Automation control and design application of factory sewage disposal system

Zhicheng Chen*

Henan University of Technology, Henan Zhengzhou 450001

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Abstract

Intellectualization and automatization become the key technology of sewage disposal for effective realization of sewage disposal technology, continuous and stable operation of system and water quality standard. This paper took a full consideration on the function of online instrumentation in autonomous system and confirmed monitoring system scheme of three-in-one network (data, video and voice) and PLC control scheme adopting means of centralized management and decentralized control combining with sewage disposal technology. Factory adopts Ethernet looped network of optical fibre industry as backbone network for communication and located monitoring system at the central control room of comprehensive office building in sewage disposal factory. It realizes collection and monitoring of procedure parameter, analysis and processing of data, remote monitoring of core equipment. Coarse screen system subprogram, fine screen system screen, immersible pump subprogram, return sludge system program and return sludge system subprogram were detailed described according to technology requirement and design principle of PLC substation. It also discussed test quality guarantee of autonomous system.

Keywords: Sewage disposal, autonomous system, data communication, PLC system

1 Introduction

Urban sewage usually enters drainage system by urban sewage collection pipe. These sewage contain pathogenic microorganism such as bacteria and virus [1]. Therefore, urban sewage must be disposed. Sewage disposal factory can play fatal function for local environment protection. However, sewage disposal technology environment in current stage is relatively serious, which requires sewage disposal system to have high automatization control level [2]. Sewage disposal factory in our country started late. Although current autonomous system basically realizes domestication [3], part of key equipment and component still need to be imported. Operating cost of disposal factory relies on the financial situation of government, which is easy to cause lack of cost consciousness, overstaff and old-fashioned management means [4]. Therefore, it is urgent need to do optimal design on automation control of sewage disposal system.

Domestic sewage disposal factories adopt a few automatic control systems. They can be divided into SCADA system, DCS system, IPC+ PLC system and system composed of bus-based industrial computer [5]. Li Yan [6] from Tianjin University applied control technology of PLC and PROFIBUS fieldbus in automation system design of sewage disposal factory, adopted DCS form of IPC+PLC structure and selected communication scheme of industrial Ethernet+ PROFIBUS fieldbus. Chen Zhengjing [7] adopts star optical fibre Ethernet structure as computer monitoring system and established Client/ Serber structure based on TCP/IP networking protocol. Shan Liang [8] composed control system based on PLC monitoring technology and open network integrated technology and realized optimizing of automatic control process through optimal design and selection of PLC and instrument of automatic control system. This paper adopted computer monitoring (SCADA) main system of central control room to monitor water input and output and water quality index. Relative data will be stored for at least one year as basis of assisted decision for production and operation in future. It has significant function on flexible, efficient, and reliable of sewage disposal process and lower the cost of early construction and capital construction.

2 Overview of sewage disposal autonomous system technology

Control substation realizes unattended operation. Mainstream product in automation control equipment industry is selected and expansion space is reserved on design. Monitoring system adopts sharing network of 100 Mbps optical fibre Ethernet with self-healing capacity, automatic monitoring system and video monitoring system, that is, three-in-one network of data, video and voice. The selected software is modularization and structuralization software for edit, debugging, modification and update of user program [9]. Control means is central control, workshop control and site equipment control, which combines automation and

* ***Corresponding author*** e-mail chen_1958@163.com

manual operation. Local control level is prior [10]. It is shown in Fig.1.

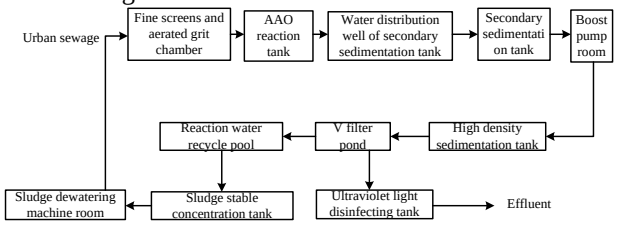

FIGURE 1 diagram of technology flow in sewage factory

Automatization control system of sewage disposal factory is required to realize running mode of centralized management and decentralized control for dispersing breakdown. System allocation needs flexibility as well as compatibility, openness, expansibility for realizing standardization and modularization construction [11]. Software interface standard OPC is regarded as data standard because it can realize data share of soft hardware of different brands.

3 Structure design of sewage disposal autonomous system

3.1 SYSTEM COMPOSITION

This paper adopts mode of "centralized management and decentralized control". Autonomous system can be divided into central control, workshop control and site equipment control. Automation and mutual control are combined together. And local control level is prior. Main control system adopts S7-200 and S7-300 series PLC produced by Germany SIEMENS corporation [12]. And dewatering room and technology section of oil desilting field adopt moisture proof and anticorrosive PACR2 control system produced by OPTO Corporation.

Autonomous system of sewage disposal factory is composed of PLC 1 (including coarse screen room, influent room and primary power distribution room), PLC 2 (including fine screen room, grit chamber, drain tank and pump room), PLC 3 (biological pool and sludge dewatering room), PLC 4 (blower room and power distribution room), PLC 5 (secondary sedimentation tank, water distribution well and chlorine dosing room) and PLC 6 (boost pump room, filter pond, backwash pump room and power distribution room). Every substation is made up of PLC system, HIMI man-machine interface, industrial Ethernet switching, uninterruptible power supply (UPS) and lighting proof protection device. Substation selects SIEMENS S7-300 series PLC and CPU317-2DP/PN PLC controller. MP277 colour touch screen of SEMENS Corporation is equipped in every substation as man-machine interface of PLC control station. PLC 6 control substation includes seven control subsites PLC6.1-PLC6.7. Every substation monitors two filter. These seven subsites select SEMENS S7-200 series PLC and CPU226 controller. Every substation is equipped one 5.7 inches colour touch screen. Mater station and substation, substation and subsite are connected by industrial Ethernet as shown in Fig.2.

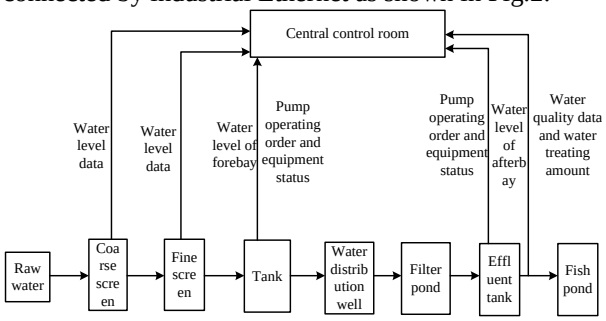

FIGURE 2 structure diagram of autonomous system of sewage disposal factory

3.2 NETWORK COMPOSITION SCHEME

Computer monitoring system of sewage disposal factory adopts 100 Mbps optical fibre Ethernet with self healing function which is sharing network of video monitoring system and autonomous system. That is three-in-one network of data, voice and video. Communication backbone adopts optical fibre Ethernet. Autonomous system design adopts PLC integrated control system.

4 Model Construction

4.1 SETTING OF ENGINEERING CONTROL MODE

Engineering control mode can be divided into manual mode and automatic mode.

(1) Manual control mode: equipment can operate independently to avoid effect on other equipment's when one equipment is broken down. Mud scraper, grillage machine, reverse dosing equipment, washing equipment, water pump and valve are individually controlled by site control button.

(2) Autonomous control pattern: equipment operation does not need manual intervention. It is start-stop controlled by technology parameter and PLC according to working condition of sewage factory.

And flow chart is shown in Fig.3.

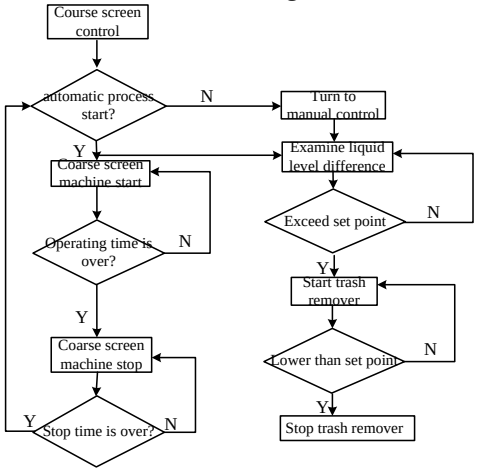

FIGURE 3 working flow diagram of coarse screen

The function of coarse screen system subprogram is to control the operating of coarse screen and trash remover. In automatic mode, coarse screen starts and is timed. Coarse screen stop operating after 20 min and is timing 2 h. coarse screen continues to operate for 20 min after 2 h. It moves in such circles. Meanwhile, liquid level difference is examined. If liquid level difference exceeds set point, then trash remover starts. If liquid differences lower than set point, then trash remover stops. Fine screen system subprogram is similar to coarse screen. The only difference is that fine screen controls the operating of fine course and trash remover.

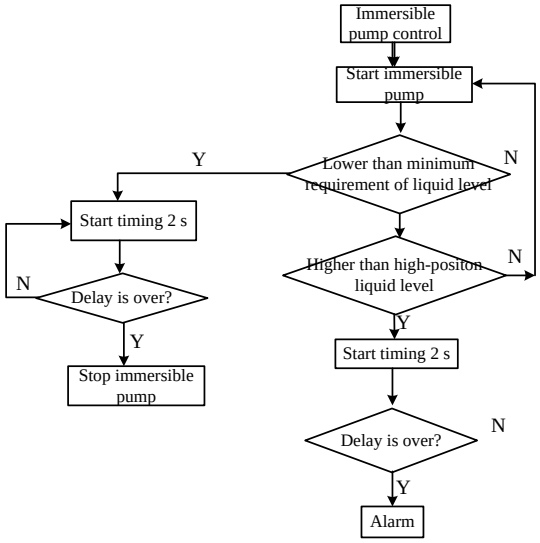

FIGURE 4 work flow of immersible pump

Function of immersible pump subprogram is to control the operating mode of immersible pump. In automatic mode, immersible pump starts. At that moment, liquid level is examined whether it is lower that lowest-position sensor. It it is, and then timing starts for preventing misjudgment. If liquid level is still lower than the lowest-position sensor when the timing is over, then immersible pump stops operating. Otherwise, immersible pump continues to operating. If liquid level is between meso-position and high-position sensor, then timing starts for preventing misjudgment. If liquid level is still in high-position sensor when timing is over, then alerting signal is output.

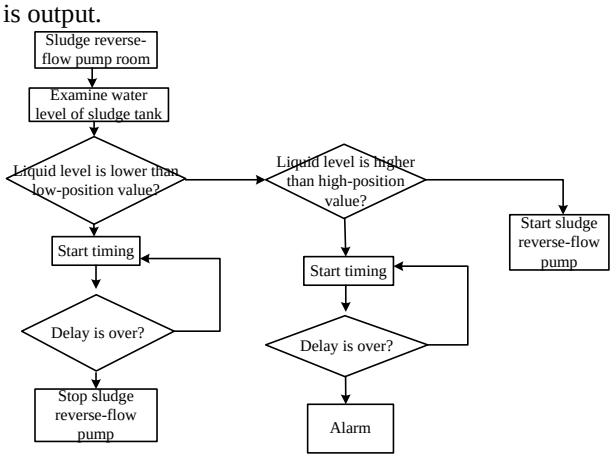

FIGURE 5 workflow of sludge reverse-flow system

The function of sludge reverse-flow system program is to control start and stop of sludge reverse-flow pump. In automatic mode, liquid level is monitored. If it is lower than lowest liquid value, then timer starts. If liquid level is still lower than lowest liquid level sensor when timing is over, then the reverse-flow pump automatically stop operating. If the liquid level is between highest-position and lowest-position, sludge reverse-flow pump starts. If it is higher than highest-position, then timer starts. If liquid level is still in the highest-position when timing is over, then alerting signal of accidents is output.

Function of sludge dewatering system program is to control centrifugal extractor. Centrifugal extractor and timer starts. When timing of timer is over, then polymer pump starts. At this moment, timer starts again. When the timing is over, then cutting machine and sludge reverse-flow pump starts operating.

4.2 REALIZATION OF SYSTEM FUNCTION

Automatic control function of sewage disposal factory is realized by main system of computer monitoring (SCADA) in central control room. Four monitor workstations in central control room operate configuration monitoring program. And configuration software realizes quantum hot standby. SCADA can adjust the production process of the whole factory, monitor operating of subsystems and equipment's intensively and realize information management function.

4.3 VIDEO DISPLAY OF CENTRAL CONTROL ROOM

Video display frames provided by superior system have following kinds: overall display picture of overview map of whole factory, overall display picture of technological process of whole factory, main picture display of monitoring system, summary picture of overall signal, summary picture of alarming, production curve picture, picture of system menu and detailed monitoring picture of equipment or facilities.

4.5 QUALITY CONTROL MEASURE OF AUTOMATIC CONTROL SYSTEM FUNCTION TEST OF SEWAGE FACTORY

System fault caused by current software failure has become a problem that cannot be neglected in industrial automatic control system. Software failures have two characteristics compared to hardware failure. One is that software failure will not change with time. Second is that software failure is mostly caused by inherited error in procedure code. Interface error between software and hardware is also an important factor of configuration software failure [8]. Therefore, key point of software is the test before leaving factory and in early period of use, especially the system test after integration of software and hardware.

System test environment. We need to establish a system test environment for the operating of software in real hardware environment, adding test case into tested software by testers and collecting test data, as shown in Fig.6. It is a test platform composed of software and hardware

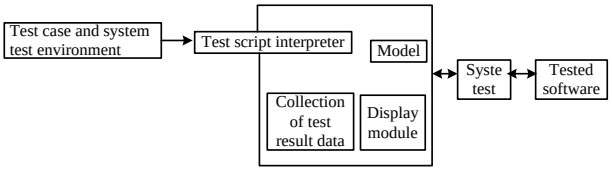

FIGURE 6 diagram of software system test environment

System test process. After establishing test environment, we can use it to do system test. System test can be divided into following procedures: design test case, operating test, analysis of test results and test conclusion.

TABLE 1 classification of design test case

Design test case		
normal function test	***boundary situation test***	***abnormal operation test***
Simulate some representative operation according to the normal use situation of tested engine	boundary test on analogy quantity input in tested system	For inspecting abnormal condition processing ability of industrial automatization control system software

It can be considered from normal function, boundary situation, abnormal operating according to the different emphasis of test while designing test case. Content or objective is shown in Table 1. In graphical editing environment provided by test environment, test case that have been designed transforms into test script form which can be identified by test environment by drawing picture or text. A test case transforms into a test script [14]. After test, test environment will automatically collect operating data of tested equipment. These data and expected result in test case are compared and analysed to judge whether this test equipment is broken down.

5 Conclusion

This design adopts mode of centralized management and decentralized control, monitoring system scheme of three-in-one network of data, video and voice and PLC control scheme according to technology requirement and design principle of PLC substation. Factory communication applies optical fibre industrial Ethernet as backbone network. Autonomous system can be divided into central control, workshop control and site equipment control. Automatic control and manual control are combined. And local control level is prior. Autonomous system of sewage disposal factory in this design is composed of central monitor station and six site control substations. And PLC system is made model selection. Dewatering machine room and oil desilting field adopt moisture proof and anticorrosive PACR2 control system produced by OPTO Corporation. And substation selects SIEMENS S 7-300 series PLC. Subsite selects SIEMENS S 7-200 series PLC. Software should be tested before leaving factory and in early period of use for ensuring autonomous system function, especially the system test after integration of software and hardware.

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Authors

Chen Zhicheng, born in February, 1960, Henan Province of China

Current position, grades: associate professor
University studies: Master degree was earned in major of vegetable protein and comprehensive utilization, Jiangnan University in 2001.
Scientific interest: computer and factory automation