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Automation and Simulation of Hydraulics and Pneumatics

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7.1 Introduction

In today's fast-moving, highly competitive industrial world, a company must be flexible, cost-effective and efficient if it wishes to survive. In the process and manufacturing industries, this has resulted in a great demand for industrial control systems/ automation in order to stream-line operations in terms of speed, reliability and product output. Automation plays an increasingly important role in the world economy and in daily experience.

Automation is the use of control systems and information technologies to reduce the need for human work in the production of goods and services. In the scope of industrialization, automation is a step beyond mechanization. Whereas mechanization provided human operators with machinery to assist them with the muscular requirements of work, automation greatly decreases the need for human sensory and mental requirements as well.

7.2 Automation Control System

- ▶ Automation Control System is the system that is able to control a process with minimal human assistance or without manual and have the ability to initiate, adjust, action show or measures the variables in the process and stop the process in order to obtain the desired output.
- ▶ The main objective of Automation Control System used in the industry are:
 - To increase productivity
 - To improve quality of the product
 - Control production cost

7.3 Types of Industrial Automation

- ▶ Systems are usually categorized into four types
 1. Fixed Automation System
 2. Programmable Automation System
 3. Flexible Automation System
 4. Integrated Automation System

7.3.1 Fixed Automation System

- ▶ Fixed automation systems, or "hard automation," are typically used for production systems with exclusively allocated equipment and high-production needs.
- ▶ The equipment in a fixed automation system is manufactured and designed to perform only one set of operations on one part with high levels of efficiency.

7.3.2 Programmable Automation System

- ▶ Programmable automation allows for machine configurations and operation sequences that can change based on signals sent from electronic controls.
- ▶ With a programmable automation system, products can be produced in batches through the reprogramming of machine operations and sequences.

7.3.3 Flexible Automation System

- ▶ Flexible automation (FA) is a type of manufacturing automation which exhibits some form of "flexibility". Most commonly this flexibility is the capability of making different products in a short time frame.
- ▶ Flexible automation allows the production of a variety of part types in small or unit batch sizes.
- ▶ Benefits of Flexible Manufacturing System
 - Reduced manufacturing cost
 - Lower cost per unit produced
 - Greater labor productivity
 - Greater machine efficiency
 - Improved quality
 - Increased system reliability

- Reduced parts inventories
- Adaptability to CAD/CAM operations

7.3.4 Integrated Automation System

- ▶ Integrated automation systems incorporate the total manufacturing system into a computer-controlled, digitally processed and coordinated system.
- ▶ Integrated automation systems work through a common manufacturing system database.

7.4 Basic Elements of Automation

- ▶ Automation consists of three basic elements:
 - Power
 - Programmed of instructions
 - Control system to actuate the instructions and sense feedback from the transformation process
- ▶ Alternative power sources include: fossil fuels, solar energy, water and wind; however, their exclusive use is rare in automated systems.

7.5 Comparison Between Fixed and Flexible Automation System

- ▶ Purpose of fixed automation system is produce specific product and purpose of flexible automation system is produce variety of product.
- ▶ Ease of making changes / upgrade is difficult in fixed automation as compare to flexible.
- ▶ Maintenance hard in fixed automation as compare to flexible.
- ▶ fixed automation suitable for small system and flexible suitable for all types of systems.

7.6 Pneumatic Control System

- ▶ Pneumatic control system is a system that uses compressed air to produce power / energy to perform any task
- ▶ Pneumatic systems found in many industrial systems such as food industry, petrochemical and industrial involves robotics.
- ▶ Pneumatic systems requires:
 - Compressed air supply
 - Control valve
 - Connecting tube
 - Transducer
- ▶ Pneumatic control system can be controlled manually and automatically.

7.7 Hydraulic Control System

- ▶ Hydraulic control system is a system that uses fluid to generate power/energy.
- ▶ The hydraulic system used in the automobile industry such as power systems, braking systems, cranes, car jack, satellite and others.
- ▶ The fluid used is oil.
- ▶ The hydraulic system requires:
 - Hydraulic fluid supply
 - Control Valve
 - Cylinder
- ▶ Hydraulic control system can be controlled manually and automatically.

7.8 Electrical Control System

- ▶ A control system that uses an electric current; either direct current (DC) or current shuttle (AC) as a source of supply.
- ▶ Electrical control systems generally requires:
 - Electricity (DC) or (AC)
 - Input elements (switches, sensors, transducer, valves, electronic components, etc.)
 - Output elements (motor, lights, etc.)
 - Extension cable

7.9 Comparison between Pneumatic control systems, Hydraulic control system and Electric control system

- ▶ Pneumatic control system
 - Easy installation
 - Simple design
 - Use compressed air as a supply source to perform task
- ▶ Hydraulic control system
 - Complex to assemble
 - Use fluid like oil as a supply source to perform task
 - Potential leakage will lead to pollution
- ▶ Electric control system
 - Simple system
 - Use electricity as a supply source to perform task
 - Widely use either for home user or in industrial

7.10 Advantages of Automation Control System

- ▶ Replacing human operators in tasks that involve hard physical work.
- ▶ Replacing humans in tasks done in dangerous environments (i.e. fire, space, volcanoes, nuclear facilities, underwater, etc.)
- ▶ Performing tasks that are beyond human capabilities of size, weight, speed, endurance, etc.
- ▶ Economy improvement: Automation may improve in economy of enterprises, society or most of humanity. For example, when an enterprise invests in automation, technology recovers its investment; or when a state or country increases its income due to automation like Germany or Japan in the 20th Century.
- ▶ Reduces operation time and work handling time significantly.

7.11 Disadvantages of Automation Control System

- ▶ Unemployment rate increases due to machines replacing humans and putting those humans out of their jobs.
- ▶ Technical Limitation: Current technology is unable to automate all the desired tasks.
- ▶ Security Threats/Vulnerability: An automated system may have limited level of intelligence, hence it is most likely susceptible to commit error.
- ▶ Unpredictable development costs: The research and development cost of automating a process may exceed the cost saved by the automation itself.
- ▶ High initial cost: The automation of a new product or plant requires a huge initial investment in comparison with the unit cost of the product, although the cost of automation is spread in many product batches of things

7.12 Reference Books

1. Basic Pneumatic Systems, Principle and Maintenance by S R Majumdar, McGraw-Hill
2. Pneumatics Concepts, Design and Applications by Jagadeesha T
3. Fluid Power with Applications by Anthony Esposito, Pearson