Control system of an actuator for the actuation of submarine devices

The present invention concerns a control system for an actuator for the actuation of submarine devices, such as valves for closing and opening submarine ducts.

Plants for transporting liquids and/or gases under the sea, for example the oil pipelines that run even for hundreds of metres under the sea, even at a depth of 3000 metres, comprise a plurality of intermediate stations in which valves for opening and closing the pipes or ducts the transport such liquids or gases are foreseen.

Such valves are actuated by submarine actuators that determine the opening and closing of such valves transmitting a rotation movement to the actuation shaft of the valve itself.

Such actuators are connected to the valves near to the submarine pipelines but must, however, be controlled from the surface or from remote control stations (also submarine).

Actuators are known that are actuated manually by a robot associated with a submarine that reaches the place where the valve and the actuator are situated

and transmits the movement to the actuator itself through the robotised arm.

Hydraulic actuators are also known, which are actuated through a hydraulic station arranged at the surface having a hydraulic pipeline that connects such a station at the surface to the submarine actuator. The pipeline transports the hydraulic energy, for example compressed air, necessary for the actuation of the valve, on the bottom of the sea where the actuator is situated.

The Applicant has observed that hydraulic type actuators require the presence of an extremely large surface station of substantial environmental impact. Indeed, in such a station it is necessary to generate the necessary hydraulic pressure to actuate the submarine actuator and, moreover, the hydraulic cable suitable for transferring the hydraulic energy to the actuator must have substantial resistance to external pressure, since such actuators can be positioned in transportation plants even 3000 metres under the sea. All of this can determine insufficient reliability of the valve and of the plant as a whole, since the cable that transports the hydraulic energy under the sea could be damaged and therefore could jeopardise the good operation of the valve.

On the other hand, actuators that can just be actuated manually require the use of a submarine to carry out the operation of changing the status of the valve. Such an operation is both complex and expensive and does not allow the valve of the submarine transportation plant to be controlled in real time from the surface.

The Applicant has set itself the problem of making the actuation of a valve applied to a submarine pipeline from the surface or from whatever remote control station reliable.

The Applicant has made a submarine actuator the movement of which is carried out through at least one electric motor controlled by a remote control station. The communication between the submarine actuator and the station on the surface takes place by means of suitable electric cables, sized so as to withstand the external pressure that is present in the depths of the sea.

Moreover, the Applicant has made a system for controlling such an electromechanical actuator, in which the actuation command of the controlled submarine device, for example a hydraulic valve, can be sent from a control station independently to each electric motor present in the actuator.

An aspect of the present invention concerns an electronic control system for a submarine actuator, said actuator comprising a container body from which a drive shaft extends that is suitable for inserting in a seat of said submarine device characterised in that said system comprises an electronic control board for at least one electric motor arranged inside said container body suitable for moving said drive shaft, said electronic board being suitable for receiving an electrical control signal for said actuator, generated by a remote control station. The characteristics and advantages of the system according to the present invention shall become clearer from the following description, given as an example and not for limiting purposes, of an embodiment with reference to the attached figures in which:

figure 1 is a front view of the actuator according to the present invention;

figure 2 is a side view of the actuator according to the present invention;

figure 3 is a section view along the line A-A of figure 1 of the actuator according to the present invention;

figure 4 schematically illustrates an example of an

electronic control board of the actuator according to the present invention;

figure 5 schematically illustrates the main functions of the electronic control board according to the present invention.

With reference to the quoted figures the actuator according to the present invention is suitable for actuating a submarine device through the coupling of a drive shaft of said actuator in a suitable seat of said submarine device. The submarine device to be actuated is, for example, a valve for opening and closing a submarine pipeline.

The actuator according to the present invention comprises a container body formed from a substantially box-shaped element 2 and from a substantially cylindrical element 3 made in a single body or connected together.

From the base of said box-shaped element a drive shaft 4 projects through which the movement is transmitted to the valve to be actuated.

Inside said box-shaped element at least one electric motor is arranged suitable for transmitting the movement to said drive shaft 4.

Moreover, the movement of said motor is controlled by an electronic control board, which is inserted in

said cylindrical element 2.

In the example embodiment illustrated in the figures, the actuator, inside the box-shaped element, comprises two electric motors 21 and 22, each of which can separately control the rotation of said drive shaft 4, through the electronic control board. The presence of two electric motors that can be controlled independently from each other allows the possibility of a lack of activation of the commanded valve by the actuator to be minimised. Indeed, to block the correct operation of the valve it would be necessary for both of the motors to be shut down simultaneously.

The rotation of the drive shaft 4, able to be carried out independently by each of the motors, can, for example, be obtained through a gear mechanism, which comprises a transmission shaft 23, connected through a pair of gears to the rotation shafts of the two electric motors 21 and 22. On such a transmission shaft a worm screw 24 is provided, integral with the rotation of said shaft, which engages with a further sprocket 25 made on the extension of said drive shaft inside said box-shaped element 2.

The box-shaped element 2 is preferably filled on the inside with a lubricating liquid, for example a high-

density insulating oil, and is provided with a device for the compensation of the external pressure comprising a membrane accumulator 6, firmly connected on a side of said box-shaped element that injects pressurised oil inside it through an inlet pipeline 61.

Moreover, the drive shaft 4 completely crosses the box-shaped element and, on its upper end 41 a visual recognition device of the position taken up by the valve commanded by the movement of the drive shaft 4 is foreseen. Moreover, on such an upper end of the drive shaft a seat is formed for the insertion of a possible robotised arm suitable for rotating the drive shaft in an emergency situation in which it is not possible to actuate the drive shaft electrically.

The cylindrical element is a hermetic container into which a pressurised gas, for example nitrogen, is inserted, which encloses the electronic control boards for the motors inside it. The electrical connections between the electronic control board and the motors are carried out by means of electric cables 7 connected to said cylindrical element and to said box-shaped element through connectors and hermetic through elements.

An example of the electronic control board container

in the actuator according to the present invention is schematically illustrated in figure 3. Such a board comprises a pilot circuit 31 or 32, a power supply circuit 33 or 34 and a programmable logic unit 35 or 36 for each motor.

It is foreseen that there is, associated with the drive shaft 4 of the actuator, a transducer 26 of the position of such a shaft, which is electrically connected with each programmable logic unit.

The parts of the control board inserted inside the cylindrical element are in connection with the parts arranged inside the box-shaped element through the quoted cables 7, the quoted connectors and/or the hermetic through elements 8.

The power supply of said electric motors can be carried out through a suitable power supply cable transported by the remote control station to the submarine actuator; alternatively, the electric power supply for said motors can be directly obtained from electric power supply lines associated with the submarine transportation plant.

The control system of the electromechanical actuator according to the present invention is conveniently summarised in the block diagram of figure 5, in which for each motor 21 or 22 (in the figures the control

system for the first motor 21 is illustrated), the quoted pilot circuit 31, and the position transducer 26 and the functions that are carried out by the programmable logic unit 35 comprising a positioning block 81 that interfaces with the pilot circuit of the motor 31 (inverter), a filtering block 82 for a control signal of the actuator and a decoding block 83 of the signal generated by the position transducer 26 are illustrated.

The actuator commands the opening and closing of the valve or of the submarine device with which it is associated through a control signal sent to a control input 84. The control signal is preferably filtered through such a filtering block 82 in order to limit possible irregularities in the control signal.

The control signal SC can advantageously be of the on-off type or else it can be a continuous signal that determines a regulation command for the valve with linear displacements from 0% to 100%.

In particular, the filtered control signal SCF is obtained, having memorised a predetermined number N of prior input commands SCP from which an average MCP (average of previous commands) has been worked out according to the following formula:

$$SCF = \frac{[(MCP * N) + SC]}{N + 1}.$$

Moreover, the position signal of the valve or of the controlled submarine device is detected through the position transducer 26, which generates a signal, for example typically a 4-20 mA signal, which is decoded by said decoding block 83 and sent to the positioning block.

The decoding block carries out a comparison between the signal received and previous memorised signals corresponding to the open and closed limit positions of the valve. From such a comparison and from subsequent processing, through a linearisation function, a precise and reliable decoded position signal is obtained. The value of the transducer is monitored constantly, in order to check its validity and correct operation; indeed, an error of the transducer would result in a blocking of the positioning function and therefore a blocking of the command of the valve.

The positioning block functions 81 are substantially the core of the system and comprise the processing of the signals coming from the position transducer 26 through the decoding block 83, from the control input 84 through the filtering block 82 and from the pilot circuit 31, in order to generate an activation signal

of the electric motor 21.

Preferably, the processing consists of calculating a speed value and direction SP for the rotation of the motor starting from the position value of the valve to be reached SETP (open/closed) and from the current position of the valve POSA and sending a corresponding signal to the pilot circuit of the motor. For such a purpose, the positioning block also receives the value of the current absorbed by the motor from the pilot circuit, so as to be able to carry out a double retroaction control both through the position transducer and through such absorption current of the motor.

Therefore, in short, the electronic control board comprises a first retroaction circuit of the current absorbed by the motor between the programmable logic unit and the pilot circuit, and a second pilot circuit of the position signal of the drive shaft between said transducer and said programmable logic unit.

The speed value can be calculated through the following formula:

$SP = \sqrt{SETP - POSA} * KGAIN$

Where KGAIN represents the gain of the positioning ring with reference to the retroaction of the

position transducer.

The calculated speed maximum value is advantageously limited to a predetermined value, set based upon the displacement times that are intended to be carried out on the valve.

Moreover, the system foresees that it is possible to control the motor through an emergency control signal 85, which acts directly on the pilot circuit 31 and therefore on the electrical actuation of the motor eliminating any control carried out by the programmable logic unit of the actuator.

The actuator according to the present invention comprises at least two motors, each of which can be controlled independently from the surface through the control system described above through a master-slave type configuration, i.e. in the case in which there is an alarm on a motor or on an electronic control board of the motor, the system can automatically take care of switching the command onto the other motor of the actuator.

CLAIMS

1. Electronic control system for a submarine actuator, said actuator comprising a container body from which a drive shaft projects that is suitable for inserting in a seat of said submarine device, characterised in that said system comprises an electronic control board for at least one electric motor, arranged inside said container body suitable for moving said drive shaft, said electronic board being suitable for receiving an electrical control signal for said actuator, generated by a remote control station.

2. System according to claim 1, further comprising an electronic transducer for detecting the position of such a drive shaft electrically connected with said programmable logic unit.

3. System according to claim 1, wherein said control board comprises a pilot circuit, for said at least one motor, a power supply circuit and a programmable logic unit.

4. System according to claim 1, wherein said actuator comprises two electric motors associated with said drive shaft and said electronic control board is suitable for controlling each motor independently from the other.

5. System according to claim 1, wherein said electronic control board comprises a first retroaction circuit of the current absorbed by the motor between the programmable logic unit and the pilot circuit and a second pilot circuit of the position signal of the drive shaft between said transducer and said programmable logic unit.

6. System according to claim 5, wherein said control board is suitable for processing the signals coming from the position transducer from a control input and from the pilot circuit, in order to generate an activation signal of said at least one electric motor.

7. System according to claim 6, wherein said processing comprises calculating a speed value and direction for the rotation of the motor, starting from a position value of the drive shaft to be reached and from the current position of the shaft detected by said transducer, and sending a corresponding signal to the pilot circuit of the motor.

8. System according to claim 1, wherein said electronic control board comprises a filtering block of said control signal that compares the value of the signal received with an average of a predetermined

number of previous control signals.

9. System according to claim 2, wherein said control board carries out a comparison between the signal received by the transducer and a predetermined number of previous memorised signals corresponding to the limit positions of the movement of the drive shaft, and, from subsequent processing through a linearisation function, determines a decoded position signal.

10. System according to claim 4, wherein said electronic control board is suitable for selecting which electric motor controls the shaft and in the case of an anomaly it is able to switch from one motor to the other.