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ANALYSIS OF AUTOMATIC CONTROL SYSTEMS OF SELF-CONTAINED ELECTRIC STATIONS

The paper considers problems dealing with the development and realization of automatic systems intended for the control of shipboard power stations by conventional methods and ways of their realization applying the method of constructive-functional proximity based on Boolean algebra.

Key words: *automatic control system, logic model, shipboard power station, structurization of the object.*

Introduction

Self-contained electric stations use electric plants of rated power by parametric series from 0.5 to 3000 KW. Sources of electric energy (SEE) with internal combustion engines are most widely used. According to the type of current sources of energy are divided into: direct current sources, alternating single-phase and three-phase current sources of industrial (50 Hz) and increased frequency (400 Hz). Rated voltage of the sources can be low (30, 115 and 230 V of direct current, 230 and 400 V of alternating current) and high (6 and 10 KV). Particular case of self-contained sources are vessel power stations (VPS), range of which includes vessel power stations (VPS), power of which varies from 8 to 2500 KW, voltage is 230 and 400 V, frequency 50 Hz, these stations are automated according to I, II, III and IV levels of automation [1, 2]. Nowadays there exists all the conditions for modernization of automation control systems (AXS) of self-contained power stations, based on new technologies.

Materials of the research

Main sources of electric energy on vessels are diesel-generator sets of direct or alternating current, frequency generators rotation is within the range of 500 – 3000 r. p. m. The parameters of VPS of main types of mass-produced vessels on the basis of reference books [3 – 5] , are shown in Table 1

Table 1

Parameters of VPS of main types of mass-produced vessels of river craft

Type of the vessel / (Type of electric plant)	Drive motor-diesel			Generator					
	Type motor	Power of the motor, KW	Rotational speed, r. p. m.	Type	Type of current	Voltage, V	Power, KW	Degree of vessel automation	Quantity
«Стк1001»/ (ДГР 100/750)	6ЧН18/22 6Ч 12/14	110 58,8	750 1500	ГСС-103-8М МСС83-4	Alternating current three-phase current 50 Hz	400 390	100 50	-	2 1
Volga-Don/ (ДГР-100/750)	6Ч 18/22	120	750	ГСС-103-8М	Alternating current three-phase current 50 Hz	400 и 230	100	-	2
«Volga 4001»/ (ДГР2А 160/750, ДГ2А 100/750)	6ЧН18/22 6Ч15/18	160 100	750 1500	ГСС-114-8М МССФ92-4	Alternating current three-phase current 50 Hz	400 400	150 100	А2	3 1

«Sormovskiy 3060»/ (ДГРА 100/750, ДГА50М-9Р)	6Ч18/22 6Ч 12/14	110 58,8	750 1500	ГСС-103-8М МСС83-4	Alternating current three-phase current 50 Hz	400 400	100 50	A1	3 1
«Ladoga 101»/ (ДГРА2100/750, ДГА50, ДГА50М-9р)	6Ч18/22 6Ч 12/14 6Ч 12/14	110 60 60	750 1500 1500	ГСС-103-8М МСС83-4 МСС83-4	Alternating current three-phase current 50 Hz	390 390 390	100 50 50	A1	2 1 1
Tanker, project №19614 N. Novgorod (3*ДГР3А 160/1500, АДГР2А 62/1500)	DI12-62M 6Ч12/14	199 65	1500 1500	Stamford	Alternating current three-phase current 50 Hz	400 400	168 62	A3	3
Passenger motor vessel т/х «Anton Chekhov» project Q 056, (ДГРА 420/1000)	6НВД26/ 20АЛ 6НВД26-2	463,7 140	1000 750	CCEE568 -6B ССЕД458 -8	Alternating current three-phase current 50 Hz	390 390	420 124	A1	2 1
Pushboat-tug project № Н3290 ДГР 150/750	6ЧН 18/22 6Ч12/14	165 58,8	750 1500	ГСС-114-8М МСК83-4	Alternating current three-phase current 50 Hz	400 400	150 50	-	2 1
Project №19614	DI12 62M IDE 452TG	199 81	1500 1500	НСМ434 С1 VDE 0530	50 Hz	400	168 62	A3	3
«Valerian Kuibyshev» project 92 016/ ДГ-480/750	6Ч 18/22	450	750	SRED-63У	Alternating current three-phase current 50 Hz	400	380	-	2
Project № 576 ДГ-25/1-2 ПН 290	4ЧА 10,5/13 -	40 -	1500 -	МС82-4 -	Alternating current three-phase current 50 Hz Direct current, d. c.	220 230	25 23,5		2 1

Analysis of VPS parameters of the vessels, manufactured in Russian Federation shows that synchronous generators of МС, МСК, ГСС, SSED types, of various degrees of automation are widely used, but automatic control systems (ACS) of greater part of these generators are constructed on out-dated relay-contact element base [1 – 5].

Analysis of automatic control systems (ACS) of VPS of river craft of Russia shows that greater part of vessel power plants requires modernization [2]. But the lack at Russian market competitive control systems of Russian fabrication forces shipbuilders to install automatic control systems of foreign manufacture, failures of which cannot be removed by the staff of the vessel, especially, if electromechanics are not among the members of the crew. Sometimes this is connected with lack of schematic diagrams and programming code of the controllers in the instruction manuals of ACS of foreign manufacture and qualification of the staff. Taking into account the above-mentioned problems it is necessary to develop domestic ACS of vessel power stations, meeting modern requirements, concerning automation and reliability.

For the development of ACS Boolean algebra apparatus is widely used [6], due to the necessity of the transition to digital element base. One of the methods of the realization of this apparatus for the description of ACS structure of vessel power plants is the method of constructive-functional proximity.

Usually, while division of structural models into elements, principle of constructive proximity not taking into account signals, transmitted across constructive element is used or principle of functional proximity is used, the essence of this principle is that at determination of the internal content of the object, elements operating for the formation of common output signal at one output are collected in it. The signals of the same origin are considered. But in the combined systems, power station being such system, availability of heterogeneous signals and constructive realization of pieces and units in greater part of cases does not allow to apply separately principles of constructive and functional proximity. That is why, to improve reliability (failure-free performance maintainability) of VPS it is expedient to apply the method of constructive-functional proximity for systems structuring while designing new ACS of vessel power plants. Method of constructive-functional proximity assumes the constructive unity and division of input signals by their functional designation or physical nature of the signals.

Proceeding from the structural analysis of ACS of vessel power plant by the given method it becomes possible to synthesize structural model of vessel power plant, describe signals of various nature and take into account very weak signals, passing across constructive elements of VPS, that finally prevents a number of errors and reduces the time of restoration if failure occurs.

This conclusion is proved by statistic analysis of ship's journals of passenger motor vessels of 92 016 and Q 056 project, and dry-cargo vessel of 576 project. Total power of the generators, installed at motor vessels, ranges within 40 to 500 KVA per one electric unit. Investigations have been performed in standard modes and emergency situations simulation. The results of the analysis show that the time of VPP restoration decreases from 5 % to 25 % due to reduction of fault search time as a result of application of ACS, constructed by the method of constructive-functional proximity.

Fig. 1 shows the dependences of *ΔE* on the power of electric equipment, connected to electric unit, for thee motor vessels, taking into account the duration of navigational period of 200 days.

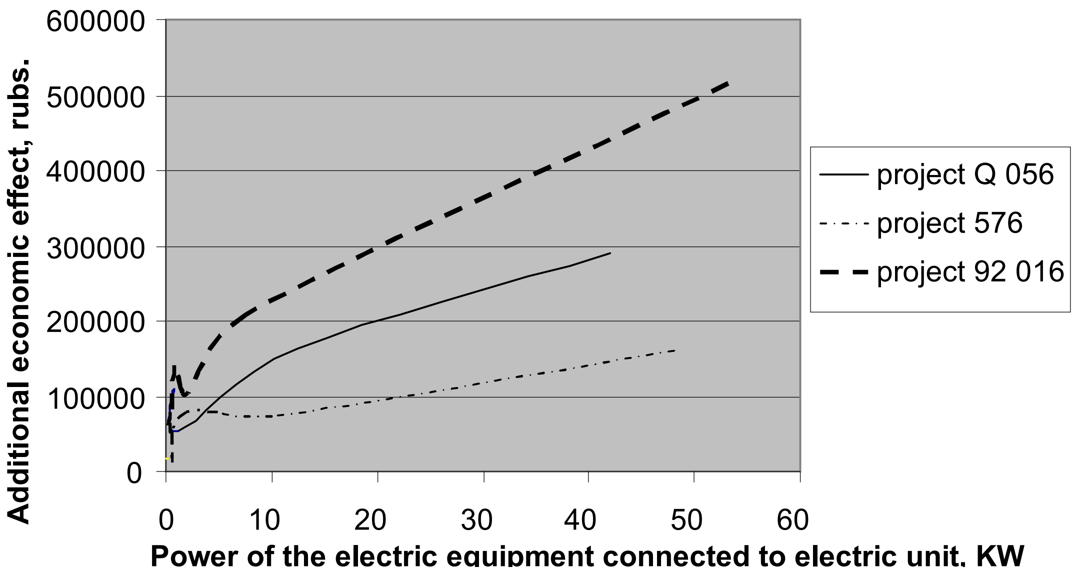

Fig. 1. Dependence of *ΔE* on the power of the equipment, connected to electric plant

Differences of *ΔE* characteristics at power of the connected equipment of up to 75 KW are caused by different values of failures intensities of small power loads. Reduction of the time of VPP restoration gives additional economic effect *ΔE*. Calculations show that at increase of power of the equipment, connected to VPP *ΔE* increases.

Conclusions

Application of the method of constructive functional proximity allows to realize the apparatus of Boolean algebra for the control of self- contained power stations, describe more completely the structure of vessel power plants ACS, that increases their failure- free performance and reduce time of restoration.

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