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APPROACHES TO IMPROVING THE MOVEMENT CONTROL OF A LARGE-SIZED PORTAL MANIPULATOR

The object of the operator control is a specialized portal manipulator (**PM**), located above the cooling pond (**CP**) and designed to perform the following technological functions: search and detection of leaks in the welds of the cooling pond coating; defects areas cleansing; identified CP coating defects mending by patch method, using glue; applied patches leakage detection; patches reapplying in case of need.

Inspection and control of CP walls is exercised step by step, as CP bottom and walls are freed from the stored fuel assemblies (**FA**).

Plant specific features are conditioned by following technical parameters: large linear dimensions of plant and work area: more than 14 meters length, 6.5 meters width and 20 meters deep (Fig. 1); large manipulator structure weight: up to 20 tons; operating temperature up to 60 Celsius degrees; hydrostatic pressure operating conditions: up to 2 atm.;

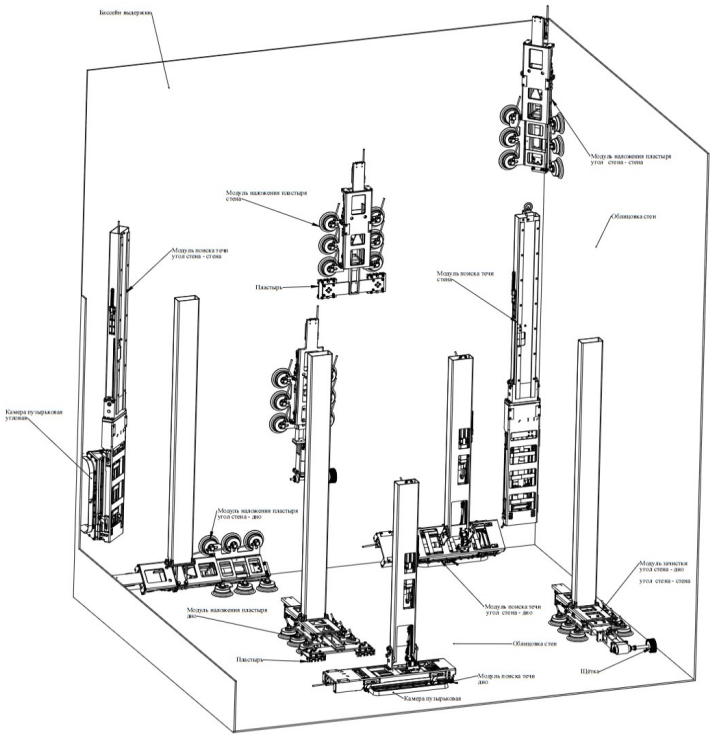

Fig. 1. Operating device position examples

high radiation background: specific absorption rate 30 000 Gy. per hour; work area scheme and dimensions changing within work space of the manipulator; replaceable highly specialized modules of the operating device (**OD**) of the manipulator; operator's camera surveillance restriction. The control is carried out by the operator from a specially equipped workplace using a personal computer with specialized software, as in others interactive non-destructive testing systems [1]. Portal manipulator control system (**CS**) is a distributed multicomponent system linked by local and controller area network. Control data exchange is performed via Ethernet, CAN, RS-485 bus interfaces and discrete sensor channels using Modbus TCP, CANOpen, FHPP and Modbus ASCII communication protocols.

During plant operating according to algorithm below shown on Fig. 2, operator is responsible for OD strategic trajectory planning and motion regime. Optimal OD trajectory formation task is beyond operator strength due to human factor, man-machine interaction specifics [2] and operator view restrictions.

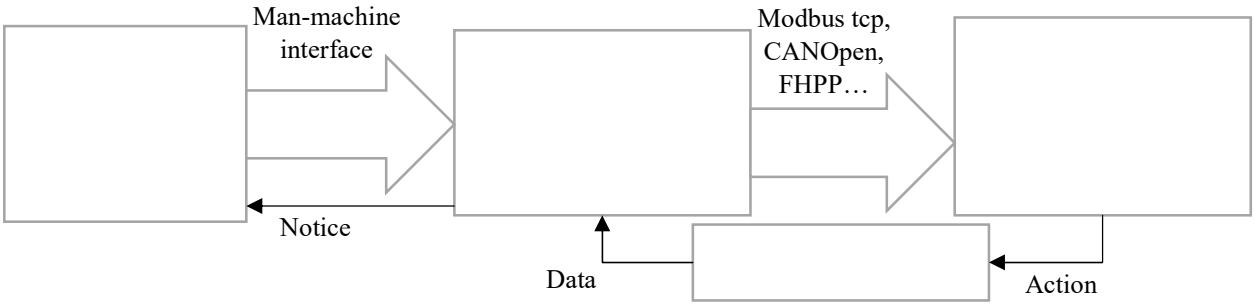

Fig. 2. Operator manipulator control scheme

Within the control process there will be trajectory deviations and overruns which results in extra motions to reach the end point. Described control scheme may cause following undesirable effects such as: motor winding overheat; the increased wear of PM mechanics; excessive energy consumption; increased PM auxiliary time; increased OD service time.

Thus, it is required to solve a multicriteria optimization problem in order to reduce the negative effects of the PM operator management.

Distributed CS includes programmable logic controller (**PLC**) OWEN for discrete signals processing and automatic control of OD changeable modules pneumatic system, FESTO PLC for servomotor groups setting and control, and

servomotors, grouped and controlled in master-slave mode. There is also a way to reduce the impact of undesirable effects through the specified structure: setting intentionally understated velocity limitations; setting servomotor acceleration and deceleration torque limitations to prove operator always stay well within the safe range.

These measures can reduce wear of the equipment at the cost of extra time consumption. Increase in PM auxiliary time and inevitable increase in CP service time will negatively affect total cost. More effective control algorithm creation will allow both to avoid negative factors of manual control, and to reduce time consumption. Operator actions audit will promote the creation of more efficient mechanical trajectory and motion regime with less acceleration and deceleration expenses.

Auditing is possible by comparing the actual operator actions data with an automatically generated dataset. There are different ways for generating preferable actions dataset, including algorithms based on so called “artificial intelligence systems”. PM working area is represented as a finite set of all possible link configurations, the total number of which is $a = N^n$, where N – sampling parameter of configurational space (number of the considered joint provisions), n – number of joints. One of the possible trajectory generation algorithms assumes the representation of an admissible manipulator configurations as a graph of configurations, after which the appropriate one is chosen with regard to the selected optimality criterion [3]. Another method includes an artificial multilayer neural network learning algorithm, where each neuron is associated with a specific manipulator configuration, and the weights of the synaptic connections with other neurons form a potential field for quantifying the cost of a transition, taking into account reachability, mechanical work and time spent [4]. In addition, there are evolutionary (genetic) algorithms that requires determination of the selection and modification rules for manipulator configurations, taken from current set (population) [5]. The listed methods require full information about working area obstacles. Trajectories containing inadmissible configurations are automatically excluded.

Inadmissible manipulator configuration data is inaccessible in the considered CS. Periodic FS positioning change prevents unambiguous delimitation of working area, and OD is in no way sensitive to obstacles. In such conditions, the CS has the data obtained during manual control. Admissible manipulator configurations set is formed using executed movements data, from which optimized by the chosen criterion trajectory is selected. Such an approach is less effective than previously mentioned, but it allows to improve manipulator efficiency with no hardware changes, decreasing PM auxiliary time and service time of CP.

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