rollers or plastic primers but in this project we did not use that kind of method because it's expensive. For motion, we used NEMA 17 and NEMA 23 high powerful and high precision stepper motors, as they can function very accurately therefore this instrument had minimum errors in operation. A customized vacuum pump was used so it's ultra-powerful and due to user requirements we can change its parameters. In this developed system, we include a glue tank with a volume close to 2liters. Therefore won't arise due to running out of glue in long-time operation. For pumping glue, Peristaltic pump (Dosing pump) was used by changing RPM of the motor which changes flow rate and due to second pump system there will be no extra glue on the sponge, all extra glue will be returned to tank by the same pump that we used to pump in, but using different stage on the same pump. We used stamp manufactured recommend glue and the advantage of this system is that glue can be diluted by adding 70% water mixed with glue. So this system can save glue more than the usual methods that are being used today. The system provides glue therefore normal stamps that we use can be used.

MG 995 metal servo used for moving z-axis. When coding and testing, there were some difficulties and problems arisen from voltage pulses and electromagnet disturbance. Stamp pick and place vacuum pump tack high power from the same circuit so it can create voltage pulses. To omit those problems, an innovative method was and that solution work. Nowadays, due to the ongoing pandemic; Covid-19, spread in every country, and in most cases, it spread by human saliva. People normally paste envelopes and stamps also using saliva. So, if it is required to send a small or large amount of letters safely, using this system is the better solution.



Figure 3. Operating procedure

Figure 4 shows the step by step operation of the system. First, you put the envelope inside the instrument. Then put stamps in its holding area. Next power is turn on. The vacuum arm is starting to move and it grabs the stamp by making a vacuum and the pressure difference is helps to grab and hold the stamp. Then the vacuum pump is going to glue the sponge and put glue under the stamp. Next, it moves the appropriate area on the envelope and past the stamp and apply some pressure on the stamp and release the vacuum. Finally, the conveyor system is starting to move and exist processed envelop using the roller to press and past stamp permanently.

5. Conclusion

It can be concluded that the main task was successfully completed and the developed system can be used by anyone to paste stamps on their letters. The main features of this system are; automatically pick and placed stamps, pump glue and remove excess glue from the glue holder that can store more than 2 bottles (2000ml) of glue so it is not required to refill in a short period. The system can handle most commonly used envelopes and can paste any size of stamps. As an additional feature, the total processed output will be shown so the user can have an idea about the process and idea about the number of available stamps. The developed system can handle any stamps in the range of (20-82×25-60) mm with any envelop sizes of (140-250×93-385) mm which cover the most common sizes worldwide. Compare to other machines this system can manufacture with a low production cost and importantly it is with less operation cost. Moreover, the required space is conveniently manageable in any office and required minimum power.

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