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Electromechanics vs. Mechatronics –Points of View

Mechatronics–this emerging boundary subject is largely disputed among scientific, business, and engineering collectivities both in the plane of methods and applications, and in the plane of concepts and approaches. From ideas which consider it as a make-up form of electromechanics or deny its scientific emerging character, until apologizing concepts declaring it as a philosophy of intelligent machines engineering of 21st century, a few dozen of concepts and opinions exist in formal and no formal debates among interested collectivities. The paper deals with an overview of these ideas, with pro and contra augments emerged from a particular topic- equipment for mining industry, the latest beneficiary of the topic.

1. Introduction

The simplest definition of "mechatronics" is that it is a branch of engineering that deals with combined mechanical, electronic and software systems. The elements of mechatronics systems include sensors, actuators, microcontrollers (or microprocessors) and real-time control software.

One of the features which distinguishes mechatronic systems or products from earlier electromechanical systems or products is the replacement of some mechanical functions with electronic and software ones. This results in much greater flexibility of both design and operation.

Another feature of the mechatronic products is increased speed and precision of performance. A third is the ability to conduct automated data collection and reporting. In addition, advanced mechatronics systems now have the ability to implement distributed control in complex systems.

The term "mechatronics" was first coined in Japan. It was initially used in the late 1960s at Yaskawa Electric Company Ltd in reference to the application of electronic control of the company's electric motors.

This term remains popular in Japan, where it usually refers to a fusion of mechanical parts and a broadly defined electronics (i.e., including semiconductor control devices, sensors and optoelectronic devices).

The term "mechatronics" has also been widely used in continental Europe for many years. In the past decade, it gained acceptance as a distinct field of study and practice in the US , UK, Germany and other European industrialized countries, evidenced by the rising number of undergraduate and postgraduate university courses now being offered.

There has always been a close relationship between mechatronics and robotics, and, in fact, many engineers contend that the former grew out of the latter. A number of innovations that were first applied to robotics were subsequently applied to other types of high performance machinery. Examples include sensory feedback and the coordination of movements, both of which made robots more flexible and increased productivity.

Mechatronics technology has continued to advance rapidly since the coining of this term. These advances are concerned largely with precision, speed, durability, miniaturization, flexibility, safety, power consumption, intelligence and cost.

This is the result of the swift progress in all of the components and technologies of mechatronics systems, including actuators, sensors, microcontrollers and software as well as materials science, fuzzy logic, lasers, communications, kinematics, machine vision and virtual reality.

In spite of the rapid progress that has been made and the emergence of whole new classes of products, not everyone is convinced that "mechatronics" should be considered as a distinct new field of engineering.

This is, in the skeptics opinion, because mechatronics is an evolutionary rather than a revolutionary development. It is just a natural progression to incorporate sensors, microcontrollers and other advanced electronic components into mechanical products now that they have become so inexpensive and small that they can be put into even the cheapest and tiniest of products.

Some engineers point out that the term "mechatronics," while once an appropriate updating of the term "electromechanics," has itself now become somewhat of a misnomer. This is because the field has swiftly incorporated advances from a growing number of other fields, and the share (measured in terms of function, cost, etc.) of mechanical components in individual systems continues to decrease.

Indeed, mechatronics is increasingly incorporating every aspect of engineering. Perhaps the real key to a system or a product being a mechatronics one is that it contains moving mechanical parts.

Regardless of the terminology, the future of what many people call "mechatronics" is very bright. This is because advances continue to be made in all of the components and technologies used in such systems and because no slowdown is in sight for this progress. The result will be a continued improvement in the performance of mechatronics systems and a further growth in the number of applications.

Another trend is to extrapolate the principles of mechatronics towards the general engineering design field, considering the mechatrinic approach as a new philosophy of design. Two key elements support this concept, first the possibility to analyze complex systems using multi-domain techniques, and secondly, to design and manufacture quickly marketable, highly "intelligent" products, the so called precision engineering products.

Mechatronics products are in general devices or instruments that are used for production, transference or processing of signals, and they are found almost everywhere in technique in great variances.

2. Mechatronic approach in mining equipment design

The constructive complexity, the variety and the aggressiveness of the operating environment a lead to a sinuous and conjectural evolution of the equipment for mineral industry, the implementation of new techniques and technology achievements vas performed with a large delay in comparison to other industrial fields.

On the other hand, a systemic methodology for design, development and manufacturing of this equipment is not yet realized. However, the mining equipment experienced in the past two decades, due to the general evolution of the technology, a degree of sophistication and a complexity without precedent.

The new achievements in the field of Information technology, of sensors, actuators and other elements determined an advance of steering and monitoring systems overcoming the technological level of the mechanical and driving systems.

Mechatronics – the new emerging border science is able to offer new availability and performance to mining equipment, influencing also the thinking of designers.

The steering, control, monitoring and regulation systems are not only „added", they are embedded parts of the entire system. The equipment is designed and conceived as a whole in which the mechanical, hydraulic, electrical and IT systems are integrated elements, and not separate functional blocks.

New acquisitions of the science of Mechatronics design able to consider multidomain systems can be utilized more and more in the design of this equipment.

For the engineering design practice, the mechatronic philosophy marked the jump from traditional, sequential engineering design towards the parallel, concurrent design.

The actual approach in mining equipment design is focused on split design of different parts, such as mechanical, electrical, hydraulic and steering subsystems.

The lesson learnt from the mechatronics philosophy of design, can provide guidelines of innovative design of any mining equipment, including open pit mining equipment, which consist in many multidomain subsystems, making the design difficult and amended by over considering some aspects in relation with other ones.

The application of the results of the engineering design based on Mechatronics philosophy, is related both with the aspects of connected domains which can be translated in the sphere of mining equipment, and the achievements which are currently working tools in the leading mining equipment companies.

Mechatronics means an interdisciplinary development approach which was established for the development of products with mechanically oriented tasks. Mechatronic products are realized through a tight spatial, technological and functional integration of mechanical, electrical and information processing subsystems. These integrated systems allow the design of completely new products with considerably improved performances.

The human factor consideration, the life cycle assessment, the switch from the linear to model based design, are supplementary assets of this design methodology. This will enable the best practice of synergetic cooperation of specialists from different disciplines for a success oriented product development. It relates to the design of systems, devices and products aimed at achieving an optimal balance between basic mechanical structure and its overall control.

It covers a wide range of application areas including consumer product design, instrumentation, manufacturing methods, computer integration and process and device control.

The designing of mechatronic systems is an important part of the product life time (Fig. 1). It is an iterative process, as designers often jump back one or more steps to redesign or tune what they have done before. Design starts with an idea of the product and includes requirement specification, conceptual and detail design, prototyping and testing, implementation and validation, production, exploitation and recycling of products.

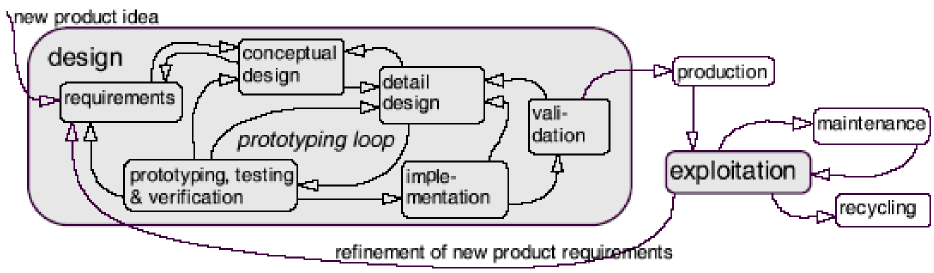

Figure 1. Design phases according to Mrozek [1]

In order to highlights the role of multidomain analysis in the mechatronic approach of equipment design, the situation presented in the reference [2] is very usefull.

At the start point of the design of an autonomous loading equipment (LHD), Marshall [2] consider a map of the excavation process, as depicted in ¯figure 2. Suppose that the loading process may be decomposed into three physical systems, namely: (i) the mechanism structure (boom, bucket, and vehicle); (ii) the actuators (hydraulic lift and dump cylinders, and possibly the tractive effort of the vehicle) which act on, and are in turn acted upon, by the mechanism structure, and; (iii) the rock pile with which the physical structure interacts during the excavation operation.

What is most interesting to note about the system illustrated by Figure 2 is that measured cylinder pressure data contain not only evidence of actuator input signals, but also information regarding the machine structure motions and its status of interaction with the rock pile. In fact, experimental observations showed this postulate to hold true.

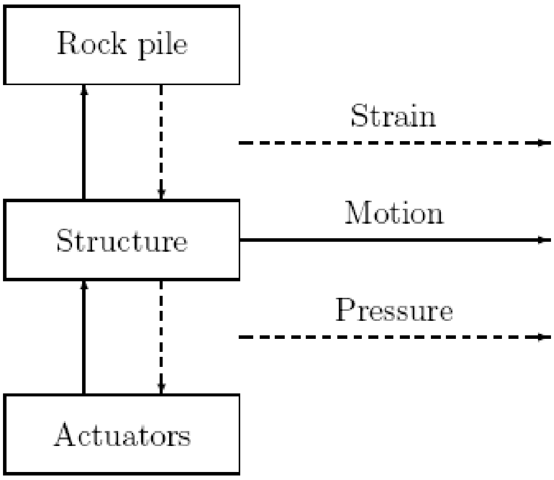

Figure 2. A map of the excavation process, according to Marshall

The main advantage of the mechatronic approach is the connected consideration of the three main flows existing in a complex equipment, such as mining one is, i.e. the matter, energy and information flow.

A suggestive illustration of this issue is presented in figure 3, according to Jürgen Gausemeier [3]

The relevant physical values of the basic system are measured by sensors and used to fulfill the designated tasks. The analog values measured are converted to digital and – possibly after some preprocessing – passed to a digital processing unit, i.e. a microcontroller.

The processing unit determines the necessary changes to the basic system using the measurement data, the users' specifications (human-machine interface) as well as any available information from other processing units (communications system).

Following digital/analog conversion and power modification these changes are then implemented on the basic system by means of suitable actuators. This approach gives rise to the control loop that is characteristic of mechatronic systems.

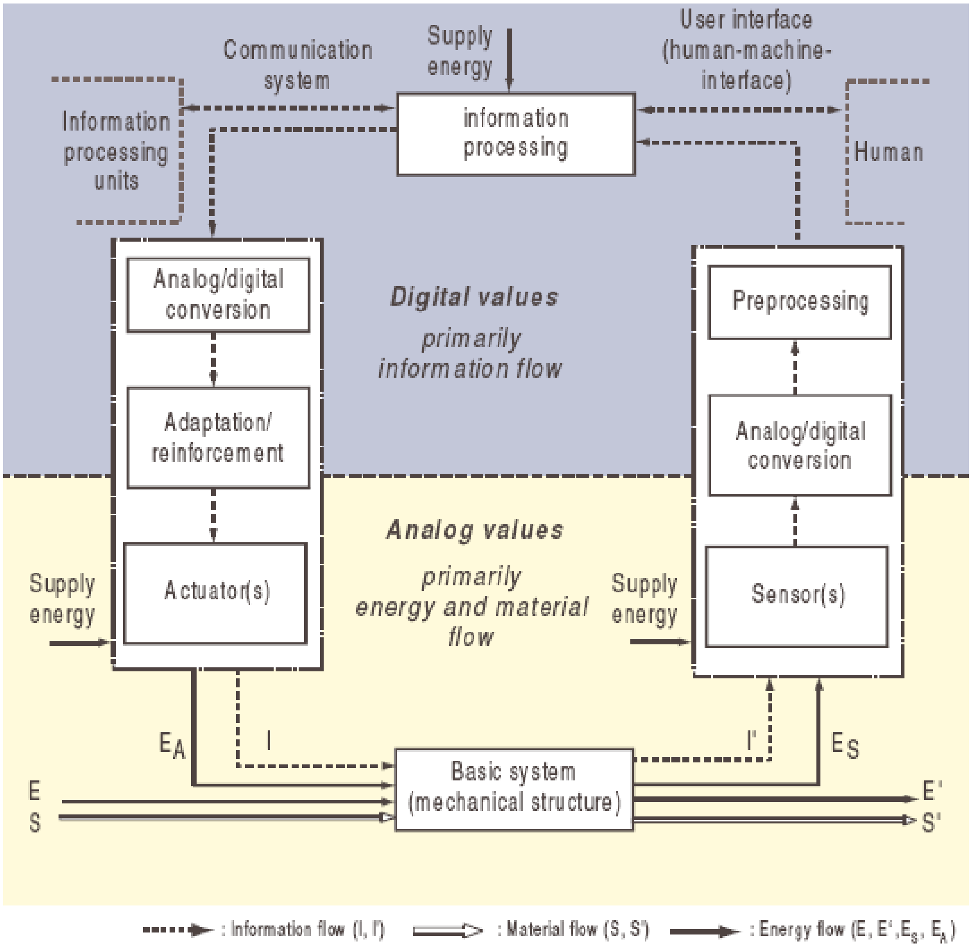

Figure 3: Basic structure of a mechatronic system based on a control loop comprising basic system, sensors, information processing and actuators

4. Conclusion

The paper is a trial to synthesize of the main ideas converging towards the application of the results of the engineering design based on Mechatronics philosophy, illustrating both the aspects of connected domains which can be translated in the sphere of mining equipment, and achievements which are currently working tools in the leading mining equipment companies

The new concepts of the Mechatronics, as a science of „Intelligent machines", emerged in the past years, as a new philosophy in the complex electromechanical systems, with embedded multi-domain systems, can offer a base to deliver a new design methodology, from operational, conceptual and procedural point of view for the realization of a new generation of equipment for mineral industry.

Mechatronics – the new emerging border science is able to offer new availability and performance to mining equipment, influencing also the thinking of designers. The steering, control, monitoring and regulation systems are not only „added", they are embedded parts of the entire system. The equipment is designed and conceived as a whole in which the mechanical, hydraulic, electrical and IT systems are integrated elements, and not separate functional blocks.

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