Design of stinger video monitoring system on deepwater pipe-laying ship

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Abstract—**The paper introduces marine pipeline laying and discusses the importance of video monitoring system during the pipeline, on the basis of deepwater pipelay crane vessel HYSY201 made by Marine Engineering company. The paper describes the structure of the video monitoring system and the installation of monitoring system on the stinger in practice. Two key technologies in the system——a protocol converter box and a deck junction box, are stated in detail in this paper. At last, the paper presents the application of the system and analyses the improving space.**

Keywords- marine pipeline laying; monitoring system; protocol converter

I. INTRODUCTION

Offshore oil development is an important aspect of today's energy development. The process of offshore oil development differs largely in the domestic and overseas, especially in the developed countries, they began the development in an early time, and developed fast. In 1982, China National Offshore Oil Corporation was established, and it means China officially started the development of offshore oil and natural gas. Just in a few decades, its development tendency, development speed, has attracted the world's attention [1].

Pipe-laying ship is the special equipment of marine pipeline laying, and the stinger is one of the pipe-laying ship's essential parts. The stinger keeps pipeline in a certain deflection before it sinks into water, so that the pipe wall can bear large bending stress and the pipeline itself can bear bump under water [2]. Although during the industrial design, the stinger is designed to control deflection and reduce bump in the most appropriate level, the complex marine environment makes the situation of docking pipeline unsuccessfully happen. The paper puts forward to designing a set of video monitoring system as the solution. The system monitors pipe-laying work process in real-time and a full range, and feeds back related video inspection information to the staffs. The video inspection information can also be stored for future reference.

The system designed in this paper can improve the efficiency of pipe laying operation in some ways.

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II. OVERALL STRUCTURE OF THE VIDEO MONITORING SYSTEM

The video monitoring system realizes control to cameras and Pan/Tilt/Zoom (PTZ), thus getting desired video information. The system mainly includes monitoring equipment, a box converting protocol and a box which provides a series of interfaces. Fig.1 gives a detailed describe of the structure of the system. Fig.2 shows the installation of the monitoring system on the stinger.

Fig.1 shows the overall structure of the video monitoring system mentioned in the paper. The system mainly consists of two parts: the overwater equipment set and the underwater equipment set. The overwater equipment set also means the equipments in the control room, mainly includes the deck junction box, keyboard, Digital Video Recorder (DVR) and monitors. The function of the deck junction box is to supply power and realize lighting adjustment for the monitoring equipment. The DVR used in this system is a kind of mature product, with 16 video channels and 4T capacity of NTSC/PAL format video data. Besides supporting video playback, it can also work continuously for 48 hours. Staffs can select the control protocol of DVR by themselves; therefore, this paper chooses Pelco-D [3] protocol as the control protocol in DVR. Once entering a key on the keyboard, the system sends corresponding instruction to camera or PTZ. When a camera or PTZ gets the instruction, it will make right change. Then the required video data is taken and displayed on the screen in time. The staff can choose whether to store the data for future reference. Using the network interface, the system realizes remote control, which makes monitoring more convenient. The underwater equipment set is comprised of 8 cameras and 2 PTZs with LEDs and protocol converter boxes companied with them. Because the light underwater is not easy to tell, the paper uses LEDs on the monitor equipment. By adjusting the LED lamp, clear pictures are caught. The Pelco-D protocol in the DVR is not fit with cameras and PTZs. In order to solve this problem, the paper designs a protocol converter box to convert Pelco-D protocol transferred by RS485 channel to protocol transferred by RS232 channel that camera and PTZ can identify[4].

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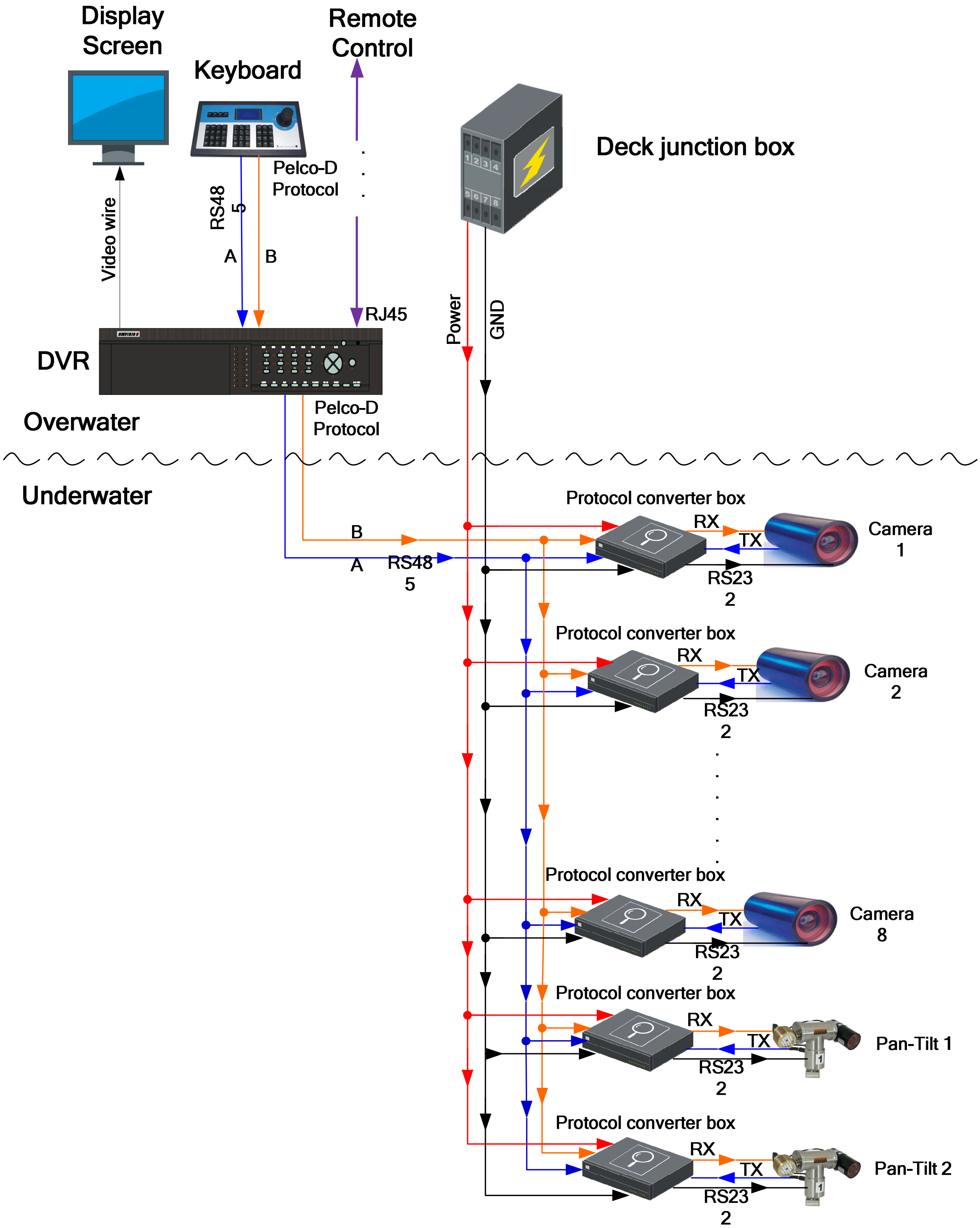

Fig.1 overall structure of the system

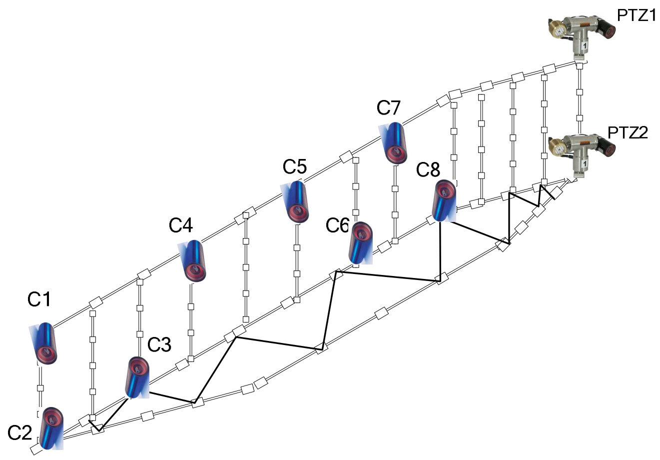

Fig.2 installation on the stinger

Fig.2 shows how the monitoring system is installed on the stinger. Two PTZs (PTZ1, PTZ2) are installed on the head of the stinger with corresponding devices (LED lamps and protocol converter boxes). The type of the PTZ is Company Kongsberg's OE10-102. The horizontal rotation range of this kind of PTZ is -180°~+180°and the vertical range is -45°~+45°. The stinger installs 8 cameras (C1~C8) with corresponding devices (LED lamps and protocol converter boxes). And the type of the camera is Company Tritech's Typhoon. This kind of camera can adapt to underwater 3000m environment and the zoom range under water is 4 ° ~44 °. The camera itself has a black compensation function. The video monitoring system designed in the paper realizes monitoring 3 jackets on the stinger in real-time, ensuring underwater pipeline-laying works more accurately, safely and reliably.

The protocol converter box and deck junction box are the two main key technologies in the system, and the details of this two parts are illustrated in below.

III. DESIGN OF PROTOCOL CONVERTER BOX

Protocol converter is the key point in this part, as well as in the whole system. Although Pelco's monitoring equipment is widely used, not all devices meet Pelco protocol. The camera [5] and PTZ [6] used in the paper is not fit with such protocol is just an example. They can only respond to commands that their manufactures has customize. Therefore, camera and PTZ cannot respond to Peclco protocol directly. For example, to the command of "Focus Far", the expression of Pelco-D is:

Command	Address	Data1	Data2	Data3	Data4	Check
FFH	00H~3FH	00H	80H	00H	00H	00H~FFH

While to camera, such command is expressed as "%FF\r\n". The expressions are largely different and can't transfer directly. To make their transform available, the protocol converter box is designed to analyze Pelco-D protocol to protocol that camera and PTZ can identify.

The design realizes switching the 485 level to the 232 level during the hardware design. For RS485 channel allows remote signal transmission [7], so the Pelco-D protocol is transferred by RS485 channel, but the camera and PTZ transform their signal in RS232 channel, so level switch is essential in the design. In Fig.3, Pelco-D signal transfers to the protocol converter box by RS485 channel, the STM32 MCU [8] finishes protocol analyses and gives corresponding control command to cameras and PTZs by RS232channel. SP3485 and SP3232 realizes level switch, making data transmission successfully [9].

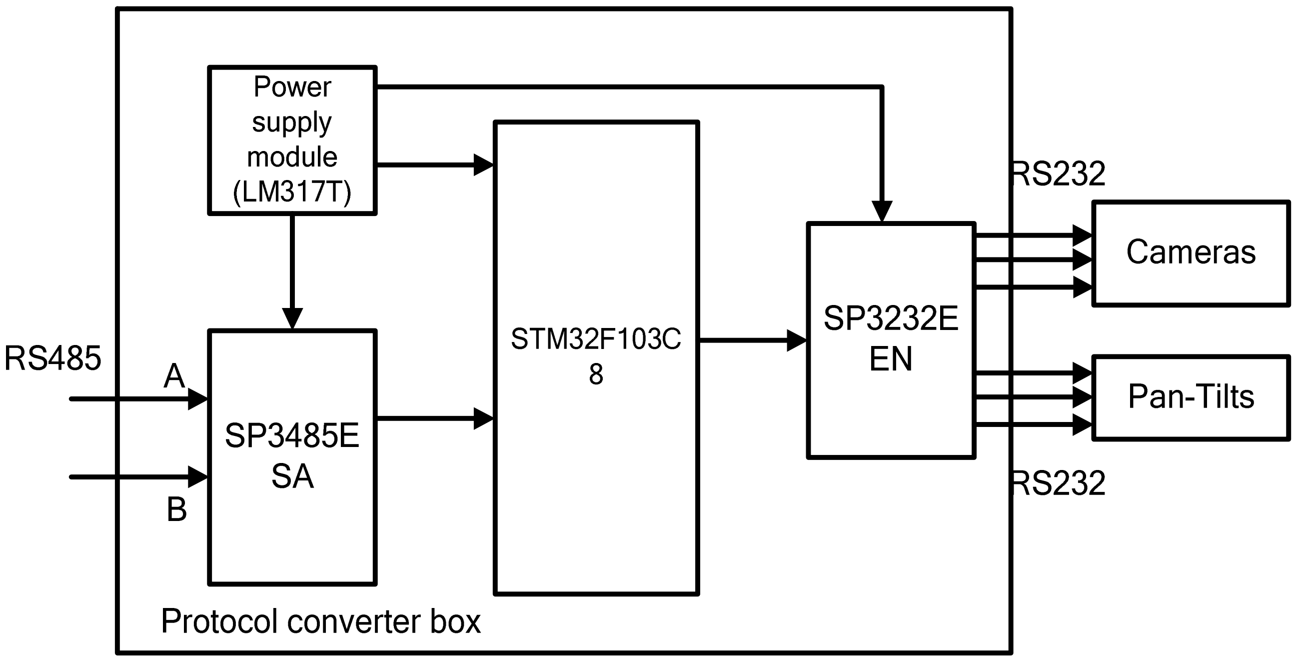

Fig.3 Hardware of the protocol converter box

Software design realizes converter Pelco-D signal to signal that camera or PTZ can identify. Fig.4 is the block diagram of software design. System initialization mainly finishes the initialization of system clock, serial ports, watchdog and related GPIO, and setting its own address. PTZ initialization determines the stop bit of PTZ rotation, which ensures the PTZ won't rotate unlimitedly by man-made misoperation. While getting the valid instruction, the instruction can be analyzed and the ports produce corresponding control command to make the cameras and PTZs respond in right action.

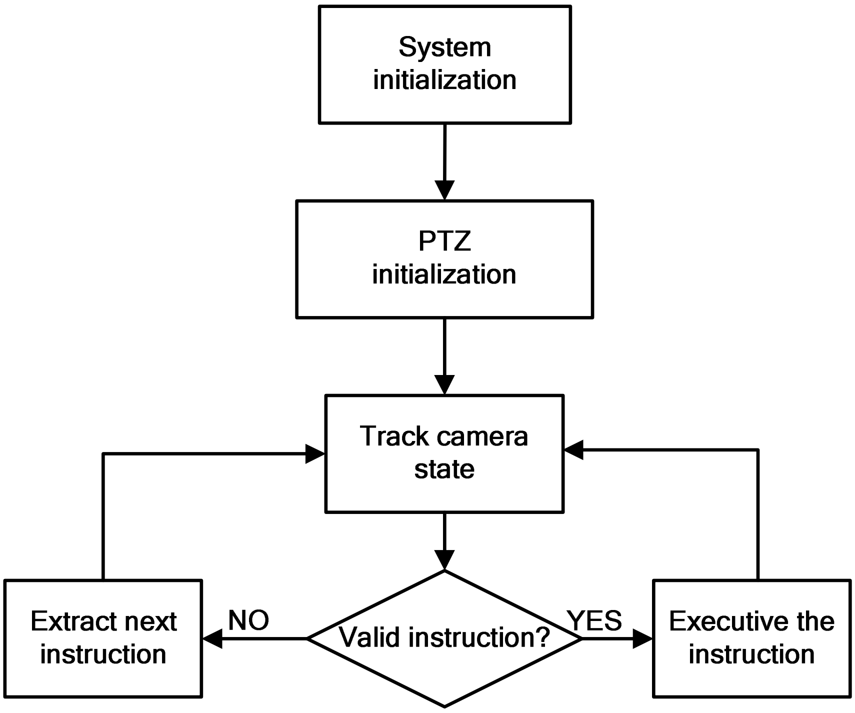

Fig.4 Software of the protocol converter box

IV. DESIGN OF DECK JUNCTION BOX

The deck junction box integrates power interfaces (L, N, E), camera interfaces (Camera1~Camera8), PTZ interfaces (PTZ1, PTZ2), video interfaces (V1~V16) and lighting adjustment knobs (S1~S10). Fig.5 shows the hardware of the deck junction box. In practice, all the interfaces are first integrated in aviation plug buttons separately. Then the video wires among them will be welded to special video interfaces. In order to expand RS485 interfaces, the paper uses RS485 Hub to obtain them (A1B1~A10B10). A1B1~A10B10 are connected to aviation plug buttons in Fig. 5. In consideration of LED's low internal resistance and the impendence on the cable, the paper achieves the lighting adjustment through a constant current source. C1~C10 on the constant current source in Fig. 5 are connected to aviation plug buttons, too. While choosing power modules (MW-450-48, MW-600-36, MW-350-27), the paper takes monitoring equipment's (cameras and PTZs) and LEDs' operating voltage, power, and the impendence on the cable into account to make sure the deck junction box can supply operating power and LEDs can work normally.

The emphasis during the deck junction box designing is to choose the appropriate (appropriate power, appropriate voltage) power modules.

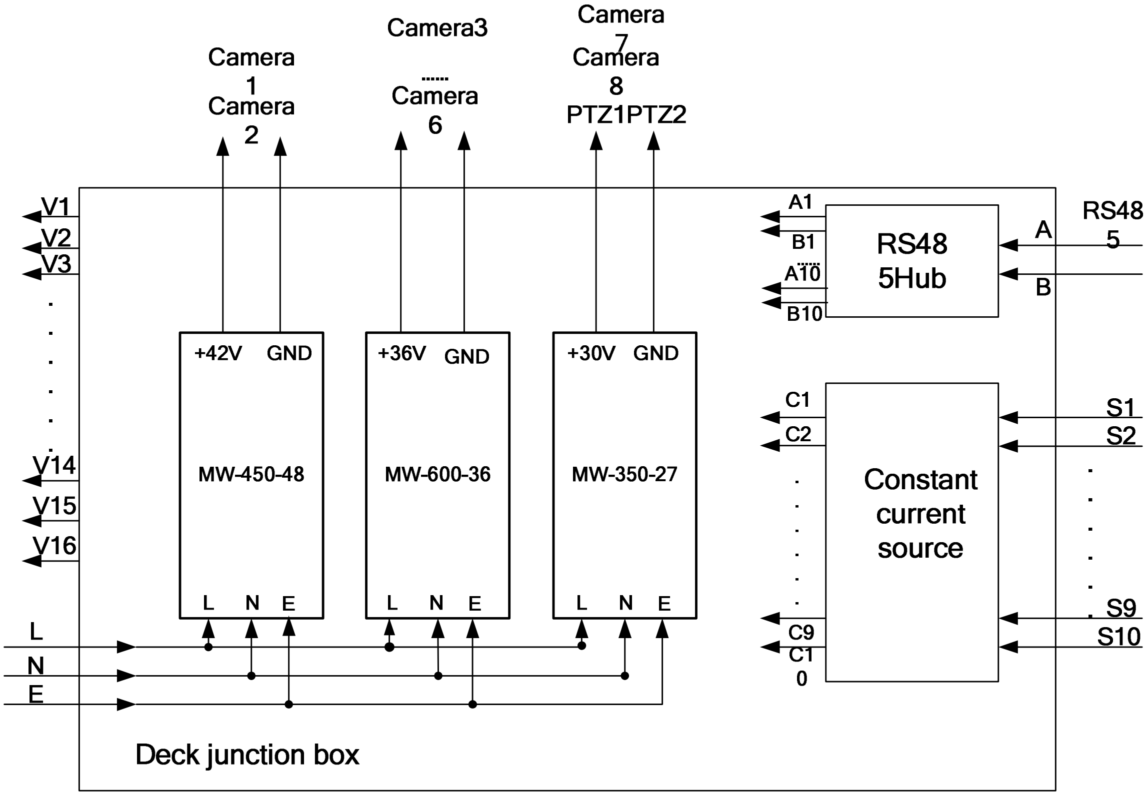

Fig.5 Hardware of the deck junction box

Table.1 Voltage and Power list

Name	Working Voltage	Nominal Voltage/Nominal Power
Camera Typhoon	12V~24V	24V/5W
PTZ OE10-102	12V~24V	24V /70W
LED lamp OE11-150	18V~30V	24V /50W

Note: impendence on the cable: 40Ω/1km

It is easy to find that the nominal power and normal working voltage differ largely among the camera, PTZ and LED lamps from Fig.6. What's more, the impendence on the cable can be large enough to cause great voltage drop, while in long distance transmission. For example, if 24V is chosen as the working voltage for camera, PTZ and LED lamp, it seems all of them can work normally, but the truth is: the deck junction box is put on the pipe-laying ship, and the monitoring devices are put on the stinger, they are connected by the cables. When the cable length is 50 meters, the total length of the signal transmission is 100 meters, including go and return. From Table.1, the impendence on the cable then reaches 4Ω. At nominal voltage and nominal power operating conditions, the voltage on the cable is about 8V. In this way, the voltage LED lamp can get only 16V, which can't make the LED lamp work normally. In consideration of all situations above, the paper uses several power modules to supply power, and chooses multi-core cable in practice. By paralleling the cable, the paper realizes reducing the impendence to reduce the voltage drop to a certain extent.

V. RESULTS

The stinger video monitoring system on deepwater pipe-laying ship discussed in the paper has been produced and put into use. Practice has proved that the system is reliable and stable and can work properly underwater with perfect real-time monitoring, strong remote controlling capability and simple operation.

Fig. 6 The deck junction box

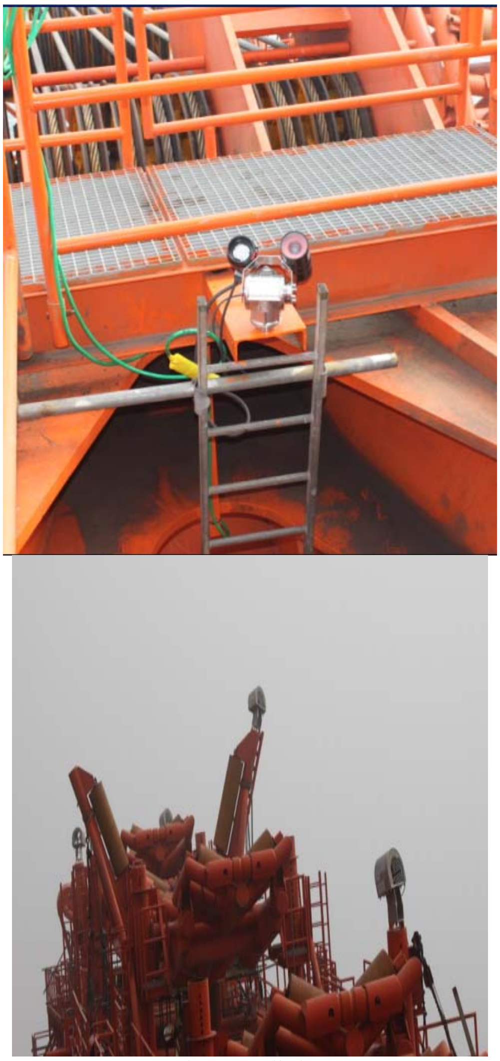

Fig. 7 Installation

Fig.6 displays the end product of the deck junction box. Fig.7 shows the installation of underwater part in practice. The protocol converter box is put in the yellow container.

VI. CONCLUSIONS

The paper discusses the importance and necessity of the video monitoring system during the marine pipeline laying operation, realizes two key technologies. The final finished system has good real-time performance and powerful remote control feature. Its practical application is really widely. But, the system still has some space to improve. The application program in the protocol converter box is updated by RS232 channel. RS232 has a limited communication distance. If the update can be achieved by RS485 channel, remote online program update will make practical operation more convenient.

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