Design and Implementation of Automatic Loading Control System for Oil Terminal

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***Abstract*—In order to enhance the automation degree of the oil terminal operation, improve efficiency and measurement accuracy of the loading operation, and ensure operational security at the terminal, this paper describes the control process and its control strategy of automatic loading system based on the actual business of oil terminal. On this basis, the oil terminal automatic loading control system is designed and implemented. The system adopts PLC (Programmable Logic Controller), network communication technology, sensors and other advanced technologies, implementing various functions of the system which consists of a remote control part, a field operation part and a corresponding network communication device with design. The on-site operation part is used for collecting various data such as the data on the storage and transportation system, loading, shipping and process status of the storage tank area. Then the collected data will be transmitted to the remote control part through the communication equipment of the internet and the LAN (local area network). After processed by the remote control part, it is graphically displayed on the remote control screen in real time to realize tank area metering monitoring management, oil product process management, loading process management, TV monitoring management, alarm supervision and other related functions. The automatic loading control system of the oil terminal provides auxiliary support for the terminal operation, which reduces the mistakes caused by human operation and the labor intensity of the operators, improves the automation degree of the terminal operation, and ensures the safety and efficiency of oil storage and transportation.**

***Index Terms*—oil, automation control, terminal, loading, measurement accuracy**

I. Introduction

Because oily goods are prone to leakage and evaporation during storage or transportation, they are more likely to be the direct cause of fire, explosion, poisoning and other accidents. In the port area, loading operations are an important part of the storage and transportation of oily goods [1].To ensure the safety of loading operations, which is necessary to ensure the safety and health of personnel and to realize the safety of storage and transportation. Based on the oily goods logistics model, the existing process of production and operation is studied and analyzed. [2] This paper designs an integrated control system for oily goods terminals that is managed and controlled to achieve process protection, eliminates the phenomenon of wrong valves and error-turning processes caused by artificial reason, and monitors internal leakage of valves by technical means to prevent oil leakage accidents, in order to ensure safely automatic loading and sales [3].

II. System Technical Characteristics

The oily goods terminal automatic loading system is based on the business needs of the cargo terminal, using advanced technologies such as PLC and network technology to build a professional terminal automation control system which based on sensors, control technology and display technology. It mainly has the following technical features:

1) The system includes an independent control network, which is separate from the office network, so that the reasonable use of communication resources can be ensured without interference from the office network.

2) The communication between the main control PLC and the upper computer operation station adopts the ring Ethernet structure to ensure the stability of Ethernet data communication.

3) By controlling the pressure fluctuation of the variable frequency pump control system, the constant pressure loading in a small range is maintained [4].

III. Overall System Design

Tank truck loading requires strict safety operations. The loading and unloading operations and the personnel, crafts, equipment, and tools on the site must meet the requirements for safe operation. For example, it is forbidden to use non-explosion-proof tools, implements and equipment, and to carry fire sources, use non-explosion-proof tools (such as iron wrenches, pliers, etc.), communication camera equipment (such as mobile phones, cameras, etc.).

The transport personnel need to be certified and the escort's escort certificate is complete and effective. When obtaining the oil quantity of the tanker, if the on-board oil tank has been metered and calibrated, the oil level can be measured by the dipstick, and the oil storage amount can be found according to the conversion comparison table. If you haven't done it, you can use the two weighing method, that is, the car is lifted on the ground and weighed, and then the oil is emptied and weighed again.

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The two subtractions are the weight of the oil. The volume of the oil can be converted by the specific gravity of the oil. This method relies on humans, but the error is large and time consuming [5].

Based on modern control and information technology, this study designs an oily goods terminal automation control system, which is divided into four subsystems: central control room, MCC motor control room, dock control room and remote service. The overall design is shown in Fig. 1.

The central control room is connected to the PLC system, the loading monitoring station and the terminal control station in the MCC motor control room. The loading monitoring station is connected with the billing management station, the platform management station and the hub system; the central control room is designed with a server for storing the tank storage and transportation system data, loading data, shipping data, process status data, fire monitoring alarm Data; operation station, used to monitor the data in the library area, can control the field device, and can directly transmit the display signal to the large-screen display system, display various data, various three-dimensional process state diagrams on the large screen.

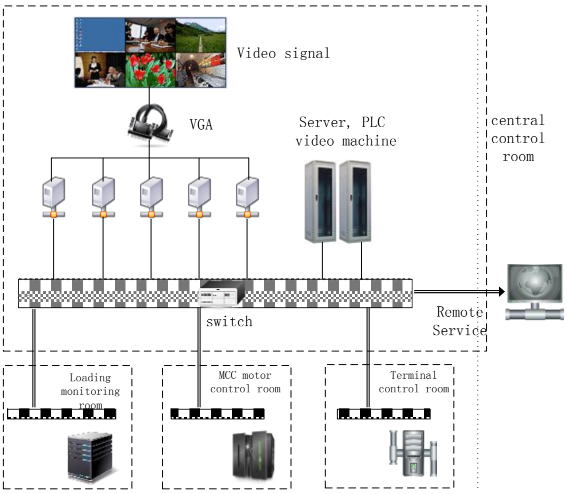

Figure 1. Overall design.

A. Software System Architecture Design

The system structure adopts the combination of C/S and B/S to ensure the system is stable, reliable and easy to use. The terminal node to the server, such as the loading monitoring room, the MCC motor control room, and the terminal control room, adopts a C/S structure, and the data distribution of the server adopts a B/S structure.

B. Design of Oil Product Sales System

The sales system is an important part of oil sales. In the sales system, the loading system is included to make the entire business process closer to reality, improve work efficiency, and improve management.

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1) Sales network topology diagram

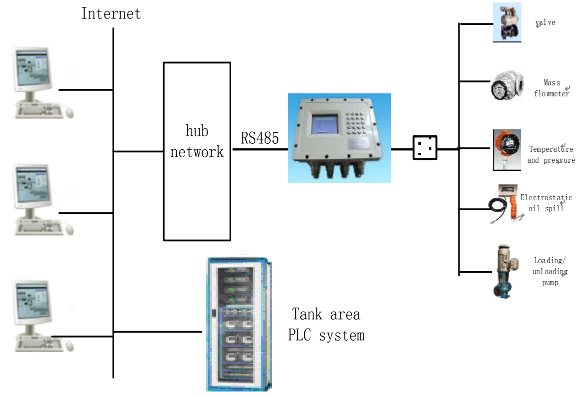

Figure 2. Sales network topology.

The system adopts the idea of distributed control centralized management (DCS) to ensure stable, reliable and convenient management during the whole system operation, including control substation and monitoring management station. The valve control signal, pump control signal, flow signal, alarm signal (anti-overflow, grounding) of each loading crane position are directly connected to the monitoring sub-station, and the monitoring sub-station is installed at the loading station. It is also responsible for the data signal acquisition calculation and logic control of each crane position. This scheme improves the measurement accuracy and operational reliability. All monitoring substations are connected to the monitoring and management machine (hub) of the measuring room via the RS485 bus. The purpose of this is to reduce the amount of wiring. The monitoring sub-station can be installed on the desktop or on the wall according to the actual situation. The monitoring management machine and each monitoring sub-station perform real-time data communication to centrally manage the oil data information. The monitoring substation has two working modes, online and single. After the upper monitoring and management failure, the system can still realize the quantitative loading control. Oil product Sales process data flow is shown in Fig. 3.

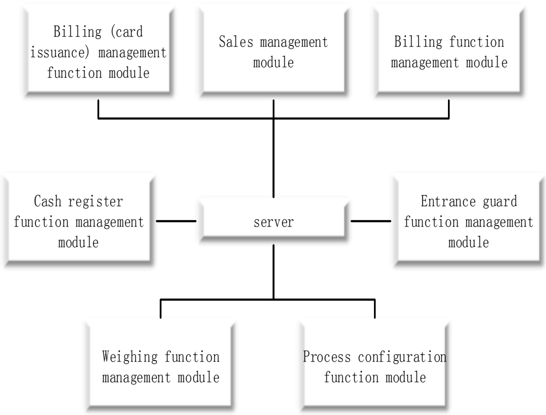

Figure 3. Sales process data flow.

Data sharing and easy management through the Internet. The billing management machine and the monitoring management machine are connected via Ethernet, and the billing data information can be transmitted to the monitoring management machine in real time, which not only ensures data validity but also reduces data input workload. The system also has a sub-assembly function to meet the needs of canning and barreling before and after.

2) Access control system architecture design

As is shown in Fig. 4, the access control system is used in conjunction with the loading system. The access control system includes the automatic recognition function of the vehicle. The system is combined with the loading management system to realize the vehicle effectiveness check and access control management functions to prevent illegal operation.

Through the access control management system, the access control, the car number identification, and the completion of the loading process are realized. As part of the sales process, you can set the role and behavior of the access control system throughout the sales process, such as checking the vehicle's effectiveness.

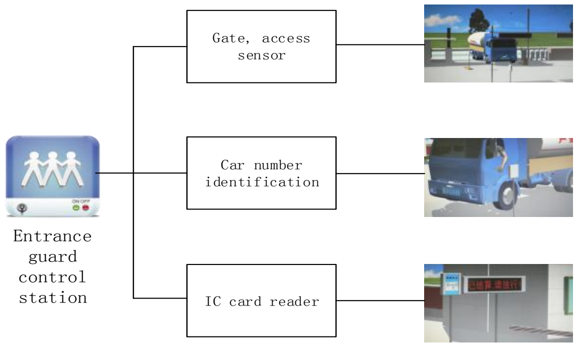

Figure 4. Entrance guard control system architecture.

D. Telecom and Video Surveillance System Design

The telecom and network monitoring system includes two parts: tank area monitoring and terminal monitoring. The tank area monitoring includes telephone and network systems, closed circuit television monitoring system, television monitoring system, access control system, wireless intercom system, information release system, and conference facilities system. The dock monitoring system includes a television monitoring system. Finally, the dock TV monitoring system is connected to the large screen of the tank monitoring area.

The system consists of the input interface of the PLC system of the tank area, the input interface of the loading system, the input interface of the loading and unloading system, and the electronic patrol input interface. The large screen can display all signals of the entire integrated control system, including: tank area measurement information, process control information, fire alarm information, security video surveillance information. The structure principle is shown in Fig. 5.

As shown in the figure, the TV monitor video signal is connected to the video matrix, and the output of the video matrix is connected to the large screen system; the signals of other systems are connected to the VGA matrix through the operation station VGA output of the central control room, and the output of the VGA matrix is connected to the large Screen system.

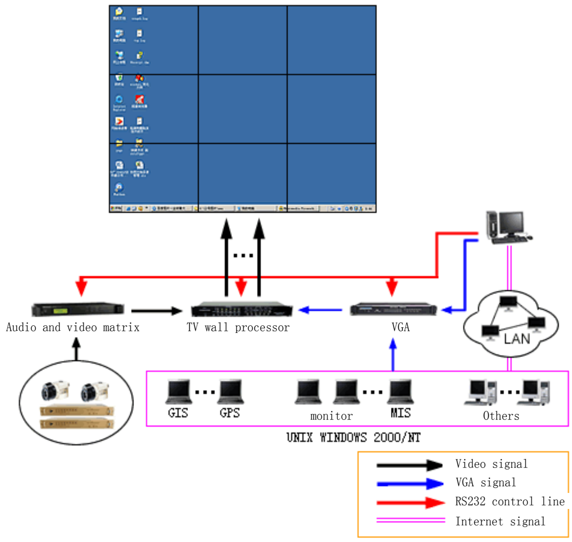

Figure 5. Telecom and video surveillance.

IV. Key Technologies for System Implementation

A. Measurement Accuracy Control Technology

There are three main factors that affect the accuracy of loading:

1) Flowmeter accuracy

Under a certain pressure condition, the flow rate of the flowmeter basically has a certain range. If it exceeds this range, the system automatically prompts the flowmeter to alarm, thereby realizing the automatic detection of the flowmeter accuracy function.

2) Accuracy problems caused by flow overshoot

As is shown in Fig. 6, the closing of the flowmeter valve takes time. After the shutdown is performed, the liquid continues to flow out due to the inertia and pressure of the liquid itself, which causes a measurement error. Therefore, under certain conditions, predicting the momentum of the liquid is the key to solving the problem. The system reduces the pressure fluctuation of the variable frequency pump control system as much as possible, keeps the constant pressure loading in a small range, and the system itself has a fuzzy algorithm, automatically corrects the advance parameter, and tries to make the loading data reach the highest precision and control the valve. In the quantitative phase, small flow loading is achieved to achieve the highest precision.

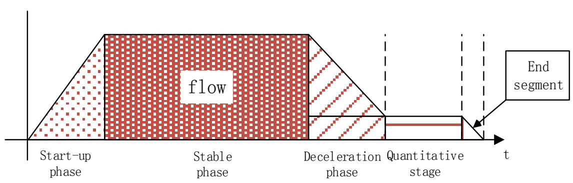

Figure 6. Flow control chart.

3) Accuracy problems caused by temperature fluctuations

If the loading system uses a volumetric flowmeter, the temperature fluctuations have an impact on the actual mass calculation accuracy of the loading. According to the definition of the 98th edition of the petroleum meter, the product quality $G=(\rho 20-0.0011)*VCF*Vt$, Where $\rho 20$ is the standard density, 0.0011 is the effect of air buoyancy, VCF is the volumetric correction factor for the standard volume, Vt is the actual measured volume of the flowmeter, and VCF varies with temperature. The system automatically corrects the VCF based on temperature to achieve the highest accuracy. The system contains the product measurement 98 standard. When the temperature changes, the system will automatically check the corresponding VCF at the calculation.

B. Safety Control Technology

1) Anti-overflow

In the system anti-overflow design, hardware interlock control and software control are adopted. The hardware interlock control is interlocked with the pump through the overflow alarm to prevent overflow. The software control is to close the electro-hydraulic valve and the oil pump by reaching the set oil quantity field controller. At this time, if the electro-hydraulic valve and the oil pump are out of shutdown, the system will give an alarm and issue a close command again; the alarm will be automatically released after the command is valid, otherwise it should be manually stopped. Load the car to prevent spillage.

2) Electrostatic protection

The electrostatic system is equipped with an electrostatic alarm device. When the electrostatic connection of the system does not meet the requirements, the electrostatic protector issues an alarm and the system cannot start or stop loading.

V. System Function Introduction

A. Tank Area PLC System Function

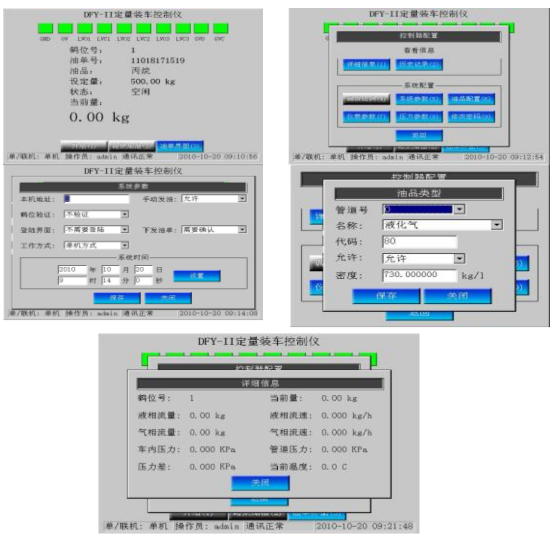

Figure 7. Status data control and display.

The operator station provides a variety of intuitive human-machine interfaces that allow the operator to control the equipment under normal or abnormal conditions and monitor the operational status data control and display (Fig. 7); with data acquisition, calculation, display, control, and storage management functions The system realizes the functions of the port monitoring and management platform (Fig. 8); liquid parameters such as liquid level, temperature and volume; alarm signal; valve, pump switch signal; oil tank status data signals such as oil, oil, static, and rate of change; Car data; process status display (Fig. 9), control; sewage system signal monitoring, display; various screen control, display functions, including three-dimensional storage and transportation process status and data (Fig. 10), various fire alarm signal display, loading and unloading system data browsing display, etc. Through the electrical interlock control function system, the interlock control can be conveniently realized through configuration, ensuring automatic interlocking control of the process state when an alarm signal affecting safety production is generated.

Figure 8. Overview picture.

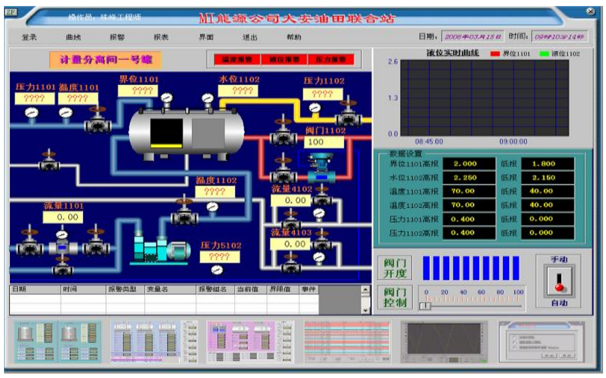

Figure 9. Process flow chart.

As is shown in Fig. 11, the monitoring management screen can display the status of each device at the loading site in real time, as well as the progress of the loading process. For example, it can monitor the status of the valve, the status of the electrostatic oil spill alarm, the real-time reading of the flow meter, and the current loading capacity. The monitoring management station submits the data to the server in real time, then the management personnel can get information about the on-site loading situation and the operation of the field equipments.

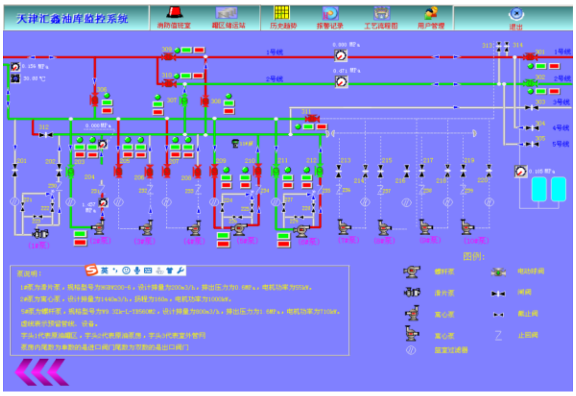

Figure 10. Stereo pipeline process picture.

Figure 11. Oil product monitoring and management system.

VI. CONCLUSION

The system adopts advanced technologies such as PLC and network technology to build a professional dock automation control system based on sensors, control technology and display technology, which provides a more reliable, intuitive and accurate dock for cargo loading and unloading and sales of cargo terminals. Although the automatic control system realized the control function of liquid cargo measurement, still, there are some errors. In future research, we will study the accuracy of liquid cargo measurement in a further extent, optimize the control algorithm and make the loading system much better. Also, we'll continue studying the monitoring system in depth, whose portability allows regulators to control the status of the cargo terminal at any time and in any place.

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