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THE CONCEPT OF MECHATRONICS IN FLUIDICS

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Abstract: In this paper, is analyzed the way of promoting mechatronics in the structures of fluid, respectively pneumatic and hydraulic actuation systems. Mechatronic structures obtained impress new qualities in these types of operations, frequently found in practice, especially in machines, digital control plants and industrial robots structure. It was established a pattern of automatic adjustment and control that can be applied in the most proportional equipments, and also the possibilities to integrate computer systems and microprocessors in their operation.

The study is focused on products manufactured by the companies REXROTH and FESTO.

1. INTRODUCTION:

The term „Mechatronics" was introduced in 1969 by Yosakawa Electric – Japan and defines mechatronics as: *The word mechatronics is composed of "mecha" from mechanism (mechanics) and "tronics" from electronics, in other words, technologies and products developed incorporate mechanics, electronics and computer science*. The definition of mechatronics has continued to evolve over time. One of the commonly used definition was presented by Harushima, Tomizuka and Fucada in 1996.

Mechatronics is defined as synergetic integration by mechanical engineering, electronics and control with intelligent computer in the design and the manufacture of industrial products and processes. There were also other definitions of mechatronics, but each of them, itself, fails to capture all of mechatronics. This fact shows that the area is alive, that it is a young and a credited subject.

It is obvious that the study provides mechatronics as a mechanism for scientists interested in understanding and explaining the design process, to define, classify, organize and integrate many product design aspect into one coherent package.

As a specialty, the study of mechatronics offers an educational way that is beneficial for students and engineers to go through Bachelor or Master studies, programs recognized worldwide as a vibrant area of study.

Mechatronics penetrated many industrial and non industrial areas and, lately, it penetrated the field of fluidics, respectively pneumatic and hydraulic operations.

2. THE CONCEPT OF PNEUTRONICS AND HYDRONICS

Pneumatics and hydraulics, as sub-domains of mechanics, in general, integrated in their equipments' structure, even since their beginning, electrical components, both in their operating area, such as electromagnets with functional behavior of type "all" or "nothing"; and in the operating area of actuation systems where electrical part is materialized by contacts and relays. Since actuation systems were designed to achieve forces and moments of high and very high values or high speeds, requirements that nowadays are timely, their debut can be considered as pneumatic and hydraulic power.

These equipments fit into the electro-mechanical phase of systems evolution.

By the early 1980s, a number of famous companies in the manufacture of hydraulic systems, including Rexroth, Bosch, Parker, Festo etc, promoted the idea that fluid (hydraulic) actuators should take, together with the power function, the "positioning accuracy" function. Thus, in the operation area of fluid equipments were developed new electric components: proportional electromagnet and torque electric engine.

Thus, actuation systems became control systems, in the traditional sense of the theory of automatic control systems. They were controlled by electronic systems. Electrical component takes the qualitative leap to the basic electronic component – the transistor.

During the phase when the actuator system become an automatic control system, closed by means of one or of several reaction circuits, it also occurred the penetration of electronics and of computer science in pneumatics and hydraulics.

Adjusted sizes – output sizes from a fluid automatic systems are: the flow and/or the fluid pressure at the level of pneumatic and hydraulic equipments: position, speed, acceleration, force or the moment at the level of pneumatic or hydraulic actuation systems (engines).

Thus, at this phase, we can mention that certain pneumatic and hydraulic equipments and systems incorporated, in their mechanical structure, electronics and computer science, achieving high operative accuracy, features of Mechatronics field. From this moment, we can talk about pneumomechatronics (pneutronics) and hydromechatronics (hydronics).

Mechatronics in pneumatics and hydraulics represent a third phase of their technical revolution by similarity with the accepted definition of mechatronics, at the pneumatics and hydraulics level, we can define pneutronics and hydronics as the synergetic integration of electronics and computer science in the pneumatic and hydraulic equipments and systems, in order to design and manufacture them, and also the automated control of the operation. In such a concept, pneumatic and hydraulic products/equipments and systems, although they are faster, they become more stable and accurate, being characterized by a certain degree of intelligence.

On the grounds of those aforementioned, in figure 1 is showed the structure of a pneutronic or hydronic equipment, and in figure 2 the structure of a pneutronic or hydronic system.

At the level of the equipment's, pneutronics or hydronics identifies with the automatic control systems of the flows and/or of pressures – figure 1, and at the level of actuation systems, they identify with the automatic control systems of positions, speeds, forces or moments, figure 2. Being control systems, they are structured and developed according to the automatic systems science and theory: state sizes pursued in reaction circuits become flows and databases, processed in real time by a computer system and performed in real time by electrical or electrohydraulic, respectively electropneumatic system. The functions of automatic control and optimization computer system, as well as those of the control system are ensured by means of some softwares, by a dedicated hardware, controller type, that can be configured with logical circuits (CL), integrated circuits (CI), microprocessors (μP) or personal computers (PC).

In line with the changes caused by mechatronics in products and systems philosophy, is expected that in pneutronics and hydronics too, be produces a stronger development of the software against hardware. Will be required softwares and hardwares dedicated to pneumatics and to hydraulics both in order to give flexibility, accuracy and reliability to the products from these fields and especially for economic reasons, considering the very large number of actuations of this kind in the world.

The simultaneous pursuit of output-reaction position sizes or others is made using appropriate sensors and transducers that form a sensory system (S).

Information flow from the output from sensory system (S), always electrical, must be compatible with the type and the level of signals with which the controller operates through an analogue/digital (A/D) converter system.

The function of this system, for a faster data access by the microprocessor or personal computer controller, is taken by the data acquisition cards (PAD).The data

acquisition cards can have at the output doors one or several analogical sizes resulting from a digital/analogue (D/A) conversion.

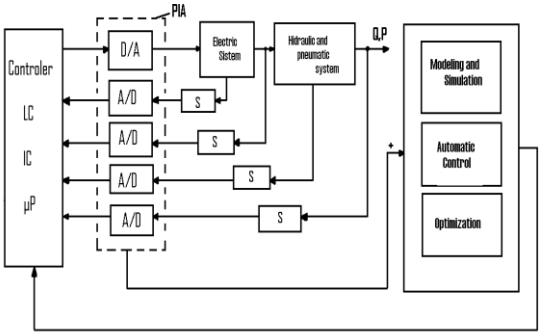

Figure 1. The structure of a pneutronic or hydronic equipment

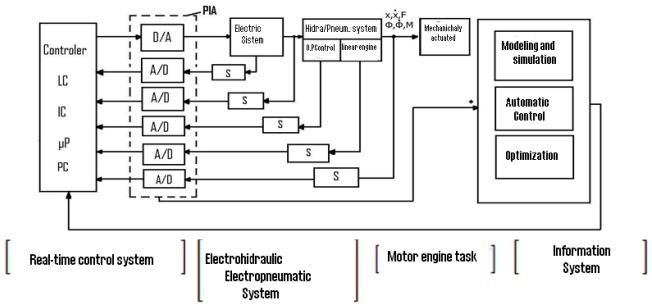

Figure 2. The structure of a pneutronic or hydronic system

In order to illustrate, on a physical model, the structure of mechatronic (hydronic) hydraulic equipment is showed, in figure 2, a proportional hydraulic distributor, with position control with transducer, produced by REXROTH Company.

The distributor has an electro-hydraulic structure in a single stage.

The proportional distributor is formed of the following main elements: 1. Distributor body, 2. Proportional electromagnets, 3. Position transducer. 4. Control piston, 5. Balancing springs.

In figure 4 is showed the schematic diagram of a hydraulic translation axis from the structure of an industrial robot and the elements of the management system (fig. 7.4. from TVA thesis)

As known in specialty literature, the actuation function with precise adjustment of the position is one of the basic functions that promoted mechatronics. In the field of electrical actuations, where the concerns are older in terms of a displacement and of a low operating power, the positioning precision already achieved micrometer and even sub-micrometer values. In the area of average and large powers, it appealed to hydraulics.

The same requirements imposed to pneumatics have, yet, unsatisfactory results. Pneutronics has the task of making pneumatic systems feasible in terms of precision criterion.

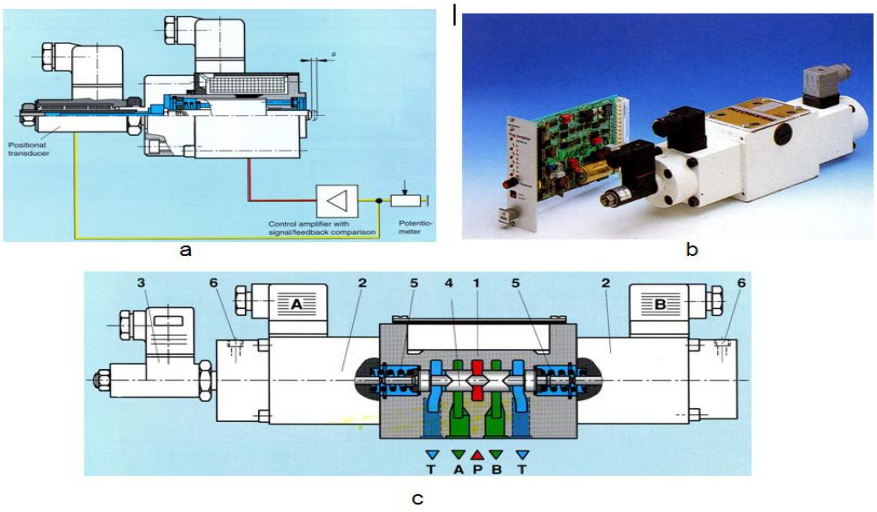

Figure. 3 a. Proportional distributor REXROTH, b. Picture distributor and control system, c. Constructive elements,

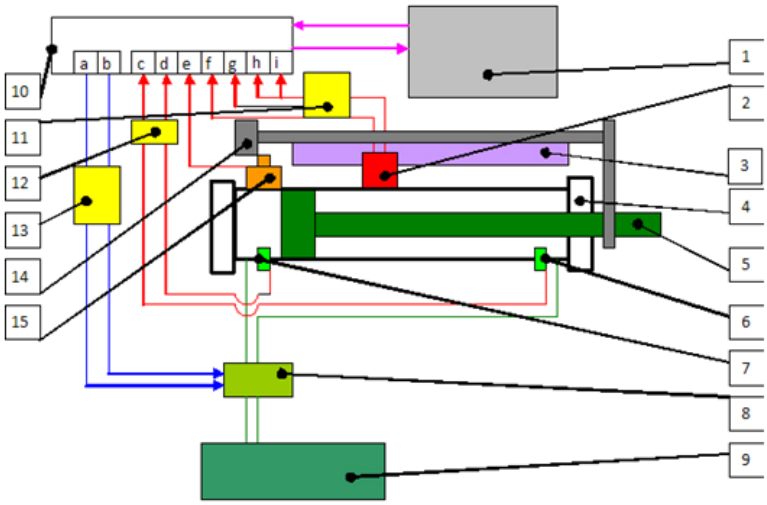

Figure 4 Hydraulic axis with mechatronic (hydronic) translation
Components: 1. Computer PC, 2-3. Position transducer, 4-5. Hydraulic actuator, 6-7. Pressure transducer, 8. Proportional distributor, 9. Hydraulic power source , 10. Data acquisition card, 11. Position conversion circuit, 12. Pressure conversion circuit.

By servo-hydraulics, hydraulic actuation systems were much closer to the concept of mechatronics. Operating systems having also the positioning function are successfully promoted in robotics or in the field of numerically controlled plants.

In what concerns pneumatic or hydraulic operating systems, due to some internal factors acting on the system, for their modeling are used several simplifications and approximations, a number of physical quantities although they are variable, they are considered constant, some being nonlinear and approximated.

In this context, in order to increase the positioning accuracy, an abusive application of the concept of mechatronics would mean promoting a sensory system that pursuit and create data for all sizes.

Establishing some operable software's, dedicated to pneutronics and hydronics, is an opened and future issue, for specialists and researchers in the field.

3. CONCLUSIONS

The multidisciplinary character of the approach of these issues is imposed as a requirement for the training of future specialists both regarding the basic knowledge of pneumatics and hydraulics applied, of electronics and of computer science as well as the latest achievements in the field of actuators and engines, sensors and transducers, micro-electronics and micro-mechanics, of the structures of automatic systems forming artificial intelligence (neural networks, fuzzy controllers, etc.), foster systems, etc.

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