The use of digital technology when positioning the spreader relative to the plane of the container

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Abstract. Currently, the technological process for processing containers in the presence of a roll or trim of the vessel involves the participation of working personnel. This technological operation is poorly automated, so the spreader is positioned relative to the plane of the container with the help of people, which increases the load cycle, reducing effective and economic indicators. The development of microprocessor technology allows us to automate partially or fully technological processes of container reloading in the port. The most important part of the container handling process is the spreader. Existing systems of automation of the spreader allow detecting gaps between containers, which increases the accuracy of installing the container at the storage location. The developed experimental model offers the option of automating the positioning of the spreader relative to the plane of the container, complementing existing automation systems, such as vibration dampers, sensors for monitoring the position of the container, etc. Using an experimental model allows to reduce the processing time of the vessel, and also eliminates operator errors. The issue of ensuring the operability of electronic components and sensors in the Arctic climate is also important, as they are most exposed to the environment. When using electrical equipment at low temperatures, there are two main problems: safety and operation. The functionality of electrical equipment may change or deteriorate, and the failure of one of the electrical systems entails stopping the loading cycle until it is detected and fully fixed the problem. Therefore, in this paper, we consider possible options for preventing the negative consequences that arise when working at low temperatures.

1. Introduction

For modern transshipment processes, the issues of the rational organization of operation and effective management of the operation of equipment are becoming increasingly relevant. In light of this, particular attention is paid to strategies designed to reduce operating costs without compromising reliability. The development of such strategies has been the central theme of most domestic and foreign studies over the past few decades.

In the problem of scientific and technological progress, a significant role is given to hoisting transport engineering, which is tasked with the widespread introduction of comprehensive mechanization and automation of production processes and auxiliary technological operations.
Therefore, the handling equipment has now become one of the main decisive factors determining the efficiency of production.

Competition in a market economy encourages terminal operators to improve the quality of their services. Reducing the processing time of containers can be achieved both by improving technological operations, and ensuring the smooth operation of handling equipment. Improvement of technological operations of the terminal is possible due to automation, ensuring smooth operation, replacing obsolete and physically obsolete equipment with new models.

As for the technical side of the container transshipment issue, it also offers its own solutions to shorten the container transshipment cycle and, if possible, eliminate downtime.

**2. The method of positioning the spreader relative to the plane of the container**

So far, the operation of positioning the plane of the spreader relative to the load is not automated. Automation of this technological operation allows you to reduce the cycle of operations, speeding up the processing of vehicles and, as a result, reduce financial costs while increasing the amount of processed cargo per unit time. At present, the technological process of loading containers onto a vessel provides for the presence of working personnel who monitors the loading process and, if a roll / trim occurs, a command is given to fill in the corresponding ballast tanks to level the vessel. However, despite this, situations arise when the necessary commands are not given or given at the wrong time. Most often, the human factor is to blame. Such situations complicate the process of loading the vessel, as a result, increasing the cycle of loading operations with the loss of economic efficiency [1].

To solve this problem, an experimental model of a self-stabilizing load-gripping body (SGB) was developed, which has the ability to stabilize its plane relative to the plane of the container.

In the four corners of the SGB laser time-of-flight infrared sensors of the VL6180 type (STMicroelectronics) are placed [2]. Sensors collect information about the plane over which the SGB is located. Data is transferred to a 32-bit microcontroller based on the ARM Cortex M4 core - STM32f407vgt6 (STMicroelectronics) [3]. The microcontroller, processing the data from the sensors, supplies a control signal to the two-bridge driver for controlling the electric motors, setting them in motion, thereby exposing the SGB plane parallel to the load plane [4]. In order to align the horizon of the SGB, it provides for the installation of a three-axis digital accelerometer LIS302DL (STMicroelectronics) [5]. According to a predetermined algorithm, the accelerometer transmits data on the angle of inclination to the microcontroller. That, in turn, controlling the motors, seeks to reduce the angle of inclination to zero (Fig. 1).

The software for the microcontroller, written in the programming language "C", involves exceptions (interruptions). They prohibit the lowering of the SGB or its further deviation from the horizontal axis. These interruptions exclude false triggering of the SGB when the values from the sensors fall into the following range of introduced errors - restrictions:

1. Small differences between the values of the pulses from the sensors - the first error, taking into account the roughness of the container (Fig. 2a). In this case, it may be a damaged container.
2. Too big differences between the sensor pulses - the second error, which takes into account the situation when the spreader is not yet pointed at the container, which eliminates the increase in the angle of deviation of the spreader from the horizon (Fig. 2b).

![Figure 2. The first error (a) and the second error (b) of the sensors](image)

Also, interrupts are triggered when the values from the sensors are close to critical, when further work of the program can lead to a violation of the integrity of the SGB or the overloaded cargo. For example, a large angle of inclination (Fig. 3) [6].

![Figure 3. Exceeding the permissible angle of inclination](image)

The SGB microcontroller receives 20 distance values from each sensor per second. However, such “raw” data cannot be used in work since with possible false values from the sensors, the system will respond to them and its behavior will be unstable [7].

To eliminate such situations, the program implements median filtering. Median filtering is a method of initial digital signal preprocessing that eliminates abnormal outliers in data arrays.

Abnormal values from the VL6180 sensors are spaced at least 10 points apart. Based on this, a median filter implementation of 3 is acceptable.

The filter is implemented as follows:
1. three raw values from the sensor are written to the uint_8t buff [3] array.
2. The filter in the processing program sorts the input data in ascending order.
3. The processing program returns the data value recorded in the second cell of the sorted array uint_8t buff (Fig. 4).
3. Ensuring operability in the Arctic climate

Ensuring operability in the conditions of the Arctic climate is due to the low air temperature, which in some areas can drop to -50 °C. In coastal areas, hurricane winds, which can last for several weeks, are not uncommon [8].

Basically, control devices and sensors are a printed circuit board with electronic components located on it. It is they which are most exposed to the influence of negative temperatures and negative external factors.

If one of the electronic components fails, the system may start to work incorrectly or unpredictably, which can lead to a number of more serious failures, and the diagnosis and correction of malfunctions in electronics is a laborious process. On the metal structures, the cold climate does not have such a strong negative effect as on electronics. Therefore, first of all, it is necessary to take care of the stable operation of the electronic system of the product.

When choosing a component base, you must pay attention to the range of operating temperatures. The following temperature ranges are shared in imported digital electronic components:
- C - Commercial temperature range (0 ... +70 C)
- I - Industrial temperature range (-40 ... +85 C)
- A - Automotive temperature range (-40 ... +125 C)
- M - Military temperature range (-55 ... +125 C)

As a rule, for industrial electronic products operating at low temperatures, preference is given to the industrial or automotive range [9].

For stable operation of the device, laser distance sensors are preferred over ultrasonic ones because ultrasonic sensors have a relatively low measurement accuracy relative to laser ones. This is due to the fact that the environment with high humidity, ice on the surface to which the distance is measured and wind loads introduce significant distortions into the measurements. Also, when using ultrasonic sensors, the ambient temperature must be taken into account. It is important to remember the fact that with a temperature increase of 1C, the speed of sound propagation increases by 0.6m / s. (Table 1) [10]. Therefore, if you receive data from ultrasonic sensors without taking into account the ambient temperature, the data will "drift" when the temperature changes.

| Temperature Range | Description |
|-------------------|-------------|
| C                 | Commercial  |
| I                 | Industrial  |
| A                 | Automotive  |
| M                 | Military    |

Table 1. Sound propagation velocity at various temperatures
An active element in maintaining the operability of an electronic system at low temperatures is an additional heating circuit. As a rule, it is mounted in a system together with temperature sensors located in close proximity to the most important elements of the system. An additional heating circuit is activated when a critical minimum temperature is reached inside the electronic product housing. When installing an additional heating circuit, it is necessary that:

- The most important elements, as well as elements with the smallest operating temperature range, were heated first.
- The working surfaces of electronic components, such as distance sensors, must be heated to keep the temperature above zero (resisting icing on the working surface).
- The power supply units (voltage conversion elements) of the system must be designed for additional consumption of the heating circuit or a separate power supply of the circuit must be provided, because heating elements have significant power consumption [11].

It should also be noted that the placement of electronic components inside the device’s case plays an important role in the stable operation of the device at low temperatures. So, for example, with direct contact of the electronic component with the surface of the housing, most of the heat will be dissipated to the housing, which will require large energy costs to maintain its temperature in the operating ranges.

4. Conclusion

Automation of this technological operation allows you to reduce the cycle of operations, speeding up the processing of vehicles and, as a result, reducing financial costs while increasing the amount of processed cargo per unit time.

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