Innovative Design of Plastic Bottle Recycling Box Based on ARM

Xiong Yuedong, Huang Huadong
Suzhou Institute of Industrial Technology, 215104 Suzhou Jiangsu, China

Abstract. Aiming at the problems of on-site plastic bottles recycling and the reuse of waste, the automatic recycling system was developed on the basis of ARM. As the main controller, ARM not only controls the mechanical system of the collector to recover and break plastic bottles, but also communicates with and rewards the user by the automatic reward system through the wireless network. The experimental prototype test results show: post treated fragments of plastic bottles are small, which are convenient to transport and take advantage of; the operation of recovery is easy, and the interface of man-machine interaction is friendly which is easy to expand functions.

Keywords. ARM; plastic bottle; recycling box; innovative design

1 Introduction

Audiences around the world were impressed by the performing stage of Universiade 2011 which was built with 11 million plastic bottles [1]. China is a populous country, where a large amount of bottled water was consumed in the city every day, especially in densely populated areas. In the city's flourishing area, randomly discarded plastic bottles can be seen everywhere. According to the China Packaging Federation Information, China has an annual production of 3 million tons of plastic bottles, which consumes 18 million tons of oil, equivalent to a medium-sized oil field annual production. PET (polyethylene terephthalate) of Plastic bottles is also a raw material of polyester staple fibre and filament yarn. After simple treatment, recycled waste plastic bottles can be made into fibres, then clothing [2]. Environmentally aware people would put waste plastic bottles into trash, no such conscious people thrown plastic bottles away, thus causing environment pollution. Therefore, in order to reduce environmental pollution, renewable resources usage, and development of dedicated intelligent recovery is necessary. This paper uses ARM family embedded controllers, sensors, relays and other electrical components to control the collector mechanical system for crushing the plastic bottles; certain incentives were given to peoples who get back those bottles, and the reward also submitted via wireless network to a remote server to be handled. Recycling box developed reduces the environmental pollution caused by plastic bottles, encourags people to recycle plastic bottles, facilitates the transport of waste plastic bottles and play an active role for construction of conservation-oriented society[3,4].

2 The overall design of recycling box

Plastic bottle recycling box is new environmental protection equipment which combines electromechanical, embedded systems, wireless networking and computer technology in one. As shown in Figure 1, it is composed by three parts : server, ARM controller and mechanical structure. The ARM controller is mainly composed of ARM11 processor, touch screen, card reader and control circuit[5,6]; The mechanical structure part is mainly composed of motor and cutting tool module. The cutting tool module is driven by motor, and composed of high-speed steel knife and fixed knife. After turning on the power supply, the motor drives the rotation of three high-speed steel knife set which connected with rotating axis through belt pulley, then crush plastic bottles into tiny pieces of plastic through shear force between high-speed knife and fixed knife like scissors. Figure 2 illustrated the total control process of the intelligent recycling box's workflow: receive plastic bottles → process plastic bottles → bonus manipulator.
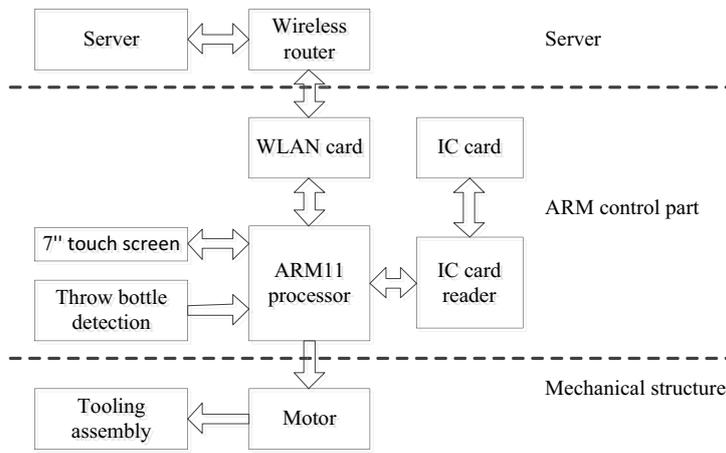
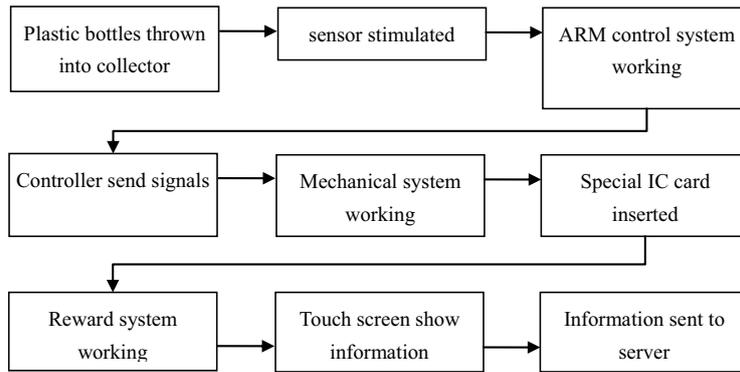**Figure 1.** Design diagram of plastic bottles the smart collector system.

**Figure 2.** Plastic bottles smart recovery workflow.

3 The system design of recycling box

3.1 The design of mechanical crushing system

The mechanical crushing system is composed of motor, v-belt and cutting tool set. After turned on the power, Motor drives the v-belt motion, then drives the belt pulley of cutting tool set. The belt pulley drives the multiple blades tool rotate, and relative motion with fixed blades, accomplished crushing plastic bottle, cut plastic bottles into pieces like scissors.

Figure 3 is the collector's structure diagram, it shows the appearance and internal basic structure of the plastic bottles smart collector, which is mainly composed of touch screen, card reader slot, plastic bottles pipeline, junk box, cutting tool component, motor, electromagnetic relay, etc.
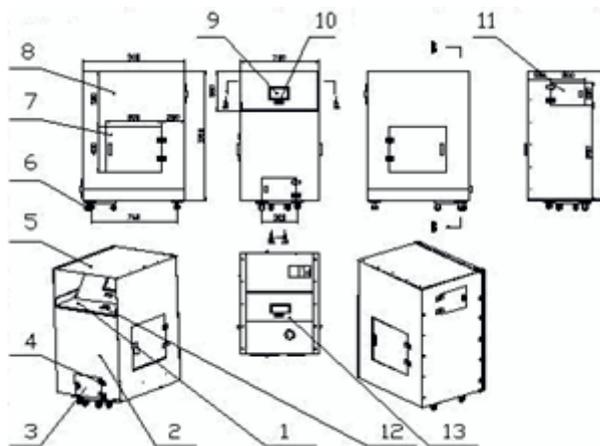
1. Top plate, 2. Front panel, 3. Drawer door, 4. Hinge, 5. Top panel, 6. Wheel, 7. Side door, 8. Side panel, 9. Touch screen, 10. Card reader slot, 11. Backdoor, 12. Plastic bottles pipe
**(a)**
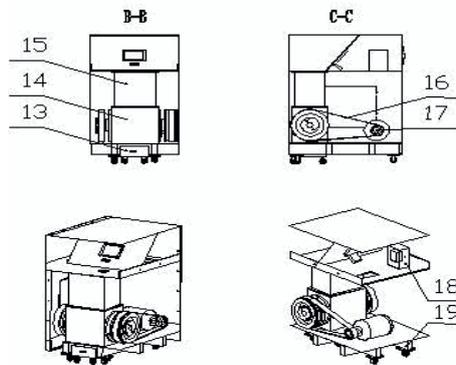
13. Junk box, 14. Cutting tool component, 15. Plastic bottles pipe, 16. V-belt, 17. Motor, 18. Electromagnetic relay, 19. Supporting bottom plate
(b)

Figure 3. Total Structure diagram of the collector.

3.2 The design of auto-control system

Figure 4 shows the plastic bottle recycling box's general control circuit, which is composed of five parts: photoswitch circuit, relay circuit, USB drive circuit, ARM main control circuit and LCD drive circuit. Among them ARM control section is developed independently, and then integrated with others through self-defined I/O protocol [3-6].

When users throw a plastic bottle into cast bottle port, the plastic bottle triggers the detection sensor of plastic bottles pipeline. The sensor sends signal to main control ARM system. On receives the signal of casted bottle, ARM sends delay signal and then causes the electromagnetic relay closing, so that turns on the motor power, and the mechanical crushing system working. When delay signal stop, the electromagnetic switches off, motor shuts down, so that mechanical crushing system stops working.
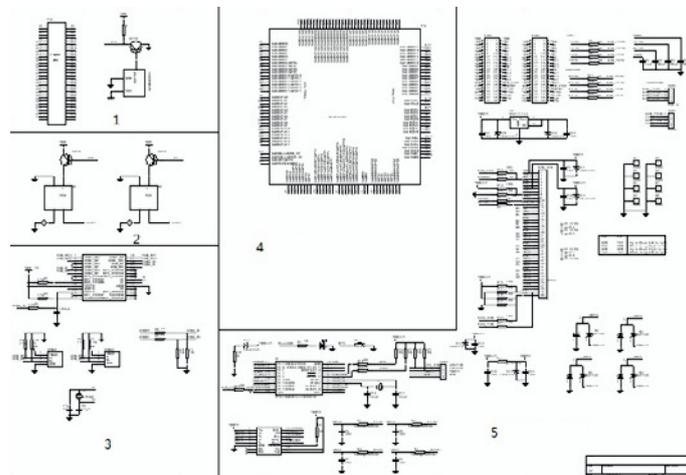
1. Photoswitch circuit, 2. Electromagnetic relay, 3. USB drive circuit 4. ARM main control circuit, 5. LCD drive circuit

Figure 4. Total control circuit diagram of the collector.

3.3 Wireless network control system design

Wireless network control system is composed of ARM main control system, wireless LAN card and terminal server (PC). The user puts bottle into machine, Inserts special IC card into card reader, touch screen renders user information that sended back from remote server through wireless network, the touch screen's interface will show information inform user to choose save the reward or donate to project hope, then the user makes the choose, which will be sent to the remote server by the wireless netork. Moreover, when the plastic pieces which stored in the junk box reaching a certain amount, detect sensor will informs ARM control system, and then the control system sends the informtaion of junk box full to the remote server through wireless network. Accordingly, the computer then sends instruction to worker to recycling.

3.4 Software design

The plastic bottle recycling box's embedded structure system took Linux system as software platform and developed [7-8]. Boot Loader is the first step of Linux embedded system software development. It links software and hardware together closely, which is critical for transplanting operating system on special hardware platform. Boot Loader program can initialize hardware device, build memory space mapping, so that bring system hardware and software environment to a suitable state which can prepare

correct environment for the final operating system kernel call. General Boot Loader has VIVI, Blob, U-Boot, etc. The system use VIVI as system boot program.

Device driver is interface of operating system kernel and machine hardware. It covers hardware detail for applications, so that to applications hardware device is just as a device file, which can operate hardware just like operate common file. Device driver is a part of kernel. It can accomplish functions as below:
- Initialize and release device.
- Send data from kernel to hardware, and read data from the hardware.
- Read data that applications sent to device file, and return data of applications require.
- Detect and handle errors appeared from device. In design, LCD drive circuit used to send infrared information, photoswitch circuit used to receive infrared induction information, relay circuit used to receive ARM's information by which to control motor work in coordination. Figure 5 is I/O control driver flowchart, it shows overall system auto running through simple I/O protocol.
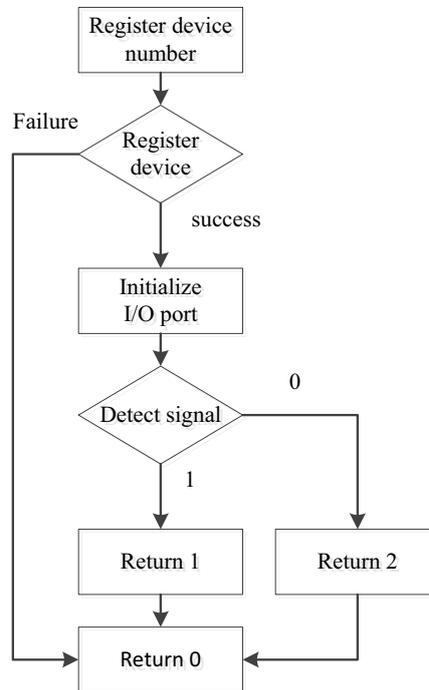

Figure 5. I / O control driver flowchart.

4 Implement

As shown in figure 3, user throw plastic bottle into plastic bottles pipe (12), sensor inside of the pipe detected plastic bottle pass by, then send signal to ARM controller, ARM controller make electromagnetic relay (18) close，motor (17) thus is switch on, and drive the motion of v-belt (16) and belt pulley of cutting tool component (14), that make the cutting tool component's moving blade rotate. Shear force between the moving blade and fixed blade accomplished the plastic bottle's mince process, and the plastic bottle fractionlet produced drop into junk box (13) through filter screen. When junk box full, the recycling's sensor will remind ARM controller to stop inputting plastic bottles, and send information of junk box full to terminal server, and the terminal send junk full signal to cleaning workers to inform him to recycle plastic fractionlet. Moreover, bottle thrown people will get reward or bonus, which is recorded on special IC card; Users insert special IC card into card reader slot (10), the touch screen (9) will show user's bottle cast information, inform user to make a choice between store the gotten bonus and reward or delivery them to Project Hop, and so on. After operation, the data submitted is sent to remote terminal server through wireless router.

5 Conclusion

Plastic bottle recycling box is a creative design production based on ARM. Application of embedding technology to waste treatment, not only broaden the technology's application field, but also enhanced the technical level of waste treatment, more over meet people's curiosity for new things, thus achieved the purpose of waste recycling. The experimental result shows the good effect of collector recycling and plastic bottle treatment. After on-site disposal, the plastic particle is very small, which is either good for transport or facilitates following reuse of plastic. Moreover, the recycling box improves the user's participation, autonomy and interesting through onboard reward interactive interface, significantly reduces labor cost through the integration of network information auto management. Recycling box with incentive mechanism, enhanced the refuse classification thinking, reinforced environmental protect awareness, provide a new idea for recycling waste and design corresponding innovation product.

References

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