СОВРЕМЕННЫЕ ПРОБЛЕМЫ НАУКИ И ТЕХНИКИ

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RELIABILITY OF MECHATRONIC SYSTEMS

The paper is based on opening part of solved work named VEGA – "Analysis and synthesis of mechatronic systems". It is partly aimed on complexity and necessity of design reliability and hierarchical distributed systems construction solving. These are complex controlled distributed electromechanical systems with different degree of inner interactions, with different physical and informational substance, with different principle of work and with various operation aims.

Изложены материалы выполненной работы по проекту ВЕГА – «Анализ и синтез мехатронных систем». В работе предложена иерархическая классификация сложных мехатронных систем, сформулированы требования к надежности их компонентов. Рассмотрены сложные распределенные электромеханические системы с учетом различных внутренних взаимосвязей составных частей различной физической и информационной структуры, различных принципов действия для выполнения различных операций.

Problem formulation

Nowadays the question of quality is important in all fields of human activities. Quality is a common term, which can be divided for example into:

– quality of human activities,
– quality of technological processes,
– quality of engineering systems, facilities and products.

Even if we accept such division, it is apparent that in mechatronic systems separate parts interact with each other and thus they can reach the high quality level [3]. In today´s world quality has become commonplace and it can be characterised by following attributes:

– functionality,
– usability,
– reliability,
– aestheticness,
– safety factor,
– efficiency,
– ecological balance.

It means that quality represents the summary of attributes, which are to satisfy presumptive or required needs of the user [7]. Each of these attributes has heterogeneous character and it is characterised by different factors. Their influence on overall level of quality is determined by the type and the level of interactions and with complex distributed systems it is in some cases very difficult to consider and establish them correctly.

One part of given task is to solve the question of mechatronic systems reliability. Reliability is according to [1, 2] defined by the set of next properties:

– operating life (life cycle),
– trouble-free operation,
– repairability,
– maintainability,
– storability,
– safety of operation,
– standby operation.

Reliability must be solved in all life cycle phases – from design to liquidation. It has to be added that the projection phase has an important role in reliability solution. It is evident that actual notional (calculated) values are determined by large number of factors such as – for example – base material, production and operation conditions etc. [8]. Accuracy of reliability determination depends on solver´s ability to involve all possible factors and thus simulate real conditions in largest possible extent.

According to [4] mechatronic system represents a collection of different components, subsystems and systems in mutual interactions (see fig. 1).

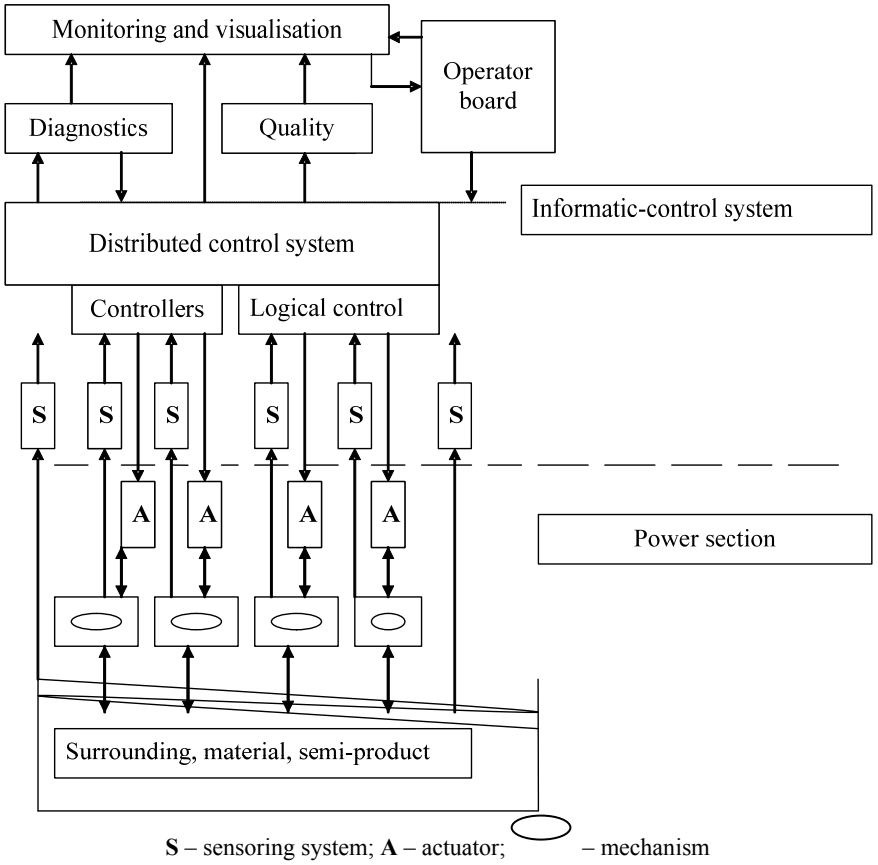

Fig. 1. Mechatronic system

Design phase of any mechatronic system must be based above all on products saleability, thus on ability to satisfy the consumer´s needs. The choice of correct strategy results from this fact and nowadays consists of:

– fast adaptability to a new product,
– ability to satisfy the customer quickly,
– high quality (and reliability),
– reasonable price,
– expansibility, compatibility etc.

Mechatronic system is a very difficult structure (as seen on fig. 1), that from the point of view of reliability must be solved both on hardware and software aspects. Components of mechatronic system work on different levels of interaction. Interaction level determines also the degree of computerization and operator´s function.

From the structural point of view it is very important for the project to ensure balanced development of all structural components. To secure the balanced development of the structure of mechatronic system [5] it is necessary to follow these rules:

– to avoid occurance of new professions with nonattractive work,
– adaptability of the computerized system,
– high reliability and security of the system.

Reliability determination is from the technical point of view influenced by type and number of components used in existing structure. Separate components can be mechanical, electrical, electronic or electromechanical. Reliability of mechatronic system depends on materials used, production technologies, production conditions etc. With electric and electronic elements the matter of reliability is solved according purpose, reparability or irreparability.

Presumption is measurness of monitored variable and way its evaluation. It starts from time-dependent or numerical characteristics.

Electromechanical elements consist of various electric, electronic and mechanic elements joined into one functional unit that performs a given task. According to [1] the evaluation of technical systems reliability (mechatronic systems as well) is based on their ability to carry out given tasks and requirements in particular time and conditions.

With the determination of reliability of component, instrument group, subsystem or system the following criteria must be taken into account:

– identification,
– physical principle,
– energy interactions,
– algorithms and the operating system type,
– manner of operating etc.

Mechatronic systems, as it has been mentioned before, represent a complex hierarchical distributed structure with two levels of control – operation level and superior (higher) level. Movement coordination of separate mechanisms and their energetic interactions are ensured by distributed control system through actuators.

Control system on superior level includes diagnostics, quality determination, visualisation and informational link with an operator [4]. Apparently, in complex distributed system information (e.g. on parameters or status etc. obtained from processing station) and horizontal and vertical communication between components, subsystems, technical equipments and operator are necessary for fulfilment of the given task.

Process level includes autonomous working controllers, CNC machines, robots, production lines etc. It ensures basic functions of automatic control system. According to [9], process level fulfils these functions and activities:

– collection and basic processing of continuous and binary technological values,

– calculation of control interventions by means of continuous or logical control algorithms,

– realisation of enumerated action interventions,

– alarms generation in case of specific events occurrence in controlled or control system,

– blocking of incorrect operation in control system and its securing,

– self-diagnostic of operation of technical equipment in control system,

– secondary processing of continuous and technological values used for securing of higher control level operation,

– mutual horizontal and vertical communication between automatic control system equipment etc.

Design of process level must secure its uninterrupted operation in case of communication failure with higher level system. Basic technical equipment of process level is the programmable controller equipped with its own operating system and application software. Programmable modules are designed generally and their specific function is determined by setting of required parameters.

Communication between subsystems of distributed control systems is based on computer networks which can be clasified according to:

– extent (LAN, MAN , WAN),

– transfer rate(clasical, high-rate network ATM, FDDI ...),

– applications (computer networks in information systems or in industry applications) [10].

For communication in industry application various standards and protocols are used. Nowadays one of the most wide-spread system is the MMS protocol based on ISO/OSI system. It can be described as 7-layer model in which every layer fulfils specific tasks. One of the basic requirements for communication in industrial computer networks is reliability, correct processing and transfer of signals. In consequence the signal transfer has to secure:

– exactness,

– promptness,

– multichannelity,

– resistance against distortion etc. [11].

Correct communication in industrial computer networks and also in mechatronic system is the basic condition for required level of control in complex multidimensional systems. Besides other factors which influence communication the following aspects need to be stressed:

– the type of operating system and program equipment,

– memory type,

– program languages,

– program compatibility,

– signal testing,

– type of interface.

Conclusion

Solving of assigned project named VEGA – ”Analysis and synthesis of mechatronic systems” brings a wide spectrum of problems many of which cannot be included in his paper. The complexity of work is apparent from several partly defined difficulties included in this paper. Although detailed methods and procedures have been developed to solve questions of technical systems reliability, working experience reveals many difficulties, e.g. the determination of critical bottlenecks.

According to [6] when designing a system the examined parameter must be defined correctly. Even if this one is defined correctly, in certain situations it can carry insufficient information value. Similarily, in real systems it can be difficult to determine reactions of system dependant on particular operational conditions even if they are based on correct methods of reliability.

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