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Development of Low-Cost Solder Paste Hand Dispenser

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Annotation:
In prototyping and piece-production, stencil printing of the solder paste is expensive, and with the use of the stencil, it is not possible to react fast on changes in the design. Therefore, automatic or manual dispensers are used. This work aimed to develop a low-cost dispensing system based on a simple principle that uses torsion springs and its plastic construction is printable by a 3D printer. Unlike other dispensing systems, the presented dispenser allows continuous deposition of the solder paste. As the performance test showed, the deposition can be as good as with a commercial dispenser. Furthermore, the cost of the dispenser does not exceed 1€. In comparison with other commercial solutions, it is a negligible amount.
Anotace:
Nanášení pájecí pasty pomocí šablonového tisku je v případě prototypování a kusové výroby drahé a nelze rychle reagovat na změnu designu desky. V těchto případech se proto používají manuální nebo automatické dávkovače. Tato práce se zabývá vývojem nízko-nákladového ručního dávkovače, který využívá jednoduchý pružinový systém a plastovou konstrukci, uzpůsobenou pro výrobu metodou 3D tisku. Navrhované řešení umožňuje na rozdíl od jiných dávkovacích systémů kontinuální vytlačování pasty. Jak ukázal test, depozice pájecí pasty je stejně kvalitní jako u tlakového dávkovače, přitom ale výrobní náklady nečiní více než 1 euro, což je zanedbatelná částka oproti jiným, komerčním řešením.

1 Introduction

The reflow soldering process consists of several steps. The first and essential step is solder paste deposition on a printed circuit board (PCB). The most popular method in the electronics industry is stencil printing. In this case, the paste is deposited through a steel stencil with holes that fit on the soldering pads. The holes on the stencil are usually cut by laser or chemically etched. This method is accurate, reliable, and repeatable. The solder paste is deposited on the PCB at once, so it provides fast manufacture. Therefore, companies that deal with electronics assembly use this method mostly in mass production.
For piece production or prototyping and development, the stencil printing is an expensive method since the stencil can be used just for one design of the PCB. In such cases, solder paste dispensers are often used. There are several types of dispensing systems that are available on the market.
In general, the dispensers use a cartridge with the solder paste. The solder paste is deposited on the PCB with a nozzle. The pressing force on the syringe piston is induced by compressed air, compressed air combined with a rotary screw line, piezo-electrical or magnetic principle, or mechanical system based on springs [1]. Dispensing of the solder paste is typically initiated by an operator action – pressing button or foot-pedal.

Solder paste dispensers, which use compressed air as the applied force, are sophisticated and bulky equipment. These dispensers offer accurate dosing of the solder paste of specific volume, which is adjustable by the time of dispensing. The operator can control the time manually, or set the time on the equipment by default if the dispenser is time-programmable [2]. However, they contain a compressor and pressure tank that increase the cost. Commercial dispensers based on this principle are available for a minimum of 500€ [3]. The high cost makes this solution unavailable for small productions, development departments, or hobby-makers.

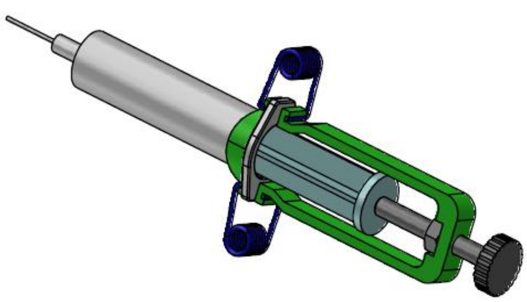

Figure 1. Illustration of the prototype dispenser

Hand-dispensers, using a spring system for the solder paste deposition, are simple-to-use equipment. They are usually in the form of a dosing gun, and the deposition is initiated by pressing the trigger. However, the cost is still relatively high. Especially in cases, when the solder paste deposition is occasional. The price is around 50€ [3].

The disadvantage of the dispensers mentioned above is the impossibility of continuous dispensing without operator interaction with the dispensing system. This can lead to slower deposition of the solder paste and increasing operator tiredness.

This work aimed to develop a dispensing system for a little cost that can be fast and simply manufactured. The cost should not exceed 1€. The presented solution (Figure 1) also provides continuous deposition of the solder paste and comfortable use.

DESIGN AND CONSTRUCTION

The design can be seen in Figure 1 and Figure 2. The dispenser consists of two main plastic parts - a ring (3) and an extender (5). The ring is mounted on the cartridge (1) and connected with the extender by two torsion springs (4). The piston (2) is pushed by a screw (6) that is fixed to the extender by a nut (7). Tightening or loosening the screw adjusts the applied force that determines the speed of dispensing. The solder paste is continually dispensed through a nozzle with slowly decreasing speed. For increasing the speed of dispensing again, a re-interaction of the operator with the dispensing system is required.

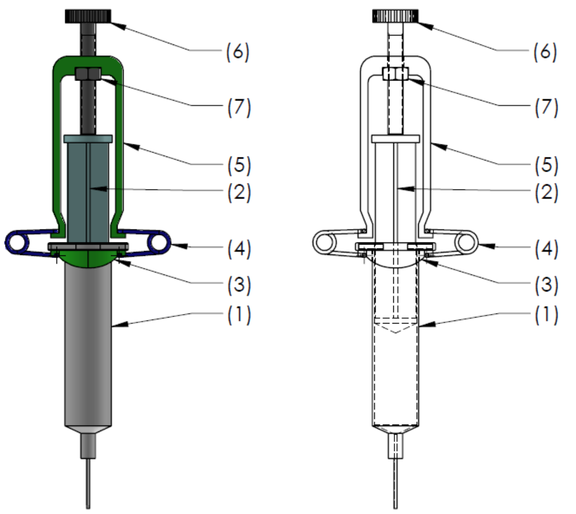

Figure 2. Schematic illustration of the presented dispensing system

The plastic parts of the dispenser are designed to be easily manufactured by 3D printing. The prototype was manufactured by 3D printer Prusa Original MK3S (Prusa Research s.r.o., Czech Republic) that is based on Fused Filament Fabrication (FFF) technology. Polyethylene terephthalate glycol-modified (PET-G) was chosen as the building material since the results of performed mechanical tests (according to the standard ASTM 638) showed a high tensile strength of PET-G in comparison with other materials (Figure 3). Furthermore, the cost of PET-G is the lowest of the selected materials [4]. The dispenser can also be manufactured by stereolithography (SLA) or other 3D printing technology. For mass production, standard manufacturing technology like injection molding is also possible.

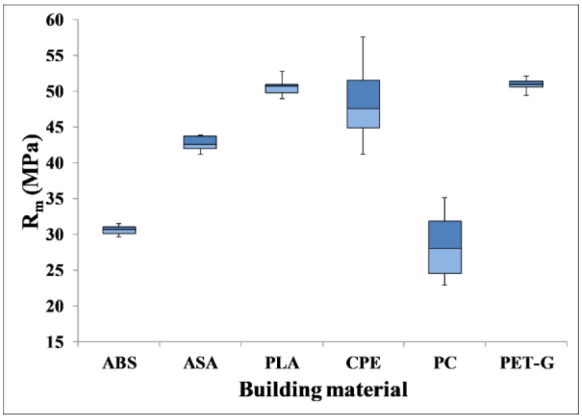

Figure 3. Comparison of the ultimate tensile strength of various building materials

The printed prototype is shown in Figure 4. Two additional pieces - a cap with wings and an extension piece; both mounted to the screw - were designed for an ergonomic work with the dispenser. The print took about one hour and forty minutes with the following settings of the printer – the height of one layer 150 µm, nozzle temperature 240 °C, bed temperature 85 °C. The model requires no building supports and no additional post-processing of the parts is required.

Figure 4. The printed prototype dispenser

PERFORMANCE TEST

In order to evaluate the performance of the dispenser and compare it with other industrial solutions, a quick performance test with an operator was conducted. Except for the prototype, dispenser based on compressed air SMR Pik&Paste by Pace, model PPS60 was used. Five sample boards with 32 soldering pads were used for each dispenser. The time of solder paste dispensing was measured, and the deposited paste was checked visually using an optical microscope. Consequently, SMD components were

placed on the boards and the boards were reflowed. The appearance of the defects was monitored.
The deposition with dispenser based on compressed air took about 5 minutes, compared with the prototype, where the deposition took about 7 minutes. Despite being longer, there was no interaction with the dispensing system required during the whole deposition. It is possible to reduce this time by increasing the speed of dispensing when the operator is skilled.
The deposited solder paste is shown in Figure 5. Based on the visual comparison of the paste deposited by the commercial dispenser (a) and the prototype (b), there is no significant difference, and the paste is deposited well. After the component placement, the boards were reflowed (Figure 6). In both cases, no solder issues were observed.

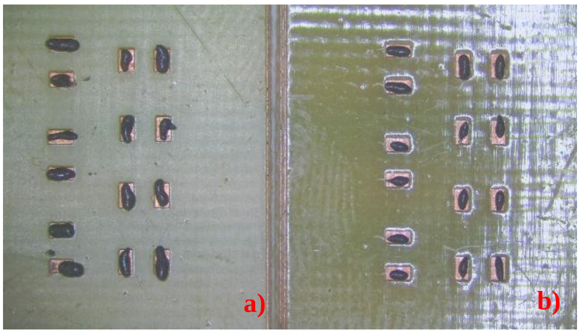

Figure 5. Deposited solder paste by (a) commercial dispenser, (b) prototype dispenser

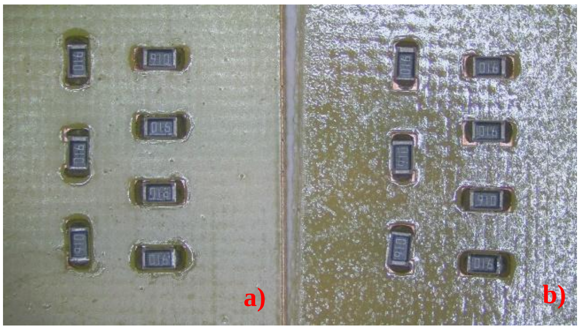

Figure 6. Reflowed test boards - (a) solder paste was deposited by commercial dispenser (b) solder paste was deposited by prototype dispenser

Cost

The cost of the dispenser consists of the plastic material cost, the cost of energy consumed during 3D printing, and the cost of metal components (torsion springs, screw, and nut). The solder paste is delivered mostly in the cartridge with the piston; therefore, their cost is not included. The final cost of the dispenser is around 0.40€ (Table 1).

Table 1. Cost analysis of the dispenser

Component	***Cost (€)***
Building material (PET-G)	0.15
Metal components	0.23
Consumed energy during printing	0.02
Final cost	**0.40**

Conclusions

In this work, the development of the low-cost solder paste dispenser was presented. The dispenser has extensive utilization in the industry. In addition to the solder paste the dispenser may be used for the deposition of various pasty substances, like fluxes, glues or electrically conductive adhesives. It is designed to be used in prototyping and small productions, where the stencil printing of the solder paste or other dispensing systems are not economically advantageous.
The presented dispenser allows continuous deposition of the solder paste, which makes the work more comfortable, and it decreases the operator's fatigue. The cost of the dispenser is negligible compared to other commercial solutions based on compressed air. It was designed to be easily and quickly manufactured by 3D printing, which makes the dispenser available for a large number of users.
The plan for the future is the development of a new version, where the effort will be put on the elimination of metal parts of the dispenser - the torsion springs, and the screw.

Acknowledgment

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