Introduction of SCIRAY electron accelerator comprehensive irradiation processing system

1. Overview

The comprehensive irradiation processing system of electron accelerator is a kind of irradiation system that uses high-energy electron beam to irradiate articles, so that the pests, germs and microorganisms in articles are damaged and killed, so as to realize the preservation of food and disinfection and sterilization of medicines and medical & sanitary articles.The physical and chemical properties of the articles can also be significantly improved by electron beam irradiation, so as to obtain higher use value.Electron beam irradiation has the advantages of fast, high efficiency, no pollution, no waste and so on. It is a green and environmental protection treatment method.

2. System composition

The comprehensive irradiation processing system of electron accelerator mainly includes: electron accelerator system, goods delivery system, central control system, radiation protection system, safety interlocking system and production information management software.

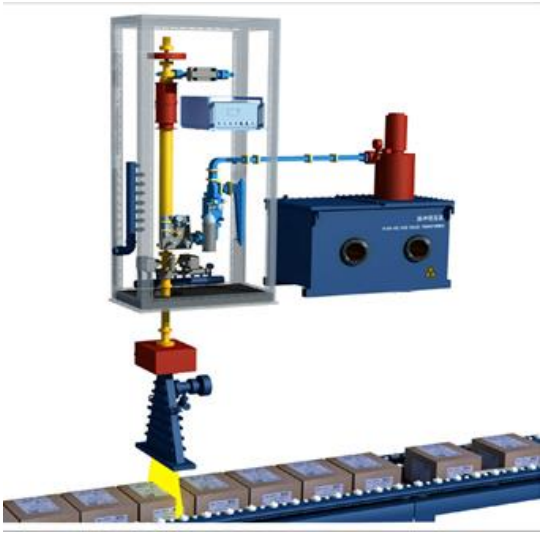
2.1 Electron accelerator system

The electron accelerator subsystem is used to generate high-energy electron beams, including accelerator head, modulator, klystron, power supply cabinet, control cabinet and water cooling unit. **Sciray** electron accelerator adopts traveling wave accelerator tube, which has the advantages of short field establishment time and small power reflection,etc.

(1)The accelerator head includes electron gun, accelerator tube, titanium pump, scanning box, scanning magnet, focusing guide coil, microwave transmission system, inflation system, etc. After heating, the electron gun filament emits an electron beam under the action of a high voltage electric field. The electron beam receives the microwave power inside the accelerator tube and obtains high energy. The high-energy electron

beam enters the scanning box from the exit of the accelerator tube and is drawn out from the scanning box in a fan distribution under the action of the scanning magnet, thus forming the high-energy electron beam that can be used to irradiate processing

(2) High-power pulse modulator is an important component of high-power irradiation accelerator.It is the pulse power source of accelerator system. The modulator system consists of distribution unit, control unit, charging unit, solid state switching unit, pulse transformer and so on.



(3) Klystron is the microwave power source of electron accelerator, and its main function is to convert pulse high voltage into microwave power. The **Sciray** electron accelerator adopts the klystron of the international famous brand, which has the advantages of large output power, high-gain and long life.

(4) The power cabinet is equipped with klystron focusing wire package

power supply, scanning magnet power supply, electron gun power supply, accelerator tube focusing power supply, titanium pump power supply, etc., to provide power distribution for the main components of the accelerator.

(5) The control cabinet is the operating platform for the operation and debugging of the accelerator. The control cabinet is equipped with PLC module(s) and touch screen, which is used for the state parameter monitoring, operation control and fault diagnosis of the accelerator system.

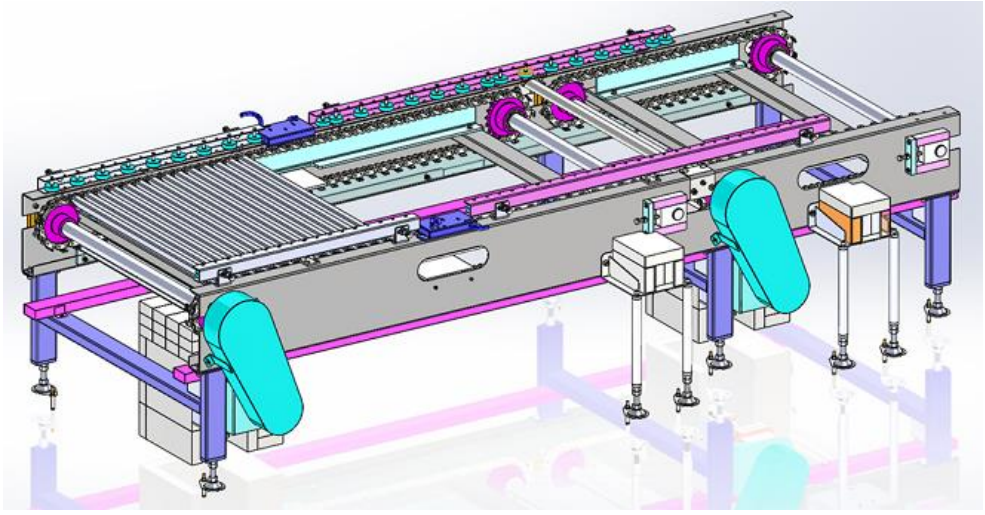
(6) The water cooling unit is used to provide cooling water that meets the requirements of temperature, flow rate and pressure for the accelerator system, and take away the excess heat during normal operation of the accelerator.

2.2 **Goods delivery system**

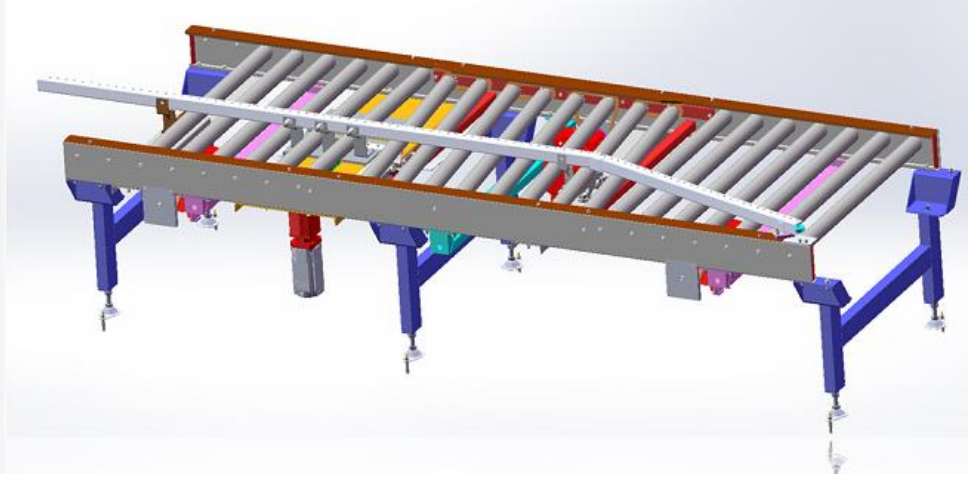
The goods delivery system is responsible for the logistics delivery of the whole system, so that the goods pass through the beam in accordance with the speed and posture required by the irradiation process, and receive the prescribed dose of irradiation. According to the different position, it can be divided into underbeam unit, goods centering unit, automatic turning over unit, loading unit, unloading unit and other

conveying unit.

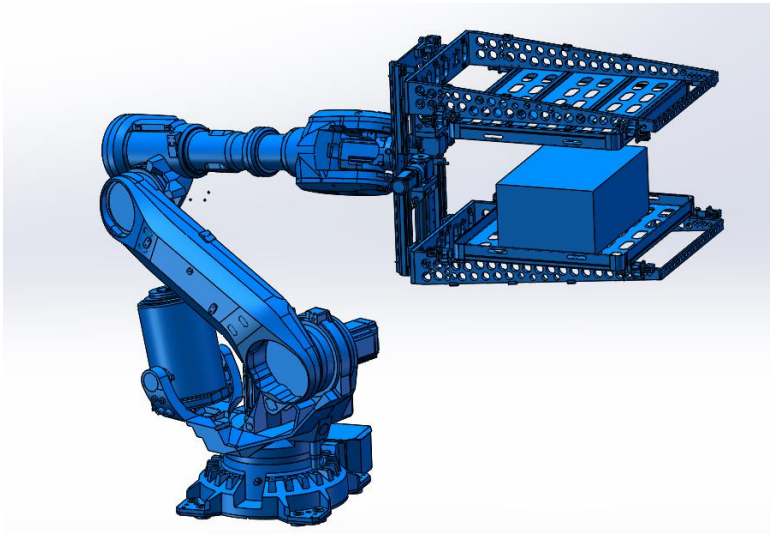
(1)The underbeam unit is located directly under the accelerator, and the items transported by it are irradiated under the beam of the accelerator.The position of the underbeam unit is beam concentrated, the radiation of the ray is very strong, the heating effect of the beam is also very obvious, and the ozone concentration is very high, so the unit under the beam is generally adopted plate chain structure, the main structural materials are stainless steel, the key components such as the motor are protected by shielding materials. In addition, the unit under the beam is driven by servo motor, which can not only meet the speed adjustment of a wide range, but also ensure the speed accuracy of the delivery of goods, so as to ensure the uniformity of the dose received by the goods.



(2) The goods centering unit is arranged in front of the underbeam unit. By adjusting the center device on both sides of the transmission line, the article is forced to be centered in the middle of the transmission line when passing through this section, so as to ensure that the article is in the middle of the electron beam when receiving irradiation through the under beam unit, so as to ensure the utilization efficiency of the beam when the article irradiation.



(3)The automatic turning over unit is generally arranged outside the shielded building, which is used for items requiring double-sided irradiation. After the first irradiation is completed, the automatic turning over unit turn over the item and then the second irradiation is performed.The automatic turning over unit generally adopts appropriate mechanical arm to complete turing over work.



(4) The loading and unloading unit as well as other conveying units adopt speed regulation by frequency conversion to match with the tranmission speed of under beam unit. In addition, it is also necessary to set up the accumulation function to achieve the overall transmission control. Generally, according to the quality control requirements, it is necessary to set up the inspection area of nonconforming products.

2.3 Central control system

The central control system is the core control unit of the whole system. It controls accelerator, goods delivery system and safety interlocking system, etc. It is composed of control cabinet, drive cabinet, operating platform, detection switch and operating system, etc. The main control functions are as follows:

(1) It can realize startup self-test, the control computer interface can display the state of each system, and provide fault pre-assessment,

through monitoring key parameters, can predict the possible failure, facilitate maintenance and maintenance in advance, reduce the downtime caused by failure.

(2) The simulation interface is used to monitor the whole working process of the system.The key parameters such as the running state of the accelerator, dosage and delivery state of items are monitored in real time.The actual position of the items is displayed, and the running log, fault log and alarm record of the delivery of items and the accelerator are recorded in detail.

(3) The control system is combined with the production management software to transform the process parameters generated by the management software into the control parameters of logistics transportation and accelerator control. These parameters are transmitted to the delivery device and accelerator through the control center, so as to control the irradiation processing process of the goods and ensure that the goods receive the required irradiation dose; The irradiation production process is recorded in real time during the irradiation process, and the irradiation process and results are recorded and fed back to the irradiation process management software system.

(4)The control system realizes the cooperative work of the accelerator

and the delivery device to realize the beam emitting before the irradiated object reaches the irradiation area. When the irradiated object does not reach the irradiation area for a long time, the system will automatically stop the beam emitting. In addition, the delivery speed of the items under the beam can also be set and adjusted through the control system to ensure that the items receive the required irradiation dose.

(5) The control system receives the signal of the safety interlocking system. In case of emergency, the accelerator power can be cut off immediately.

(6) Through the fault diagnosis interface of the control system, you can easily find the cause of the fault. You can query the running status of the device and the cause of the fault in a certain period of time through logs, and export the logs to related technical support personnel for fault cause analysis.

2.4 Radiation protection system

Radiation protection systems are designed to protect workers and the public from radiation exposure. They mainly include building shielding and ventilation facilities.

The building shielding is mainly made of labyrinth concrete building,

which is generally two-story structure, in which the accelerator head, pulse transformer, klystron and waveguide system are installed on the second floor, and the goods delivery system is installed on the first floor. The size of the building shielding shall be determined according to the shielding calculation results, and the convenience of equipment installation and maintenance shall also be considered. The concrete density is generally not less than 2.3g/cm^3.

Ventilation facilities are designed to exhaust the ozone generated in the process of irradiation to high altitude for emission degradation and meet the requirements of environmental protection. They are mainly composed of exhaust ducts and exhaust fans on buildings.

2.5 Safety interlocking system

Safety interlocking system is a set of devices to ensure the safety of personnel and equipment, consisting of various switches, acousto-optic alarm devices, control devices, etc. The safety interlocking system has the following functions:

(1) The system control room is equipped with a safety interlock key switch on the operating table. Only when the safety interlock key switch hits "on", the accelerator may release the beam; When the switch control key is turned to "OFF" or pulled out, the accelerator cannot beam out, or stop

beaming out immediately when the accelerator is beaming out.

(2) The emergency stop buttons or emergency stop pull wires are installed in the system console and important positions in the radiation protection zone. When an accident occurs, press the emergency stop button or pull down the emergency stop pull wire nearby, and the accelerator will automatically stop beaming out.

(3) All the doors of equipment room are equipped with door switches to form the door- machine interlock. Only when the door- machine interlock is ready, the accelerator can release the beam.

(4) Red, yellow and green alarm lights and alarm bells are installed at appropriate positions in the equipment room to indicate the working status of the system. When the working status indicator lights and alarm bells cannot work normally, the accelerator cannot send out the beam

(5) There is a regional dose detector respectively equipped at the gate of the equipment room and at the appropriate position in the maze passage of the equipment room on the first floor, which is used to detect whether the beam output and boundary dose of the accelerator reach the standard, so as to ensure personnel safety.

(6) In the maze passage of the first floor and the second floor, the detection photoelectric device is equipped respectively to prevent

people from entering the maze passage. In the process of the accelerator is beaming out, if someone enters the maze passage, the photoelectric device will be triggered, and the accelerator will immediately stop beaming out.

(7) The system installs a detection device at the ventilation duct for ventilation interlocking. If the ventilation is abnormal, the accelerator will stop sending out the beam.

(8) The system is equipped with a monitoring system and a broadcasting system. The operator can view the situation in the whole radiation protection zone through the monitoring screen and make voice prompt by using the broadcasting system.

2.6 Production management software

Production management software is a set of information management software specially developed for electron beam irradiation processing center, covering production process management, production information management, personnel management and production process data management, etc., which can effectively improve the information management of irradiation system and improve the quality control level. Main functions of the software are as follows:

(1) The operator directly issues the production task instruction through

the software, and the process parameters and equipment parameters in the task are automatically sent to the hardware equipment, with a high degree of automation and simple operation.

(2) The software realizes the management of the entire irradiation business process. After receiving the goods entrusted by the owner, the staff who is in charge of the external irradiation business shall input the information of the bill and the goods, and the goods shall enter into the goods management warehouse; The irradiation technologist will analyze the items in the goods warehouse, input the corresponding process parameters, and the items will enter the work queue and wait. The system monitor is responsible for completing the irradiation work of each batch of goods, and the software automatically records the equipment status (including normal or abnormal conditions) during the irradiation process. After completion, the monitor fills in the irradiation conclusion: If the goods irradiated by the technology need sampling inspection, the technologist fills in the irradiation effect conclusion after inspection; After the processing process is completed in the irradiation center, the salesman delivers the goods and fills in the invoice information such as the time. In the whole business process, the software can check the information of each batch of goods, progress status, responsible personnel and irradiation records at each stage, which is convenient for

management and quality traceability.

(3) Software management of human resources. The software records each personnel information and establishes the user, carries on the work role and the responsibility authority assignment to the personnel. The system records each user's work situation, realizes the above work link personnel responsibility system, facilitates the work record and the personnel management.

(4) Software management of ID information. In the irradiation center, to achieve strict quality management and optimal resource allocation, it is necessary to establish the ID information of the containers, pallets and personnel. ID identification generation, binding with the production process, management, information recording and so on are completed by software, to achieve ID information management.

(5) The software has a complete database and powerful data management function. The equipment information, production records, technical standards and personnel information of the electron irradiation center are stored in corresponding databases. For example: each production record remains in the job log (historical records), and can be convenient to view and retrieve. The reference information database stores international or national irradiation process standards, self-established process procedures or related technical data, which is

convenient for enterprises to accumulate technical experience, and also for the actual production work. Equipment operation history information database, easy to maintain and repair, quality back check. . The database has the functions of viewing, searching, editing and so on, which is convenient for users to manage and call the data.

(6) The software has the functions of report generation, viewing,exporting and printing.

(7) The software has the function of remote diagnosis of the system. When a fault occurs in the user's system, Sciray service center can remotely refer to the fault alarm record of the system, analyze the cause of the fault through the record, and rectify the fault through remote modification. For hardware faults, can also prepare spare parts in the first time to shorten the maintenance and troubleshooting time.