MECHATRONICS - CONCEPT OF PAST CORE COMPETENCE OF FUTURE

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ABSTRACT

The paper discuses the overall aspect of mechatronics in industry from when it was originated in 1969 to its present applications .This term was coined by Yasakawa Electric company which defined it as the ‘ synergistic integration of mechanical engineering, with electronics and intelligent computer control in the design and manufacturing”. It aims to develop a system architecture/framework suitable for embedded distributed computer control systems. There is an urging need of mechatronics in industry to meet the changing demands. Emphasis had been laid on the highly demanding carrier prospects in mechatronics by live surveys. In India like developing country various challenges in adapting the mechtronics widely have also been discussed. Mechatronics is a design philosophy which encourages engineers to concurrently integrate conventional core industries and modern processing-developing industries.

Keywords - mechatronics, control systems, multi-craft

1. CONCEPT

Mechatronics is a word originated in Japan to denote the combination of technologies which go together to produce industrial robots. The definition of mechatronics has evolved since the original definition by the Yasakawa Electric Company. In trademark application documents, Yasakawa defined mechatronics in this way [1,2].

The word, mechatronics, is composed of “mecha” from mechanism and the “tronics” from electronics . The definition of mechatronics continued to evolve . One of the quoted definition of mechatronics was presented by Harashima, Tomizuka, and Fukada in 1996 [3].In their words, mechatronics is defined as the synergistic integration of mechanical engineering, with electronics and intelligent computer control in the design and manufacturing of industrial products and processes.

Essentially, it is a blend of mechanics and the synergistic use of precision engineering, control theory, computer science, and finally sensor and actuator technology all designed to improve products and processes. But mechatronics is more than that. It also concentrates on mechanics, electronics, control and molecular engineering as well as computing, all combining to produce simpler, economical, reliable and versatile systems. Mechatronics can also be described as the totality of fundamentals and techniques in a unified framework for service and production of future-orientated machines and products.

2. EVOLUTION OF MECHATRONICS

The genesis of mechatronics began in 1969 in Japan when Tetsura Mori, a senior engineer for yaskawa Electric Corp., coined the term. Back then, mechatronics was viewed strictly as electromechanical systems or control and automation engineering. Yaskawa applied for a registered trademark for mechatronics in 1970 and won the rights to the term in 1973. Although the foundation was set for the study of mechatronics, it failed to take off to its full potential.

It wasn’t until the mid-1980s that the term began to gain popularity. Yaskawa decided not to renew its trademark and relinquish the rights to the term so as not to limit the industry’s research and advancement of the technology.

During the 1970s, mechatronics focused on servo technology, in which simple implementation aided technologies. In the 1980s, mechatronics was used to focus on information technology whereby microprocessors were imbedded into mechanical systems to improve performance. Finally, in1990s, mechatronics centered on communication technology to connect products into large networks.

3. ASPECTS ADDING WORTH TO MECHATRONICS

The replacement of the conventional approach with mechatronics is derived using the following objectives:

- **Design**

  Design from the mechanical point of view should be exercised keeping in mind the incorporation and selection of mechatronic features and components. Design should have the objectives of adopting a minimum number of components, minimum number of moving parts, and should be compact in size.

- **Data extraction**

  The input data for processing has to be extracted using sensors. Proper sensors should be selected for data such as force, torque, pressure or position.

- **Output generation**

  The development of movements such as translation and rotation has to be accomplished using electric actuators such as solenoids, motors and piezoelectric elements for small outputs and hydraulic or pneumatic actuators when the force and displacement requirement is large.

- **Processing**

  The processing of data has to be done with the aid of microprocessors which can process multiple inputs and outputs received from sensors and transferred to objectives.

- **Automation**

  The purpose of system integration, data integration, functional flexibility and reconfiguration of a programme are accomplished by automation objectives.

- **Display**

  Conventional Analog displays with many moving parts are replaced by monitors and LED digital displays for convenience and improvement.

- **Performance**

  The refinement and accuracy of outputs from mechatronic systems will induct better quality in products manufactured, functions executed and processes carried out with an improvement in performance.

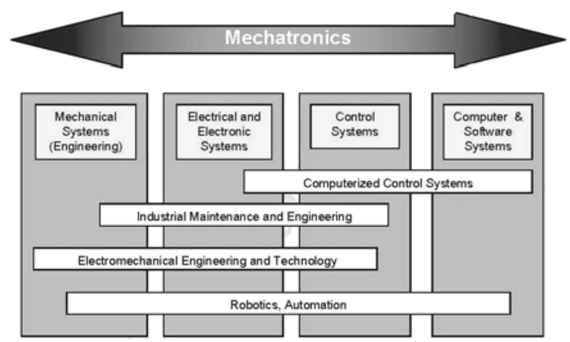
4. RELATIONSHIP OF MECHATRONICS TO EXISTING TECHNICAL FIELDS

Since the 1970s , there has been a dramatic change in the technology of these products, mainly an increasing content of electric and electronic systems integrated with the mechanical parts of the products, mechatronic. Example of products which have already moved to mechatronic technology from simple mechanical products are:-

a. Machine tools incorporating computer numerical control (CNC), electric servo drives, electronic measuring systems, precision mechanical parts, such as ball screws, antifriction guide ways and each others

b. Electronic watches incorporating fine mechanical parts and sophisticated electronic circuits.

c. Electronic consumer products – washing machines, electronic cooking appliances, fax, plain paper copiers and others.



5. MECHATRONICS – SURVIVING TOOL IN FUTURE

Industry is a plant organized to produce product and goods needed by people or industry. to produce parts, machines are needed and to make machines parts are required. Accuracy with which the parts are produced depends on machine capability. With the improvement in the part quality there is improvement in machine capabilities. With the help of mechatronics the products and process quality of competitive interest are produced to meet the demands. The need for mechatronics in industry can be summarized:-

1. **Changing market condition**

Market conditions are so volatile that often products become obsolete very fast because of the changing perception of consumers. Competition is so stringent that the seller’s market is turning into the buyer’s market. to satisfy and attract customers the use of mechatronics in industry(manufacturing) and in products is an inevitability for entrepreneurs.

2. **Variety in product ranges**

Variations in size, shape, feature, facility, performance, aesthetics are governed by customers likes, dislikes and needs. Hence, manufacturers are compelled to produce a variety of product with a wide range. This is made easy by taking advantage of mechatronics.

3. **Short production runs**

Short product cycles, batch production, and job changeovers frequently influence the possibility of short production runs, market demand, and obsoletion of features. Batch production in an industry producing products of diversified specifications is not avoidable. Job changeovers on a machine with a variety of capabilities have the option of short production runs, and have the advantage of efficient machine utilization. The answer is mechatronics adaption.

4. **Good product quality and consistency**

For a better reputation, better export turn over, maintaining product quality and producing the same product quality repeatedly is the achievers philosophy. To reach this goal mechatronics is the answer.

5. **Enahncement in process capabilities**

Process capability is enhanced by decreased deviation in the mean of the desired parameters. This is possible by good repeatability, accuracy and resolution of the production system. The capability of reproducing the same quality with minimum error depends on the least possible capability of a machine that is enhanced by mechatronic features.

6. **Demand for increased flexibility**

Flexible manufacturing systems (FMS), computer numerical control (CNC) machine tools, robots, and automatically guided vehicles (AGVs) are some of the advanced applications of mechatronics that render flexibility in manufacturing.

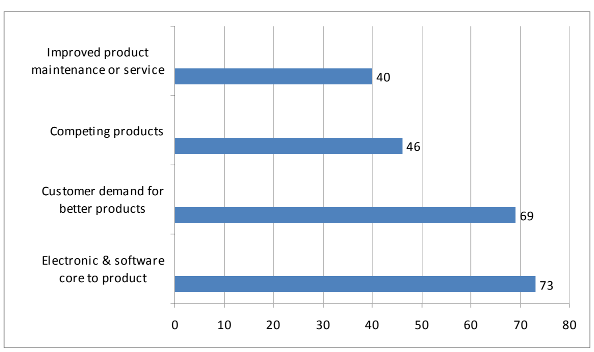


Figure 1: Influencing factors for increasing mechatronics into products [11]

6. CHALLENGES IN MANAGING PRODUCT DATA IN MECHATRONICS

Given the industry scenario, following are some of the challenges [12] faced by manufacturers in the Mechatronics domain:

1. Lack of Integrated Data management

There is no single legacy Product Data Management (PDM) system for capturing mechanical, electrical, and software design data, and are often handled in separate PDMs with no automated sharing of data between the systems.

2. Software Configuration Management

Many different ECAD and MCAD tools are currently used by OEMs and by their supply chains. Keeping different versions of software in sync and maintaining interfaces is not cost effective.

Companies are realizing embedded software is an area of competitive differentiation and are investigating on improving and streamlining their software processes .There are no commercially available systems for keeping the software version synchronized with the mechanical and electrical product data.

3. Difficulty in reducing cost

Since the PLM solutions for mechatronic product development are still in the evolving stage, many of the manufacturers are patching together homegrown systems that are expensive to develop and maintain. Due to the growing number of product variants and increasingly short lifecycles, costs for developing physical prototypes in iterations have become increasingly prohibitive.

Requirement of flexible integration techniques .Interfacing with an incumbent PDM system requires more flexible application interfaces and data standards. Product design with integrated system simulation is yet another challenge.

4. Supplier Management

Due to the increased electronic content, traditionally mechanical companies are sourcing the development of PCBs globally. Managing the supply chain and tying to as-shipped product structure is a growing challenge. IPRs are increasingly moving to suppliers, rather than OEMs, as the product behavior is moving to software. IP security related threats have to be taken care.

5. Compliance Management

Compliance to RoHS and WEEE regulations require tracking of the material specifications right from the design stage. The related processes are still maturing in this area.

As mechatronic systems get more complex, the challenges associated with successfully executing them also become more demanding. A trend that is increasingly evident is that as mechatronics systems get more complex and as functionality demands increase, in many instances software and firmware are replacing or at least supplementing hardware. A benefit of this transition from hardware to the burgeoning emphasis on software is called “Postponement,” that is, the ability to include major functionality features during the final stages of production enabled by embedded software system.

7. PROS OF MECHATRONICS

Mechatronics is at the heart of systems such as cochlear ear implants for the hearing impaired and anti-lock breaks in automobiles. Mechatronics is an enabling manufacturing technology for traditional industries and also a foundational manufacturing technology for micro-to-nano scale manufacturing.

As mechatronic products and processes have become more pervasive. Industry refers to this multidisciplinary as “multi-craft.”

- High levels of integration
- Increased functionality and better design
- More use of software instead of mechanical function
- Assumes responsibility of process and with little interference of operations
- Uses artificial intelligent and intelligent process control
- Multidisciplinary and program environment
- High reliability and safety
- Improved and less expensive

Table 1: Comparison between conventional and mechatronics systems

Conventional Systems	Mechatronics Systems
Centralized processing & control	Hybrid Control: Adaptive and/or Multi-architecture control (e.g., Centralized, Centralized processing & control Decentralized and Distributed)
Inspection/QA stage toward the end of manufacturing processes	In-process automatic inspection
Bulky componentized systems	Compact integrated systems
Lack of accuracy, backlash	Precision displacement control through adaptive control systems and servo motors
Complex mechanical mechanisms	Replacement of many complex mechanical components and/or systems with electronic, computer and/or software systems
Manual controls and data collection	Automated control, data collection and reporting
Constant speed drives	Variable speed drives
Mechanical Systems	Mechanical, Computer, Electronic, Software, and/or Network interface and/or control of physical, chemical, biological and/or neurological systems

8. APPLICATIONS

Today, mechatronic systems are commonly found in homes, offices, schools, shops, and of course, in industrial applications. Common mechatronic systems include:

Table 2: Applications with product categorization

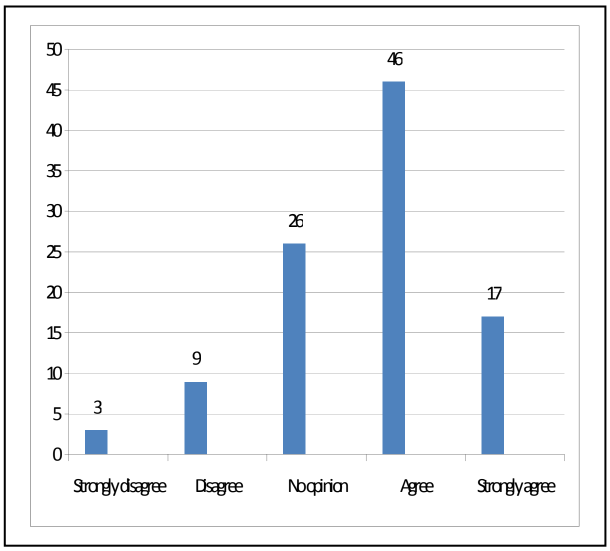
Product Categorizations	Examples
Electronic products	Cameras and audio equipment
Consumer Appliances	Refrigerators and Washing machines
Vehicle systems	Automobiles, Aircraft and Trucks
Communication systems	Satellites, Radar equipment and Telephone switches
Onboard control systems	Aerospace, Marine, Weapons and Space systems
Biomedical instrumentation`	MRI, CT scan, and Airport security systems
Office equipment	Computers, Printers, copiers, Fax machines
Industrial machinery and equipment	Turbines, Printing presses, Weapon systems
Large scale transportation equipment	Large aircrafts, Locomotives, Mass transit systems

9. MECHATRONICS AS CAREER

The job title "mechatronic technician" is not widely recognized; however, some industries that require mechatronics technicians use the term "multi-craft." There is not a mechatronic technician or a multi-craft standard occupational code. Students who graduate from mechatronic programs fill positions with existing occupational titles such as electromechanical technician, process technician and semiconductor technician.

To gather timely information concerning the employment opportunities for mechatronic technicians, Technology Futures, Inc. (TFI) and the Texas State Technical College (TSTC) Emerging Technologies conducted a survey of potential Texas employers. Greater than 60 percent of survey respondents agree that in order to maintain competency, most technicians have had to acquire mechatronic skills through On-the-Job-Training (OJT).

Survey Question: Most Technicians Hired in Recent Years Have Had to Become Mechatronics Technicians, Typically through On-The-Job Training, in Order to Maintain Job competence

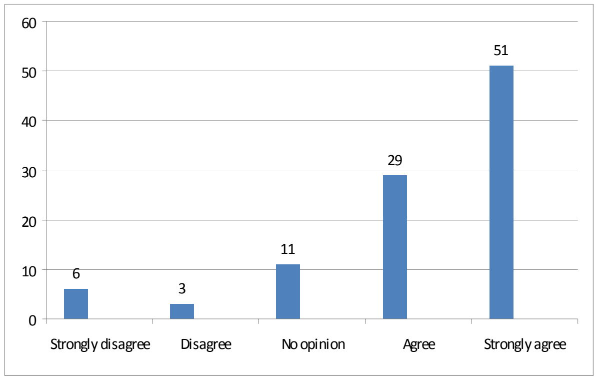


The increasing importance of mechatronic multi-craft KSAs is particularly evident in the way employers view the evolution of related labor markets.

9.1. Demand

Employers see significant value in people with formal mechatronic training. According to 80 percent of survey respondents, mechatronics training can decrease the cost and time needed to train technicians in the required skills and it minimizes the risk of hiring employees who do not have the ability or desire for multidisciplinary training.

Survey Question: Formal Mechatronics Training Can Materially Decrease the Time Necessary to Gain the Skills Required for Successful Mechatronics Employment

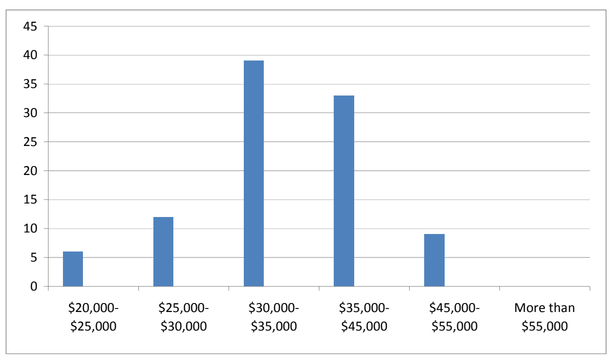


The need for technicians broadly and holistically trained in mechatronics appears to be widespread. Directors of mechatronic programs in California, Kentucky and Minnesota indicate that graduates of their programs and other comparable multidisciplinary programs, such as robotics and advanced manufacturing, have almost all been hired on or even before graduation.

9.2. Estimated Salary Levels

Seventy-three percent of survey respondents indicated that the entry-level starting salary for mechatronics-related technicians would be in the $30,000 to $45,000 range. Sixty-one percent indicated that the salary would be in excess of $45,000 for employees with five years of experience and none reported average salaries less than $30,000. According to the survey data, the average entry-level mechatronic technician salary is $34,230.

Survey Question : Average Mechatronic Technician Entry-Level Starting Salary



10. CONCLUSION

Mechatronics shouldn't change the design process, but rather give the engineer greater knowledge so that concepts can be developed more efficiently; so that communications with other engineering disciplines are improved. Client and market satisfaction are the major goals in the field of mechatronics. Once the needs of a client are expressed, product specifications can be developed from those needs. Then the design process can begin. Engineers will use and do whatever it takes to produce the end result desired in order to come up with new products and processes.

Mechatronics requires an evolution from unskilled to skilled labor in many industry and manufacturing environments. In fact, some argue that the demand for technicians trained and skilled in these new areas of electronic control is in excess of the demand for basic mechanical skills (Coyle, 2006). This trend toward multi-craft represents an opportunity; however, if we fail to act, India risks missing a great economic and technological wave which is transforming the nature of work from unskilled to skilled labor and technology education from what was once considered trade and vocational to highly advanced career and technology education.

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