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MODERN ACTUATOR

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Abstract

The main engine of the ship is a complex technical object, which provides propulsion of the screw and ensures the safety of a ship at sea. It consists of a number of control systems such as lube oil temperature control, temperature control of the cooling water, fuel viscosity control or adjustable speed control of the main engine. Each of the main propulsion control system affects the safety of the ship. Continuous automation systems are built with standard transducer of measured quantity, the controller and actuator. The actuator is responsible for the direct setting of the size of the control object. The actuator is connected to the control valve and the actuator position change translates into a change in the flow rate of the working medium. Thus, the operating element is required to operate in the linear characteristics of the standard signal range. From the other hand, the control valve provides flow characteristics linear or of equal percentage. This control principle of medium flow is used in various control systems. The actuator of the control valve is always equipped with a positioner, which corrects errors in the position of the valve relative to the input signal. The presented design of the motorized valve is an analog system. Using the technique of converting multiple digital signal causes the system complexity and predisposition to damage. Eliminating the intermediate elements can improve the quality control and system safety. Then it is beneficial to have a design of the operating element based on the direct digital processing unit. The aim of paper has been to present design of the valve actuator, which completely abandons the digital-to-analogue convertor. The new design should increase the level of security of the system and quality control. The design layout is presented in the article. The new actuator is on-off valves, which control, directly from the digital bits, the form of the output signal. The control signal may use the control algorithms to be used or developed individually to the actuator design.

Keywords: *main engine, control, controller, actuator, regulating valve, transducer*

1. Introduction

Marine vessels are the basis of transport between continents. The main propulsion of the ship is in continuous modification. Adjusting Digital develops several decades [1, 2] and is present in the systems of main propulsion. Regulators replaced by programmable logic controllers and control programs are able to control every ship system. Only digital controller output is applied for the direct or continuous control system. Digital signals do not need to be processed, are compatible with the digital signal processor used. Hence, they are widely used in the control object through relays on off and operate fine. The tasks of the adjustment, the parameters are maintained at a constant value. In the case of a continuous signal, which is not compatible with the digital signal, it should be applied the processing and digital-to-analogue converters. The analog signal is a remnant of the development period of continuous linear regulators. In this period it has been also used a regulating valve, which is based on the signal continuously changes its location and the flow rate of the working medium. For this reason, it is necessary to use the digital-to-analogue converter [5, 7]. If the design of the control valve is changed, it can be dispensed with digital-to-analogue convertor.

What can replace the continuous adjustment?

On the opposite side, the two-point control is used. It is very simple in its essence and operates on Boolean on off or zero and one. The digital signal also uses a binary zero and one as a sign. The digital signal and the two-position signal is similar to each other, and it is sought the control of the intermediate form in order to eliminate processing and the digital-to-analog converter. This will improve the control, security and reliability of control systems.

2. The digital signal

As a digital unit, the controller operates in a digital format [8]. Digital signal processing is based on the integer format – an eight-or-sixteen-bit word, using a fixed position. The floating-point format is used in the calculations, but the outputs should be always an integer value after formatting. The scaling factor ones depend only on the position at which it is stored. Every next bit is of the doubled value (Fig. 1).

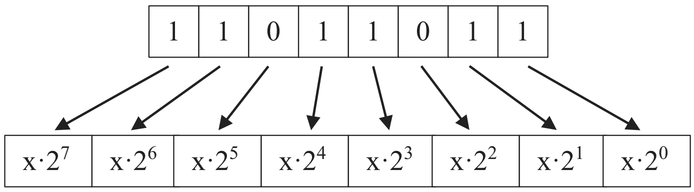

Fig. 1. Presentation of the total number of eight-bit notation

Values zero and one are used directly in the two-step control [3].

3. Binary multi-valve

How to apply digital signal directly to each bit for continuous control?

It can be constructed a set of valves and each one should be connected directly to the next bit words. Each subsequent bit is a twice value - each additional valve should force the flow doubled. A single control valve should be replaced by a multi-valve, which will consist of off valves electrically controlled bits of the digital signal like as an open-closed unit. The sum of the flow from each valve will give us the final value of the regulated flow. The task is to be implemented by each controller. The multi valve can possess a compact or single band of valves connected in parallel.

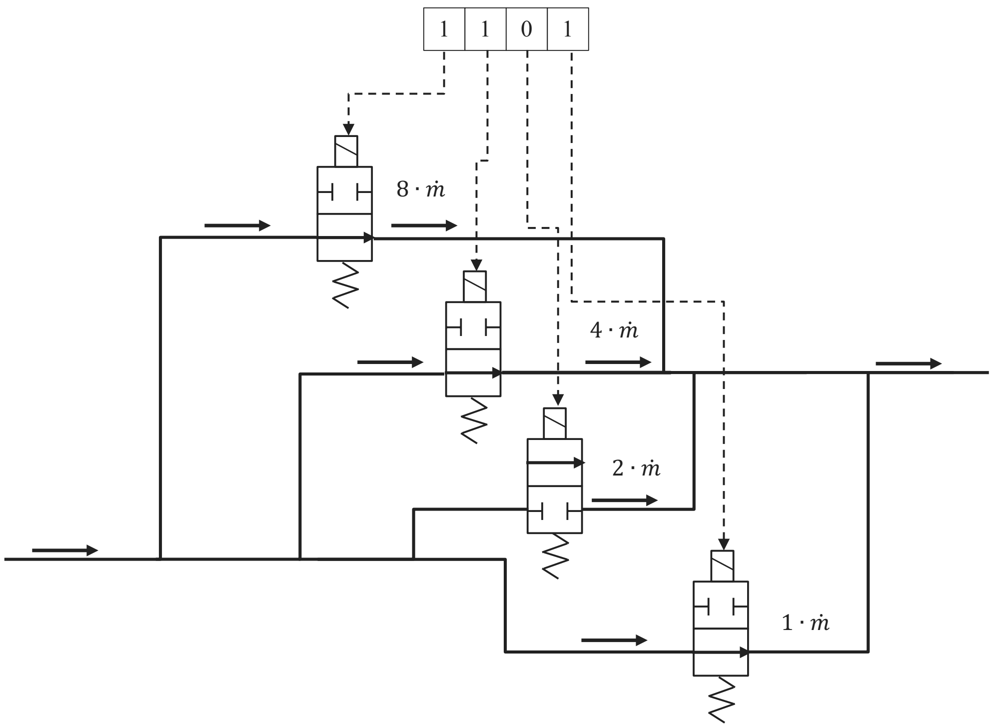

Fig. 2. The scheme and control of binary multi-valve

The Fig. 2 shows a four-bit multi-valve, which takes sixteen values. For a continuous signal in the range of the standard 4-20 mA, the output is also presented using 1 mA sixteen values. The direct digital control is comparable to the continuous control of the digital-to-analogue converter and the control valve with a resolution of at 1 mA. The characteristics of the flow is shown in the Fig. 3 is of discontinuous linear type. The presented design may be applied to adjust the viscosity of the fuel system on the ship.

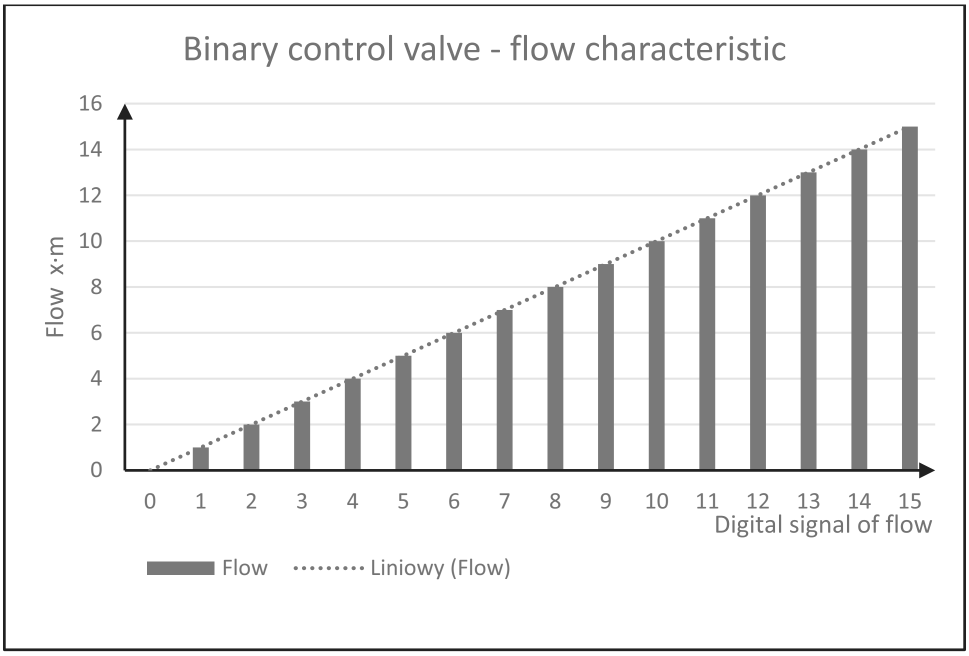

Fig. 3. Characteristics of flow through binary multi-valve

The four-bit word can be replaced by a continuous signal control. Discretization of this signal should not degrade the quality of control in analog systems. It may be expected the deviation caused by discretization the signal, which is used in control systems. In other forms of regulation the mentioned deviation also occurs. In the two-step control, which is based on controlling the one-bit exists a constant output signal amplitude adjustment and is a form often used in view of the simplicity of the system. The presented multi-valve control changes from one-bit to the multi-bit maintaining the simplicity of the system and shall be enforceable for each controller.

Controllers are using an eight-bit word length or sixteen-bit. Using current word length controller can improve the quality of multi-valve adjustment. Expansion of multi-valve can bring negative regulation. Size controlled valve decreases dramatically the least significant bit. At the same time switching frequency of this element will be the largest due to the frequent changes in the value of the least significant bit. The design of the multi-valve should begin with an insignificant word length or a four-bit one. Each controller may convert the current word length to the length required by the executive multi-valve. This will also limit the switching frequency of the next set of valves. This means a stable and long life of the multi-valve. It is a compromise between component reliability and the quality of regulation.

The presented design is very simple and uses the binary system for non-electrical quantities. At the design stage of the multi-valve it can be foreseen numerous technical problems to solve - it is the length of the word, the build of smallest valve, switching frequency, the quality of regulation.

4. Digital multi-valve

The controller as a digital device enables the realization of each algorithm. It is preferable to simplify design of the multi-valve and change the control algorithm to eliminate the defects of this system.

What can be more simplified in a simple control system based on the binary system?

The Fig. 4 shows the four-bit multi-valve, in which all elements are of the same size. This simplifies significantly the design of multi-valve. All the elements are equal. Control every element will be the revised control algorithm, which activates the next element with an increase in control signal. In this case, if the third operating element is a multi-valve working surely the first and second element, and will be turned off in reverse order. This reduces the resolution of the control. Get only four different values of the control signal. Sixteen to receive the input signal to be applied sixteen elements. This is the basic difference between the presented solutions. Despite this, I saying that the second solution is simplified, which may prove to be more practical. Use of equal parts in the structure provides a simple and effective solution. The characteristics of the flow shown in the Fig. 5 are discontinuous of the linear type.

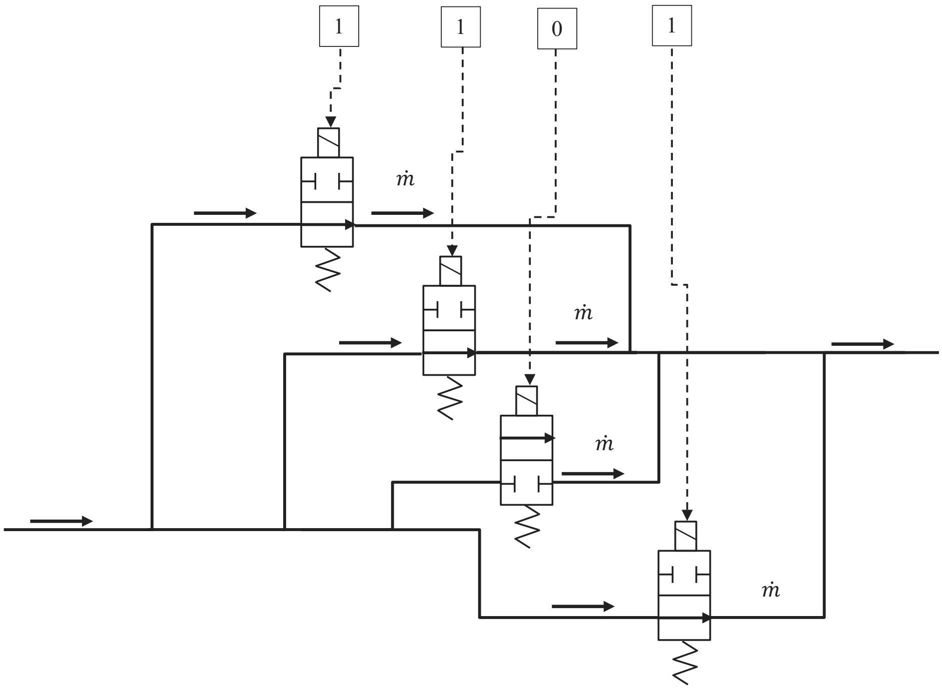

Fig. 4. The scheme and control of digital multi-valve

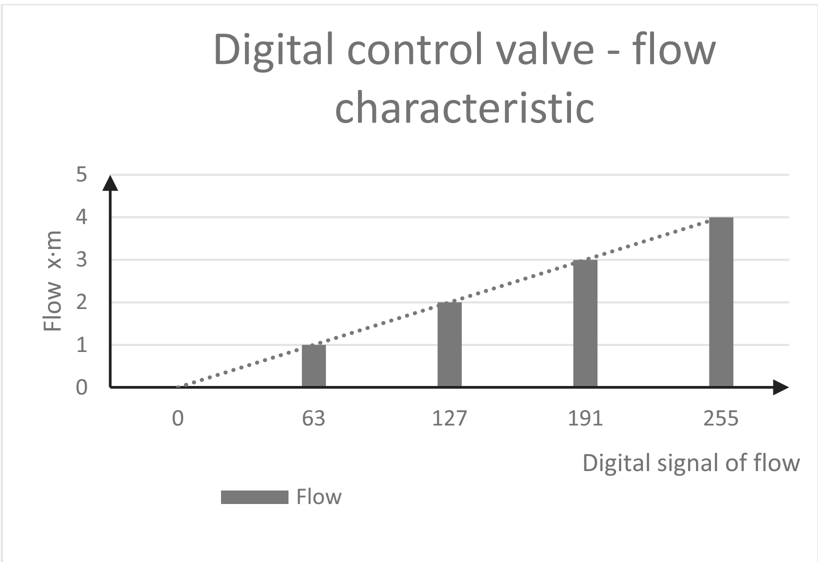

Fig. 5. Characteristics of flow through digital multi-valve

The principle of the direct digital control without the digital to analogue convertor in this solution is maintained. It is necessary to develop a new digital control algorithm for each element of a digital multi-valve. The main problem in this system is the operating time of each element, as i.e. the first element can operate continuously, and the last element only occasionally. This problem can be solved by the control algorithm and the periodic reversal order of the elements.

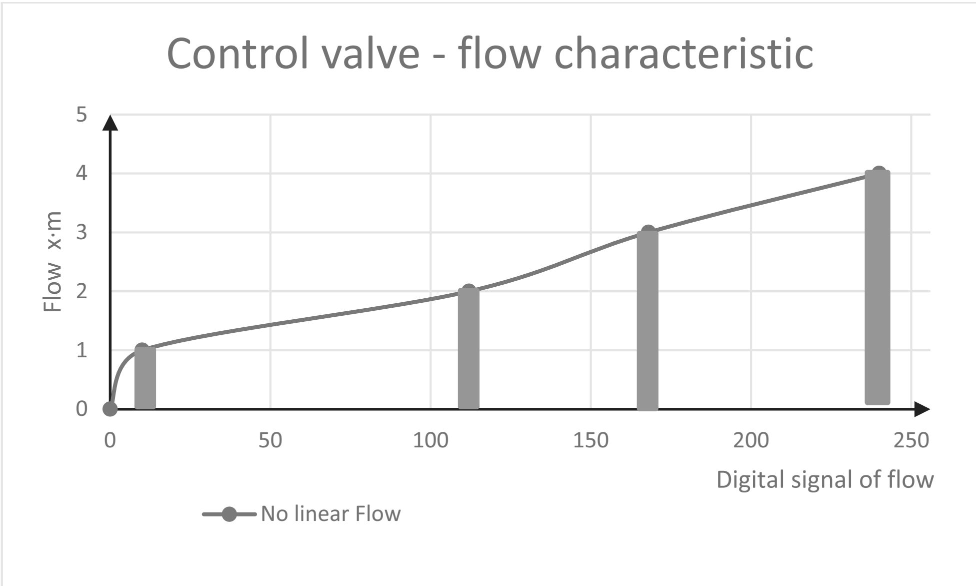

Fig. 6. The revised flow characteristics through a digital multi-valve

Valve switching point can be defined as a constant proportion to the size of the control signal. Such a valve will have a linear characteristic. Valve switching point can be adjusted by the control algorithm, which introduce non-linearity characteristics of the control. Non-linearity can be adjusted to the process (Fig. 6). Switching point element is an important parameter adjusting digital controller. In this solution, we select the number of control elements and switching point depending on the object characteristic.

The first solution contains valves graded sizes. The second solution has the valves of the same size. This raises another solution, where the on-off valves are mixed and the difference between them is the selectable proportion to achieve new effects in the control, for example the valve operation with the new adjusting characteristics.

5. Summary

Design solution can be used in any control system of the main propulsion system, and more. The paper presents new design of control valves, which are suited to digital control. The solution eliminates digital-to-analog converter from system and introduces the on-off solenoid valves. The amount of multi-valve elements and their size can be chosen depending on the differently shaped characteristic. Selected multi-valve design can mean the selection of individual digital control algorithm to process or standard PID control algorithm [4, 6]. In each solution, there are new control parameters to be included in the controller in order to achieve a good result quality control. Interesting results can occur when introducing non-linear characteristics.

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