Design of the Control System of Automatic Blood Component Fractionation Machine†

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Abstract. Ordinary method of fractionation of blood has many disadvantages, such as imprecise manual operation, complicated operating, nonstandard record, etc. This paper designs an automatic blood component separate system to improve these problems, and introduces the control system of the automatic blood component fractionation machine based on C8051F040 MCU, which can make blood component fractionation precisely and automatically. This system can produce the blood components meeting to the management standard of the Blood Bank, and has been shown adaptable in various blood bag systems.

Keywords: Blood Components Fractionation; C8051F040; Control system

1 Introduction

Human blood is formed of complex elements: erythrocytes, lymphocytes, granulocytes and platelets of plasma proteins, etg.[1] After a low speed centrifugation, the whole blood(WB) can be mainly layered into three parts--the red cell concentrates (RCC), platelet-rich plasma (PRP) anduffy-coat (BC). And after a subsequent high-speed centrifugation, the PRP can be layered into two parts--platelet concentrates (PCs) and platelet poor plasma (PPP) [2]. The automatic blood component fractionation system can separates these components from the centrifuged whole blood (WB) automatically. Comparing with ordinary manual fractionation method, the automatic blood component fractionation system has a lot of advantages: the fractionation is precise and efficient, the products are standardized, the documentation of process data can come into being automatically [3].

After centrifugation at a low speed, the WB in a bag can be delaminated into three layers, then the top of the bag is the PRP, and the bottom of the bag is RCC, while a small quantity of BC is lying between them. The automatic blood component fractionation system uses the standard of quadruple bag systems, which are WB bag (also used as RCC bag), PRP bag, BC bag and the maintaining liquid bag.

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2 Architecture of automatic blood component fractionation system

To meet with requirements of Blood Banks for blood component preparation, the fractionation should be precise and standard, the records of the process data must be saved into the detailed database. These data base makes management easy and can export the report forms flexibly. Figure 1 shows the architecture of the blood component fractionation system designed in the paper, approximately 100 fractionation machine can be connected through CAN bus [4]. These fractionation machines are managed by one PC, so the separation is highly unified and standardized.

![Architecture of automatic blood component fractionation system](image)

The fractionation machines can do the fractional operation separately, or co-workers with the PC, this can be set by the user. The basic processes of fractionation are programmed on the PC, and then send to the proper machine or to all machines. The programmed methods make the fractionation very flexible. To realize the cooperation of the PC and the fractionation machine, this paper using a lot of subprograms in the software designing on the fractionation machine, and the PC management software provides a platform of the program using the instructions according with these subprograms. When the user programmed an operation process using these instructions, and sends them to the fractionation machine, these programs will be translated into a process list; each step of the process is a subprogram. These subprograms are the basic operation of the process, such as open door, close door, upper press to xx mms, etc.

3 The hardware design of the fractionation machine’s control system

The fractionation machines have many devices such as press boards, press door, pressure valves, healing head, keyboards, electric balance, detectors, position sensors, scanner and so on. These devices can be divided into some parts of their interface—analogue devices, serial interface device, DC motor, relay controlled devices. This paper designed the control system using C8051F040 as the main controller to be controlled, which is a kind of SOC(system on chip). C8051F040 has 2 A/D converter channels up to 12 inputs, 2 10-bit D/A outputs, 4 channels of PCA, supports serial ports, SPI bus, CAN bus[5]. The structure of the control system is shown in figure 2.
This system used 8 detectors to control the proper time to stop the press process, which will direct impacts the precision of the fractionation. These detectors can be chosen by suggestions or through some experiments. The sensitive detector is placed on the tubes, so when most PRP is needed, this detector will be useful. The position sensor can detects press boards current position for displacement control. The electrical balances can provide the weights of PRP and other components.

Valves control the blood flowing into the expected bag. After all components have flowed into the correct bag, the tube will be healed, and the quadruple bag will be separated into 4 bags. The upper press and the lower press provide a smooth extrusion lets the different components flows to the bags. Top press can be used for pressing the maintaining liquid into RCC bag or for air exclusion.

Flash memory saved the programs received from PC and some setting of the machine, such as the machine number, current program number and so on. The motor in the system can control the flow speed in the tube.

4 The software design of the fractionation machine’s control system

The software of the fractionation is programmed using MCU C language, because there are many devices and some of them are complicated, the design of the software is a large project. This paper uses many sub modules to solve different functions, this modular and layered structure is easy to debug and design.

The module “Can.c” receives operation instructions or setting parameters from a PC, it also sends the result of the process to PC through can bus. The module “Adc.c” captures the sensors and computes values. “Out.c” is a very important module, which includes all subprograms of the basic processes. Since there are 9 modules in this design, the dispatch method is very important for programming. The paper introduces the status machine into the MCU software designed. This design has 4 statuses: power off status, power on status, running status, pause status.
Power off status is the initial status after having given power to the system without pressing the power key. At the status, the machine reads settings in the flash, waiting for power key. After power key pressed, the machine will turn to power on status. The system will firstly do self-test, check if there has connected to CAN bus, check if the PC is powered on, etc. Then open the door, wait for operators hang the bag and press the close key. When all have prepared, and close key is pressed, then the system will close the door and run the selected program. When, in some case, the operator can press the pause key to pause, the current operation will be paused, waiting for keys to resume or stop. This is hard to solve on the MCU. Because, the pause status doesn't just tap into an endless loop. Some pause operation must be done first before endless loop, such as if the current process is upper press to 20mms, the press is advancing until the position sensor showed the press have reached the correct position. This is a loop waiting for a special condition, but when pause status is just an endless loop, the press will not stop, and the blood will all go into a bag and all components mixed again. This design first stops the press moving, close all valves to avoid blood still flowing into the bag (the valve status should first be saved), then traps into an endless loop.

5 Conclusions

This paper introduces the design of the control system of automatic blood component fractionation system, which is flexible, precise, easy to use, and meet with the Blood Bank standards. This system can be used in most of China blood systems, and have shown to be having a good market foreground.

References