Unit 57: Mechatronic System

Unit code: F/601/1416 **QCF level: 4** **Credit value: 15**

OUTCOME 1

TUTORIAL 1 - MECHATRONIC SYSTEMS AND PRODUCTS

1. Understand the applications of a range of mechatronic systems and products

Discipline integration: need for systems to be designed in an integrated way rather than as a collection of unrelated yet interconnected constituent parts e.g. constraints in size and cost of components, reduction in cost of computing power, required reduction in process delays, compatibility of connection systems

Mechatronics systems: differentiate between systems that are mechatronics in nature and those that incorporate a number of different disciplines

Industrial and consumer examples of mechatronics systems: applications e.g. industrial robots, computer-based production and manufacture (CNC/CAM) machines, ATMs, transportation systems, 'fly by wire' aircraft, suspension control on road vehicles, brake- and steer-by-wire; auto-exposure, auto-focus cameras, vending machines, domestic appliances

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INTRODUCTION

Mechatronics is a term first used by the Japanese to describe industrial robot systems being developed in the 1970's. The word describes a process of integrating many different engineering technologies in a process that produces the best design concept and product.

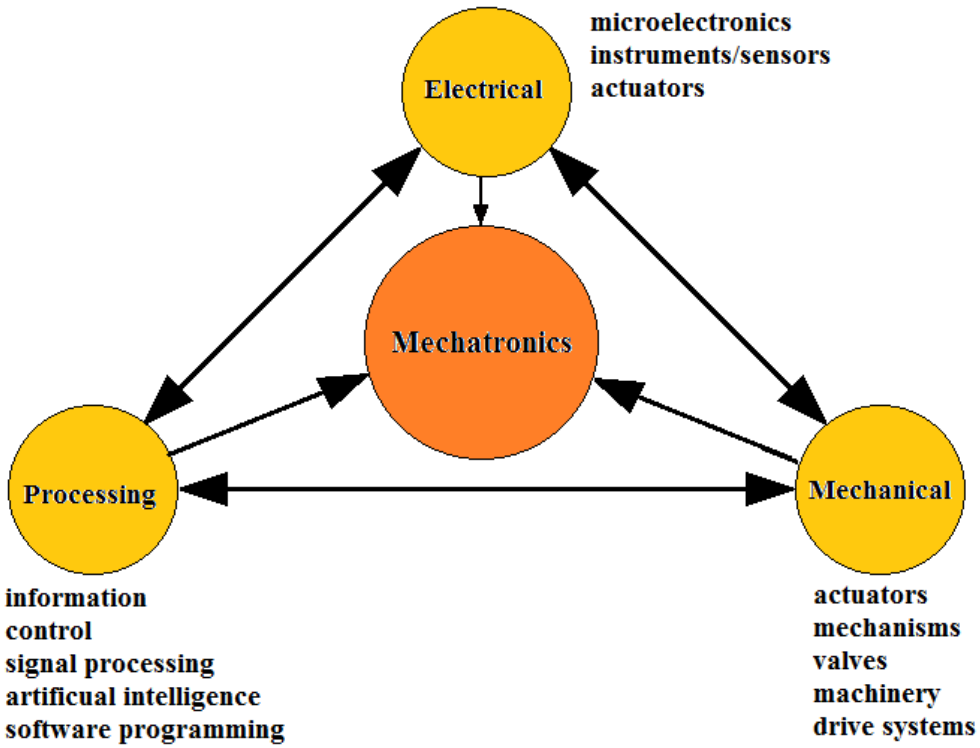
DISCIPLINE INTEGRATION

A word used to describe mechatronic systems is **Synergy.** It means working together so it is the integration of many things to make a system that works better than any of them individually. It's like having a good team.

There are three main engineering technologies to be integrated to work as a team:

- **Mechanical**
- **Electrical**
- **Computing**

The way all this is integrated is shown in the diagram below.



These three technologies have many sub-categories:

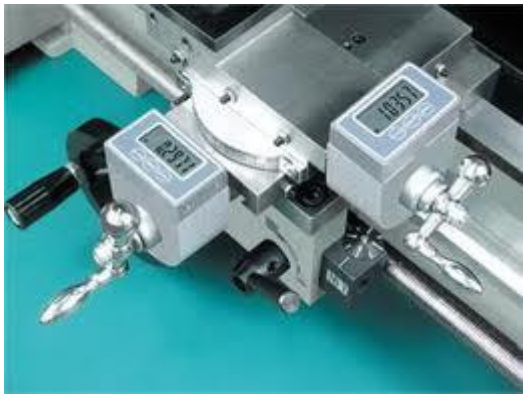
- Thermodynamics
- Fluid mechanics
- Hydraulics
- Pneumatics
- Electronics
- Electrical machinery
- Micro-electronics
- Logic functions
- Programmable logic controllers
- Software programming
- Instrumentation
- Control and so on.

The difference between systems that are mechatronics in nature and those that incorporate a number of different disciplines may be explained by example.

EXAMPLES AND COMPARISONS

CENTRE LATHE

A manual centre lathe is used to manufacture cylindrical shapes in various materials. A basic manual centre lathe is shown below. This machine is mainly mechanical (gears, lead screws, pulleys and so on) with an electric motor to turn the chuck and rotate the workpiece. The cutting tools are moved by turning handles or engaging a drive mechanism. More modern lathes have electronic indicators built in to show the movement of the tool in two directions. None of these systems are integrated and no degree of automation or computer control is used. ***This system is definitely not mechatronics.***



CNC MACHINES and MANUFACTURING CELLS

CNC means **Computer Numerical Control**. It generally refers to cutting machines which are combinations of lathes, millers and grinders (or other more exotic forms of material removal). They machine parts to the required shape and size according to a computer programme produced by Computer Aided Design software (CAD). The work piece and/or cutting tools are moved by electric, hydraulic or pneumatic actuators that can move them in the 3 dimensions (x, y and z). They will also change the cutting tool using a tool magazine and pick and place technology. The tools will have a microchip embedded in them that carries information about their dimensions. The computer checks them for wear and compensates for it and replaces them with a new one when it is excessive. The programme works out the required x, y and z coordinates and control the movement of the cutter or workpiece accordingly.

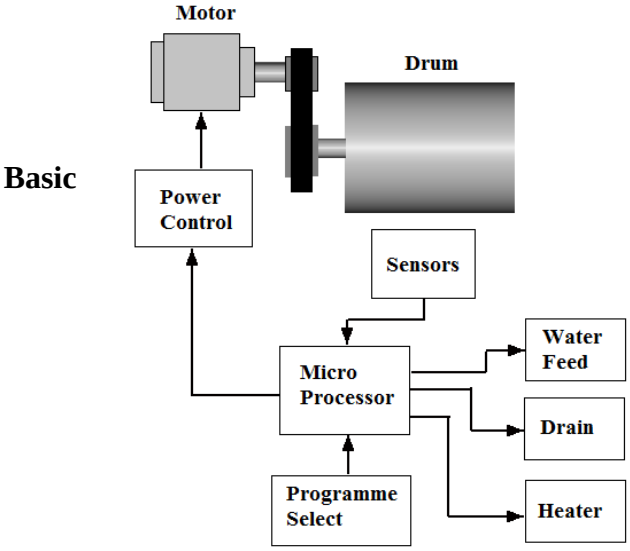
CNC machines have various forms and complexity according to the need. Other forms might be machines for cutting out shapes with lasers or flame cutters. ***These are definitely mechatronic.***

CNC machines are often integrated into even larger ***manufacturing cells*** with robots to load and remove the parts and tools. The cell may contain automated inspection equipment to check the dimensions, surface finish and so on. It may have automatic assembly machines and transportation devices such as conveyors. All together they have every element of mechatronics and quality and cost saving is the outcome.

WASHING MACHINE

Another example is a washing machine. A simple twin tub machine has a drum driven by an electric motor. Water and soap are added to the load and the machine switched on. It might contain an electric heater. Spinning is done in the second tub with manual transfer of the load. ***This is not mechatronic.***

Automatic washing machines have integrated sensors, controllers and a programmer to measure the load, fill with water and adjust the temperature. Various programmes are executed to agitate, wash, rinse and spin dry. In some cases they will even use hot air drying. This is a good example of mechatronics. The system uses solenoid valves to fill and drain the drum. It has level and temperature sensors, weight sensor and speed sensor. Depending on the programme, these are all processed to activate the power control and speed of the motor.



System for an Automatic Washing Machine

CAMCORDER

The camcorder is a good example of a mechatronic system. The software has become an integral part of the product itself, necessary for its function and operation. The micro electronics for the picture sensor, display, recording and processing are all embedded with chips designed specifically for the integrated tasks. Sensors determine the light level and focal length as well as which switches have been touched, battery status and so on. Small actuators adjust the lens. All these features can only be made to work with embedded software to coordinate the data and set the focusing point of the lens and the exposure according to the user's requirements. The software also produces the display and menu.

It is fully justified to say software has become an actual "machine element". Sophisticated products designed in this way are only possible by thinking of mechatronics as a single discipline. In other words it is more like a philosophy with a fundamental way of looking at and doing things. As a result of this, total quality is created in the manufacturing and reliability of the product. The software, computer chips and signal processing elements are embedded in the product.

Other Examples of mechatronic systems

- Industrial robots
- ATMS (cash machines or automatic tellers)
- Transportation systems
- Fly by wire aircraft
- Drones
- Suspension control on road vehicles brake- and steer-by-wire
- Vending machines
- Domestic appliances
- F1 racing car systems
- Vehicle engine management
- Printer/scanners
- 3D printers
- Aircraft simulators and so on.

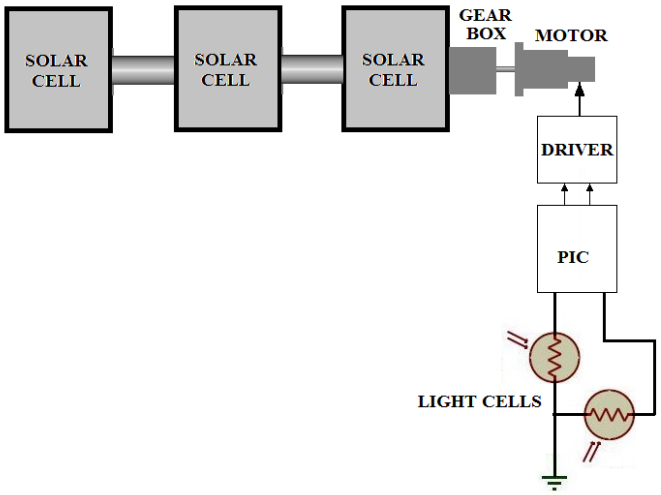
COST IMPLICATIONS

The camcorder example shows how mechatronics leads to a compact design allowing it to be miniaturised and at the same time reducing costs and increasing reliability and performance. This has come about by embedding and integrating the systems enabling better and more reliable machines to be produced in large quantity. The products can themselves be assembled by mechatronic systems with huge savings in labour cost compared to times past. For example cheap pre-programmed processing chips embedded in the product are cheaper than using separate computing systems. Embedded memory chips are cheaper than separate recording systems (e.g. tape and compact discs).

The concept is turned into a design using advanced design tools and simulation software leading to optimised performance and physical layout thus producing cheaper manufacturing.

An example of cost saving is the use of PICs ***(Peripheral Interface Controller).*** This is a computer on a single chip with connections directly to peripheral devices and it can all be embedded in a simple assembly. Prototypes are easy to make and test or modify. On prototypes the chip can be easily reprogrammed either in situ or by removing it and programming it in a programming device.

An example of this is a simple system for making solar cells tracks the sun for optimal results. The light cells provide signals that are processed and put through the drive system to rotate the cells. No external signal processing or computing is needed. The unit unit can be made cheaply with standard components. With everything being connected so simply there is no problem in compatibility of parts or interfacing it all together as this is created by the design and nature of the structure. Protocols needed to be observed in other designs are all built into the PIC.



FURTHER EXAMPLES

AUTOMATED ASSEMBLY CELL

The picture shows an automated assembly cell. Robotic assembly gives flexibility such as being able to switch to various products or dealing with changes to the product by changing the programme. They typically have an integrated vision system that allows more complex tasks such as orientation of the product or inspection of the product. This example of mechatronics has cost saving and product quality built in and is a good example of an integrated system.

AUTOMATED PACKAGING

The picture shows system for presenting cartons in conjunction with an automatic weighing machine. The units basically comprise of a conveyor feeder of empty boxes, a filling point which incorporates an up/down chute mechanism and carton vibrator. The units are designed to automatically feed a carton to the weighing machine for filling. They are flexible in that they can quickly be switched to handle different cartons and weights. The system has integrated electrical and pneumatic systems with sensors and a computer (usually a PLC) to control everything. Again cost saving and reliability are built in by using the mechatronic approach.

PAINT MIXING MACHINE

Machines like that shown pump and mix metered amounts of paints in various quantities and fills cans of various sizes.

The Mechatronic features are:

- Software control with various programmes.
- Instruments and actuators under the control of a selectable software programme
- Self-checking program runs automatically before operation
- The controller will activate an alarm through digital display and buzzer in case of any abnormality
- A digital display to show the actual and set time so that the exact mixing time is obtained.
- Automatic identification of the size of the drum to offer adequate clamping power and rotating speed.
- Automatic clamping and opening settings.
- Speed control to ensure stable operation.
- Automatically stop when the door is opened for safety.