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COMPUTER CONTROL SYSTEM OF A WHEEL EXCAVATOR

DÖNER KEPÇELİ EKSKAVATÖRÜN BİLGİSAYARLI KONTROL SİSTEMİ

Ivan LALOV, University of Mining and Geology, Sofia 1100, Bulgaria

ABSTRACT

The paper states that the wheel excavators (WE) should have highly efficient control systems Design and structure of the control system are suggested as well as criteria for efficient excavator control and for synthesis of the control structure The main functions and tasks of the excavator control system are given The functions and the tasks of the separate subjects are synthesized All main mechanisms of the excavator and the mechanism for rotation of the upper structure possess respectively microprocessor systems, that is to say programmable controllers

ÖZET

Bu çalışma, doner kepçeli ekskavatörlerin oldukça etkin kontrol sistemlerinin olması gerektiğini vurgulamaktadır Bu bağlamda, ekskavatör kontrol sistemlerinin fonksiyonları ve görevleri belirtilmiş ve ekskavatör control sistemleri üzerine (yapı, tasarım ve etkinlik) öneriler verilmektedir Sonuç olarak, ekskavatörün butun ana mekanizmalarının ve ust yapının dönme mekanizmalarının programlanabilir kontrolörlere sahip olması gerektiği belirtilmektedir

1. GENERAL PROBLEMS OF A WHEEL EXCAVATOR CONTROL SYSTEM

The wheel excavator (WE) occupies a very significant place in the technological complex (TC) as it forms a determines its technical productivity It has great effect on the specifical consumptions of electrical energy Ce for extraction, transportation and filling the overburden which are the main consumptions That states the requirement that the wheel excavators should have a highly efficient control system bringing to the maximization of the exploitational productivity of the excavator while the newly formed face space of the extracted mining mass would have parameters equal to the given values The achievement of these quantitative, technical and economical and qualitative parameters which are a target function of the excavator control can be realized only by using a hierarchical distributed information and control computer excavator system with one or two operational panels (stations) The development and the introduction of information and control wheel excavator system (ICWES) providing maximum technical and economical effect is possible only by using a system approach in solving the problems of the excavator control that is to say when the following elements are being mutually discussed technological process of the block face extraction, wheel excavator, belt conveyor transport and overburden spreader as control objects, mining and technical, natural and climatic conditions, algorithms, systems and means of automatization

2. MAIN FUNCTIONS, TASKS AND STRUCTURE OF THE CONTROL SYSTEM

The functions of the excavator control systems are informational, communicational, advising and controlling

The tasks of the control system of a wheel excavator (CS WE) working at an overburden (for example at "Maritza-iztok" mining works) are the following

1 Collect, process and increase the reliability of the information about the parameters values and the state of the main mechanisms and devices as well as the space location of the excavator and the economical parameters of its work
2 To calculate and recommend the machine and excavator operator or to realize automatically the optimum values of face block parameters, layer and coal web, number of the layers and the webs of each layer, rotation angle of the upper excavator structure (UES) etc
3 To control the digging process providing the possible maximum technical productivity under the given mining and geological conditions and the limitation of separate technological, technical and electrical values as well as heating and mechanical overloading bringing to minimum specifical expenditure for extraction and transport of mining mass
4 To control with high efficiency the maneuver operations of the separate excavator mechanisms connected with the working out of the block face and the conveyer
5 To realize the process control of planing with and without using laser and other special technics

6 To form periodically generalized information about the excavator state at the level of a machine operator and to present when necessary information about a) working regime, b) current values of the main parameters determining the normal work location from the given, c) work efficiency for a given previous period and fulfillment of the plan to the present moment, excavator working time and stay, electrical energy consumption, d) prognosticated working efficiency and productivity for a future period etc
7 To signalize at prognosis and break-down state of work of the main and secondary mechanisms and the excavator in general while there is a break-down state to signalize the mechanism to be switched off
8 To registrate at the end of the shift the parameters characterizing the loading and the use in time and productivity of the excavator and its working efficiency totally for the shift in hours etc

The structure of the CSWE, the number of the local microprocessor systems (LMPS) also called programmable controllers, the functions and their tasks should most suitably be determined on the basis of the criteria maximum functional autonomy, minimum lost of functional possibilities of the system at the appearance of a certain technical disturbance in it and higher reliability

Figure 1 suggests a structural scheme of the hierarchy of CSWE and its functions and Figure 2 suggests a ringlike net (local) structure of the system obtained on the basis of the application of the upper suggested criteria

The minimum number of the LMPS for the wheel excavator with and without a moving rotor hand is from 3 to 5 depending on the functions of the CSWE Moreover, the system should possess minimum one operator panel (station) for the excavator operator and information panel (display) for the operator filler

The application of the above mentioned criteria gives priority to the structural local net (Figure 2) in comparison with the radial Moreover, it requires such organization of the system information provision which could give the opportunity to each LMPS to realize the prognosticated functions and tasks and to achieve greater autonomy to control one or a group of mechanisms It also effects on the optimum number of the LMPS and the spatial location of the separate components of technical provision

The minimization of the number and the length of the connecting cables and the reservation of certain channels for connection increase the system reliability The chosen ringlike net with double rim topology also increases the functional system reliability The operational excavator operator station is an autonomous MPS which is connected to the common rims Moreover, it can have direct connection to the MMPS and the LMPS The software defines of the systems as main while the others are subjected as LMPS-1 to LMPS-4

For a WE without a leading excavator boom the suitable spatial location of the MPS is the following LMPS-1 in "Cabin 500v" with main function mechanism control"

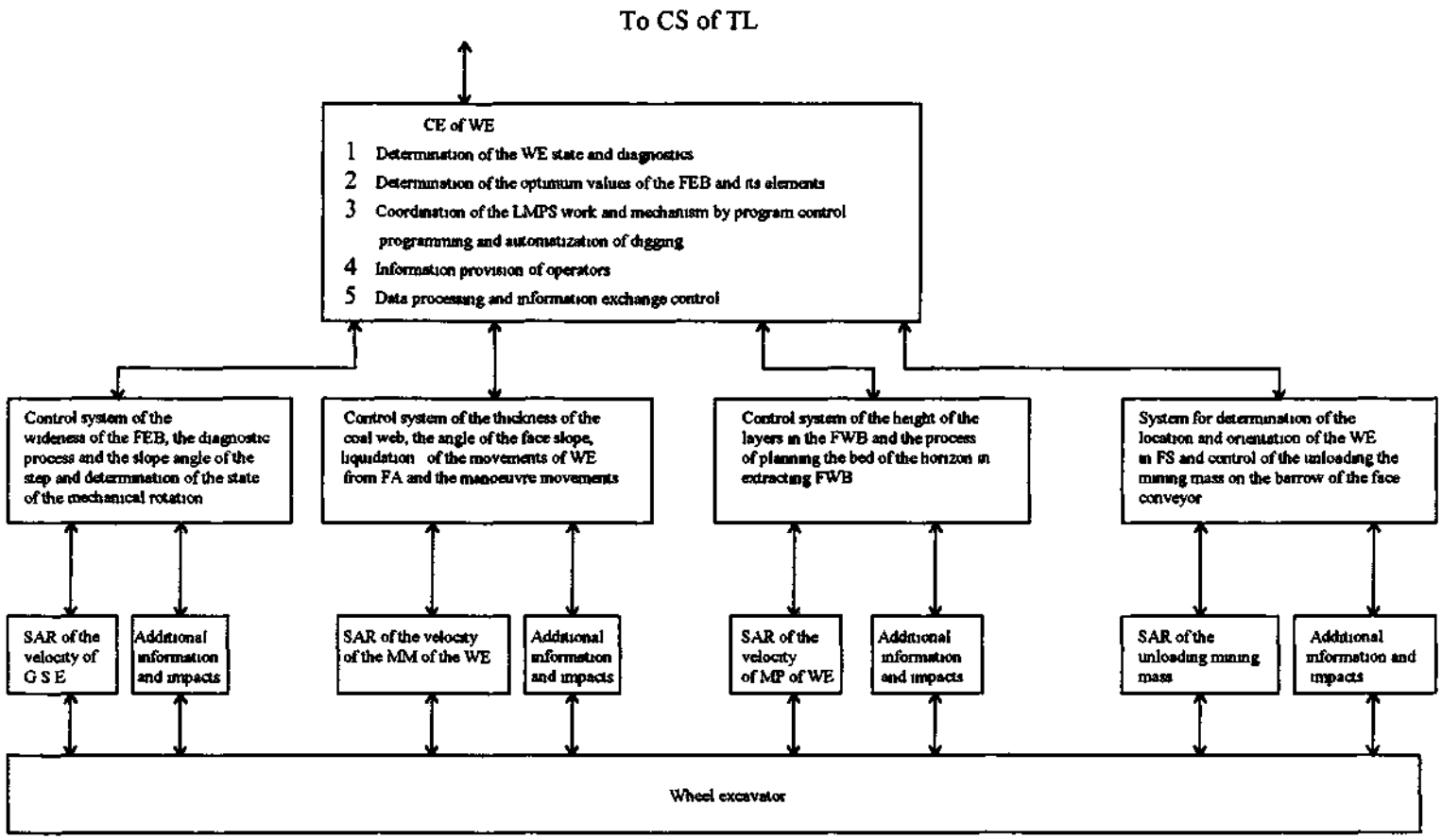

Figure 1 Functional scheme of hierarchic control system for wheel excavator

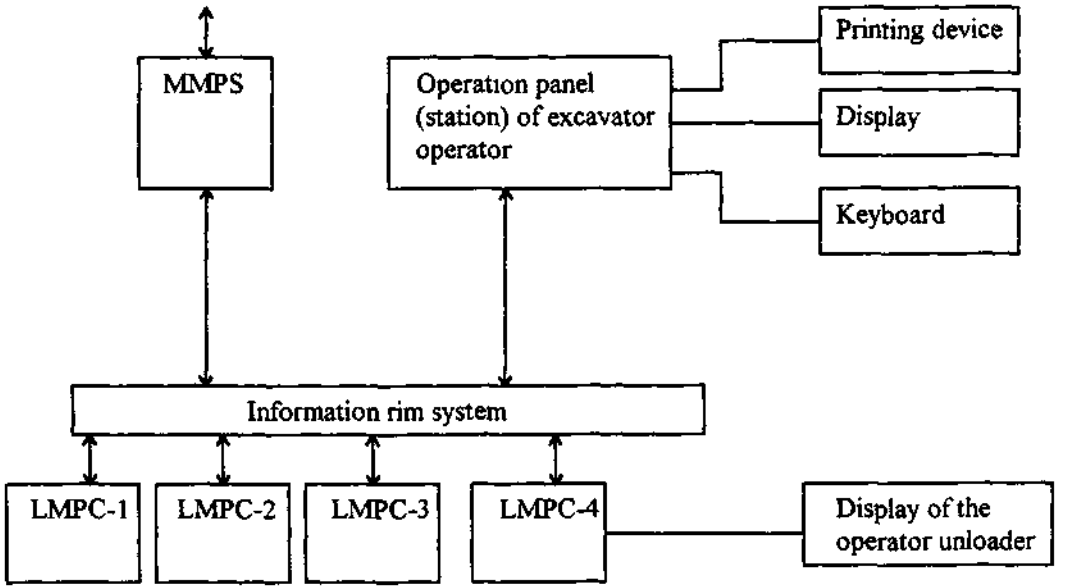

Figure 2 Rim network structure of wheel control system

rotation of the upper wheel excavator structure, LMPS-2 in "Cabin 500 v" with main function control of the "movement mechanism" and measurement of the total and separate mechanisms consumed electrical energy, LMPS-3 in "Balanced cabin" with main function lifting mechanism control, LMPS-4 in "Cabin 500" with main function determining the WE location in face space, LMPS and operational station in "Cabin of the excavator operator"

The above described architecture gives the opportunity for the following distributed optimum WE control, controlled monitoring and decentralized control of the processes by a specialized excavator operator cabin and a display, Integration of all controlling functions and devices by high speed communication road Documentation of the state of the technological processes, the wheel excavator and the operator functions, Estimation of the excavator efficiency work and the operational staff in hours and shift, Data processing their sending and receiving the information from the upper level "Control of the technological line" etc

3. FUNCTIONS AND TASKS OF THE SEPARATE MPS

A The main functions and tasks of the separate MPS together with the operational station (OS) or panel of excavator control are 1 Determining the excavator state 2 Diagnostic of break-downs 3 Determining the maximum face wideness, layer height at the cutting point and the parameters of the face excavator block, the layer and the coal web 4 Coordination of the work of the separate MPS that is to say the movements of the separate mechanisms in maneuvers, extraction, cutting, planing etc 5 Realization of all main calculating operations, connected with the provision of a) given slope angle of the step and the face, b) minimum value K,*. c) K^K,*,,,» , d) preservation from the bloom blast of the rotor arm in the side board and in the lower layer, e) current parameter values of the block, the layer and the coal webs, formation of a correcting signal to a given productivity or wideness of the coal web when reaching the current value or the motor temperature of the rotor wheel or of the rotor arm vibrations above the admissible value 7 Determination of the average values of the volume productivity for a given interval (minutes, hour, hours, shift etc) 8 Information exchange control with LMPS and SC of the Technological life (TL) 9 Data preparation for the higher level 10 Information provision of the excavator operator, spreader, electromechanic and mechanic

B The main function of the LPMS-1 are determination of the state and control of rotating the upper structure of the excavator (USE) according to give values from the MMPS It solves the following problems 1 Determination of the rotation mechanism state and its diagnostics 2 Control of the coal web wideness, rotation direction and rotation angle of the USE 3 Determination of the moment of coming out of the WE from the face when rotating in the direction to the extracted space 4 Determination and control of the smoothness of swinging 6 Limitation of the mechanism overloading and the maximum admissible angles of rotation 7 Determines the total and specifical consumption of electrical energy for digging, the working time and stay etc

C The main functions of LMPS-2 are determination of the state and control of the chain movement mechanism according to the data from MMPS or the operation system (OS) This system solves the following problems 1 Determines the state of the movement mechanism and the place of the break-down in the LMPS-2 2 Controls the formation of the depth and the number of the coal webs in one layer, the direction and the value of the shift of the excavator along the face axis and when there are deviations from it to the face axis 3 Control of the manoeuvres of the movement mechanism of the WE on the transformation from one layer to another with the aim of forming the given slope angle of the face 4 Controls the processes of switching on and off the accuracy of positioning 5 Determines the passed distance of the movement mechanism and the distance of the excavator to the face layer Determines the current values slope of the low structure of the excavator (LSE) and in certain cases the delevelling of the location of the excavator, 6 Determines the working time and stay of the mechanism etc

D The main functions of the LMPS-3 are determining the state and the control of the lifting mechanism It solves the following problems 1 Determines the state of the lifting mechanism and the location of the break-down in the LMPS-3 and the height of the face and the layer 2 Controls the formation of the layer height and the parameters of the newly formed bed on the horizon in the extraction of the lowest layer 3 Limitâtes the dynamic and temperature overloading of the lifting mechanism and the lowest and highest location of the WE 4 Determines the slope of the WE of the longitudinal and cross-section slope of the upper structure, the height of the WE and the radius of digging, the quantity of the worked out mining mass etc

E The main functions the LMPS-4 are determination of the location and the orientation of the WE in the face space, support of the unloading excavator boom at a given height of the bed of the face conveyor (above the unloading borrow) and the unloading of the capacity flow in the middle of the bed

For the total estimation of the efficiency grade of WE functioning under specifical mining and geological conditions the use of suitable parameters is suggested which give the possibility of making deeper analysis and estimation of the object and on this basis to take management decisions The use of one or other parameters or coefficients is determined by the aim of the analysis (Lalov, 1996)

4. CONCLUSIONS

WE need an adaptive information control system They should process the main subsystems providing highly efficient working regimes Moreover, the newly formed face space should have parameters equal to the preliminarily given Figure 1 gives the subsystems answering these requirements On the basis of the criteria for efficient excavator control the functions, tasks and structure of the control system are synthesized They are the basic problems to be discussed and synthesized when developing an informational control system for a wheel excavator

The distribution of the local microprocessor systems in mechanisms given in the paper as well as their respective functions and tasks should provide and realize higher reliability

and functionality under hard working conditions and when certain break-downs occur. A scientific team of UMG has developed and partially implemented the discussed control subjects of a wheel excavator.

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