TRENDS IN THE DEVELOPMENT OF NEW INTELLIGENT MECHATRONIC EQUIPMENTSWITH APPLICATIONS IN AUTOMOTIVE INDUSTRY

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Abstract: *The scientific paper deals with trends in development of intelligent mechatronic equipments with applications in automotive industry. Also, the scientific paper deals with aspects related to the concepts of approach in design of main modules constituting the intelligent mechatronic equipments, being presented a wide range of the achievement intelligent mechatronic equipments.*

Keywords: *mechatronics engineering; measurement system; automotive industry*

1. INTRODUCTION

By definition, Mechatronics is "the synergistic integration of mechanical engineering with electronics and intelligent computer control in the design and manufacture of industrial products and processes' [2]. This concept emphasizes the need for integration and intensive interaction between different branches of engineering. Figure 1 shows the different disciplines that together define the concept of Mechatronics [2].

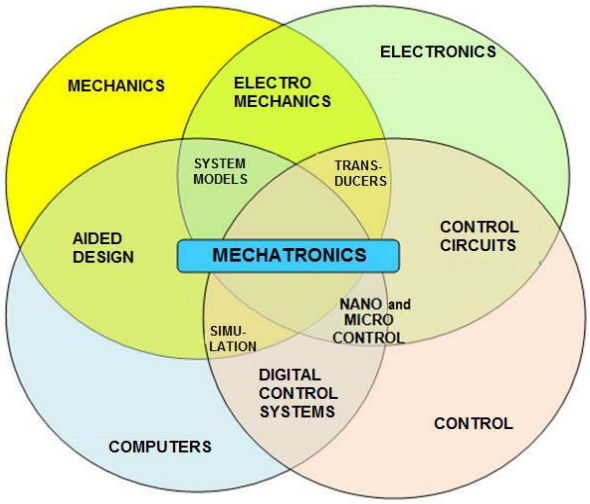

Fig. 1. The concept of Mechatronics

The key factor in the philosophy of mechatronics is the integration of microelectronics and information technology in mechanical systems so as to achieve the best technical solutions.

Mechatronic applications development and integration and expanding of intelligent control technologies in production processes are important factors for optimizing manufacturing and capacity to adapt of technological systems, for a sustainable and strategic European development.

Industries such as the automotive industry uses equipment for manufacturing, assembly and control integrated in production flow to ensure the best possible quality parts at the lowest possible prices.

2. GENERAL TRENDS

The rapid development of mechatronic systems is based on achievement and development of micro and nano-technologies, electronics and informatics. If the starting point was the content and fundament of mechatronics and µnMECHATRONICS in which emphasis was placed on micro-optical-electro-mechanical systems and micro-fabrications techniques, along with micromechanics and tribological testing of materials and components, subsequently rapid evolution of electronics and microelectronics has contributed to increasing the share of computer science in the coordination and control processes, in modernizing, automating and computerizing manufacturing and control technology systems.

INCDMTM give a great importance to developing highly complex research to high performance mechatronic systems with applications in the automotive industry. Growing demands on quality parts and subassemblies in the automotive industry, in terms of quality / price ratio optimally derived from the current economic situation, competition regime and the need to operate in increasingly demanding dynamic regimes, the need to meet protection environmental and traffic safety makes it necessary to develop manufacturing and control systems becoming more efficient and productive. Such equipment must provide, in addition to functional accuracy and reliability, and operator protection, functional safety, integration of manufacturing processes in centralized management systems.

To be internationally competitive, the design and development of mechatronic products must be performed at the same time, to ensure multidisciplinary teams to address all aspects of product realization, on the beneficiary demands, manufacturing technologies and costs.

The concept of "mechatronics" defines not only technology itself but a philosophy and approach in product design (Figure 2).

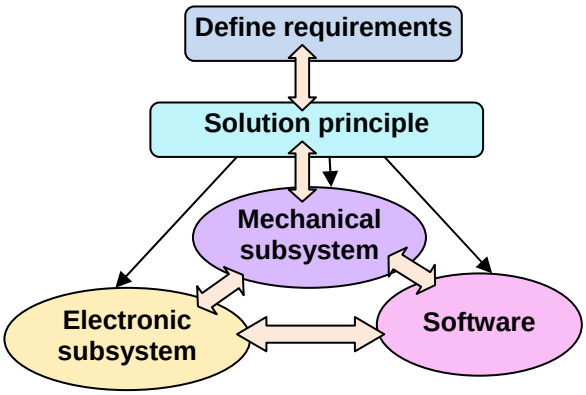

Fig. 2. Mechatronic products design

Design and implementation of mechatronic systems installation and control for production lines in the automotive industry is a complex process that involves several steps (Figure 3).

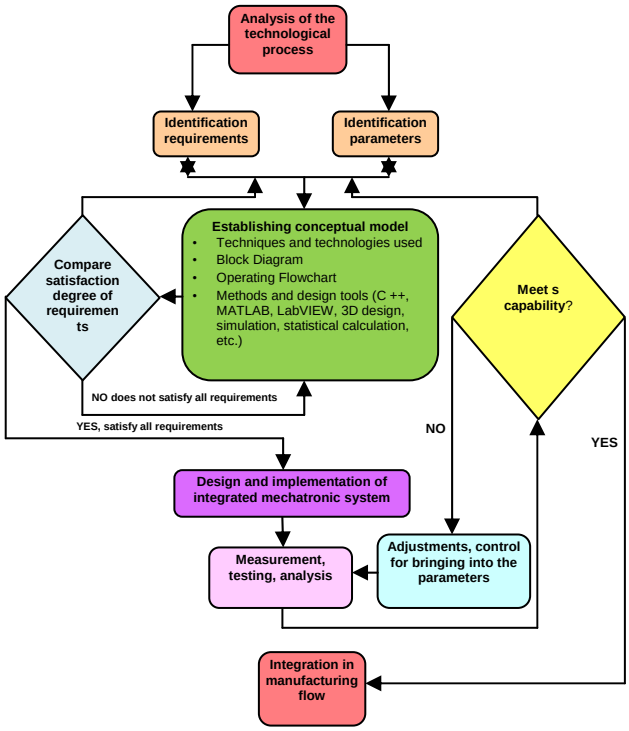

Fig. 3. Process design and execution of mechatronic systems

The main components of mechatronic systems are:

• **Tasks programming subsystem** – generates desired movements and functional sequences in accordance with the requirements or commands.

• **The controller for sequences and movement** - compares the current parameters of movement with required ones and corrections are made.

• **The power amplifier** - amplifies the signal in accordance with the requirements of actuator.

• **Actuator** - converts corrected signal in input signal (time, force, velocity, displacement) according to the process requirements.

• **Mechanisms and mechanical transmissions** – performs parameters adjustment of the actuator to the requirements of the process.

• **Sensors and transducers** - processes the information on process parameters and transmits signals corresponding to motion controller.

• **The signal conditioning device** – filters, amplifiers etc. which processes signals in accordance with the requirements of entry into motion controller.

3. EXAMPLES OF INTELLIGENT MECHATRONIC EQUIPMENTS FOR AUTOMOTIVE INDUSTRY

3.1. Mechatronic Equipments for Checking Engine Operating Parameters

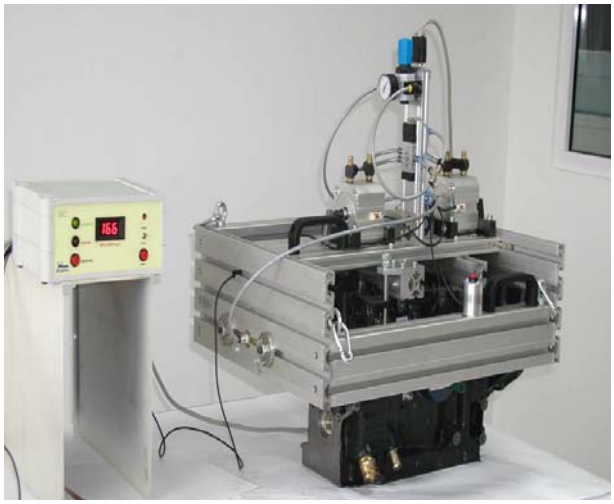

Fig. 4. Equipment for engine control parameters: load torque, axial clearance and presence bearings

Technical features:

- Torque [Nm]-range: 0-20; resolution: 0.1; accuracy: ±1
- Speed [rot./min] - 0 ... 100;
- Resolution: 0.1; accuracy: ± 2 automatically selectable in two-stages;
- Power supply pressure: 4-6 bar;
- Working pressure: 0.1 to 1 bar;
- Minimum pressure interval: 0.02 bar;
- Axial movement: 0 ... 0.500 mm; resolution 0.001 mm;
- Optical LED signaling.

Beneficiary: S.C. DACIA RENAULT S.A.

3.2. Equipments for Dimensional Control of Parts Type Brake Disc; Boss; Drum; Rim; Pipe Rods; Tappets; Balance Wheel; Crankshafts; Camshaft

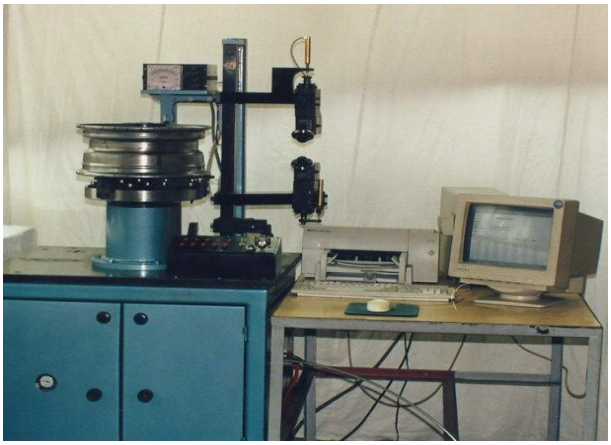

Fig. 5. Installation equipped with computers for measuring radial and axial run out on rim

Technical features:

- Measuring principle: inductive transducers
- Measured parameters: diameter, radial run out, axial run out
- Resolution: 0,001 mm

Beneficiary: S.C. Roți Auto S.A. - Drăgăşani

3.3. Mechatronic equipment for geometric control and marking of drum parts

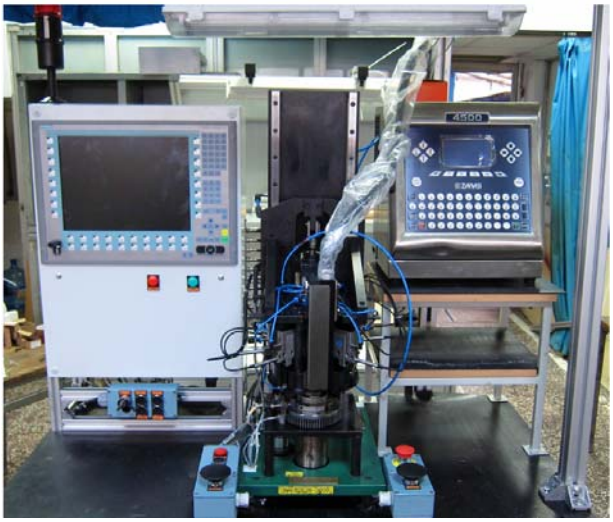

Fig. 6. Mechatronic equipment for geometric control and marking of drum parts

Technical features:

- Measurement accuracy: ± 0.005 mm
- Measurement Resolution: 0.001 mm
- Marking with inkjet (10 characters programmable);
- Power supply: 230V, 50Hz;
- Supply pressure: 4-6 bar;

Beneficiary: Dacia Group Renault

3.4. Mechatronic equipment for geometric control of hub parts

Fig. 7. Mechatronic equipment for geometric control of hub parts

Technical features:

- Measurement in semiautomatic mode
- Display data on display
- Resolution: 1µm
- Uncertainty of measurement: 2µm

Beneficiary: Dacia Group Renault

3.5. Mechatronic control equipment for crankshafts

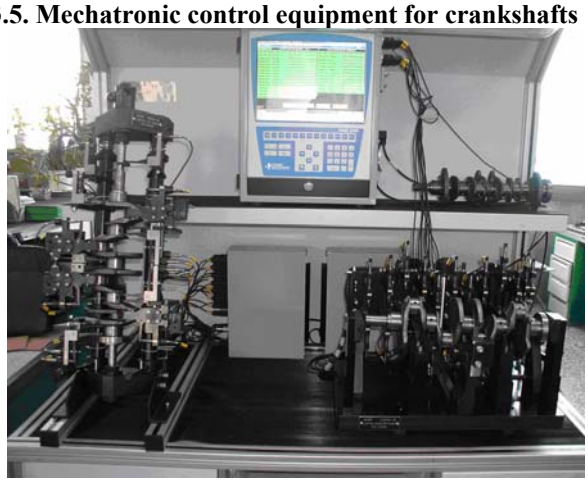

Fig. 8. Mechatronic control equipment for crankshafts

Technical features:

- Measured piece: crankshaft K
- Measured parameters: diameters, lengths
- Type: comparative, A + B gauge blocks
- Elements for measurement: ZDB 103 LVDT displacement transducers
- Resolution: 0.001 mm
- Repeatability: ± 0.001 mm
- Measuring cadence: 8 s / piece
- Display: universal measuring computer CMZ 200 with acquisition, processing and statistical control software
- Operating mode: manual / automatic

Beneficiary: Dacia Group Renault

3.6. Crankshafts control equipment H4x OP.200-210

Fig. 9.Crankshafts control equipment H4x OP.200-210

Technical features:
- Power supply: 220 V AC / 50 Hz
- Pressure Supply: 5 bar;
- Measuring time: max 10 sec. for each piece;
- Display Resolution: 0,001 mm;
- Measurement with inductive, pneumatic transducers;
- Industrial Processor: CMZ 200 ETAMIC
- Plant Interface: SATELLITE ETAMIC;
- Operating system: Windows 2000;

Beneficiary: SC Automobile Dacia Group Renault

3.7. Mechatronic equipment to control the left and right tie rod

Fig. 10. Mechatronic equipment to control the left and right tie rod

Technical features:
- Operating manner: manual and automatic
- Digital Display
- Resolution: 0,001 mm
- Flexible construction that allows measurement of both types of auxiliary connecting rod pipe (right and left)
- Electric and pneumatic actuators
- Decision criteria: validation / invalidation of the piece
- Statistical Calculation

Beneficiary: S.C. Componente Auto – Topoloveni S.A

3.8. Tappets controlling and sorting machine with dynamic mobile

Fig. 11. Tappets controlling and sorting machine with dynamic mobile

Technical features:
- Operating mode: automatic;
- Working cycle time: ~ 2 min / part;
- Measurement accuracy: ± 0.005 mm;
- Repeatability: ± 0.002 mm;
- Supply pressure: 6 bar;
- Work pressure: from 5 to 5.5 bar;
- Supply voltage: 220V50Hz;
- Dynamic mobile with 25 dimensional classes;
- No. of tappets simultaneously selected/controlled: 8;
- No. of transducers used in measurement: 16;
- Measurement with incremental transducers.

Beneficiary: S.C. DACIA RENAULT S.A

3.9. Intelligent Mechatronic Technology and equipment for controlling uniformity of auto gearbox gears by means of forced engagement (double flank)

Fig. 12. Intelligent Mechatronic Technology and equipment for controlling uniformity of auto gearbox gears by means of forced engagement (double flank)

Technical features:
• measuring range: ± 0.03 mm;
• measuring domain: ± 5 mm; accuracy: 0.1 µm;
• resolution: 0.01µm;
• repeatability: ± 0.0025 µm;

Beneficiary: S.C. DACIA RENAULT S.A

3.10. Complex control of the gearbox housing bores

Pictures from the production line

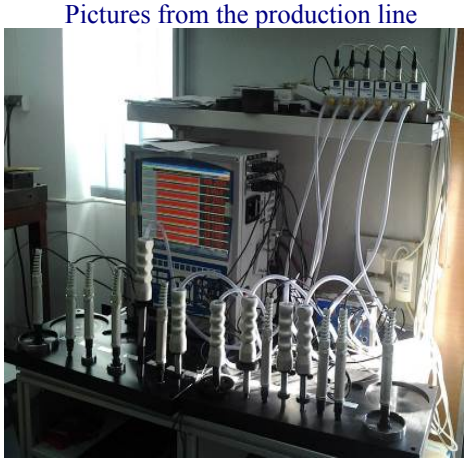

Fig. 13. Complex control of the gearbox housing bores jh3

Technical features:
- Power supply: 220 V ac / 50 Hz;
- Supply Pressure: 5 bar;
- Measuring time: maximum.10 sec / sequence;
- Resolution: 0,001 mm;
- Inductive transducers: for 9 diameters;
- Pneumatic measuring heads: for 6 diameters;
- Pneumo-electronic transducers: TPE99 / 1;
- Industrial Computer: CMZ 200 ETAMIC;
- Computer Interface: SATELIT ETAMIC;
- Operating system: Windows2000;

Beneficiary: S.C. Automobile Dacia Group Renault S.A. Mioveni, Argeş, Romania.

3.11. Mounting equipment on manufacturing flow

Fig. 14. Digital torque wrench for rocker-arms assemblage

Technical features:
- Assemblage couple: 6 Nm ± 15%;
- Counting number of assemblages performed: 1... 4;
- Optical signaling and validation assemblage cycle for engine rocker arms;
- Counting number of engines;
- Power: 220 V, 50 Hz, 30 VA.

Beneficiary: S.C. DACIA RENAULT S.A.

3.12. Tightness control equipments

Fig. 15. Tightness control intelligent mechatronic equipment (in vacuum) for gear carter JH3

Technical features:
• Power supply: 220V AC / 50Hz
• Supply pressure: 6 bar;
• Working pressure: 5 bar;
• Pressure tightness test: -0.5 bar;
• Loss of air permissible: 25 cm^3 / min;
• Accuracy: ± 0.02 cm^3 / s;
• Tightness test: ATEQ F510 cells;
• Automatic: Siemens;
• Operating panel: OP77;
• Operating system: WinCC for OP77
• Working time / tour: ~ 40 sec / piece (according to time-log)
Beneficiary: S.C. Automobile Dacia Group Renault

3.13. Equipment for tightness control of cylinder head and marking

Fig. 16. Equipment for tightness control of cylinder head and marking

Technical features:
- power: 220 V.c.a. / 50 Hz;
- compressed air: min. 6 bar;
- working pressure: 5 bar;
- tightness test pressure: 1 bar;
- permissible leakage loss: 25 cm3 / min
- cycle time: ~ 40 sec / piece.

Beneficiary: S.C. DACIA RENAULT S.A

3.14. Intelligent mechatronic equipment for measuring the tightness of the cylinder carter assembly

Fig. 17. Intelligent mechatronic equipment for measuring the tightness of the cylinder carter assembly

Technical features:
- Power supply: 220 V AC / 50 Hz;
- Supply pressure: min. 6 bar;
- Working pressure: 4.5 bar;
- Tightness test pressure: 1 bar;
- Allowable air leakage:
  -12 cm^3 / min low-pressure circuit;
  -25 cm^3 / min in the high-pressure circuit;
- Working time / tour: ~ 83 sec / piece.
- Leak Test: ATEQ F570 cell with 2 circuits;
- Automatic: Siemens;
- Operating panel: OP77;
- Operating system: WinCC for OP77;

Beneficiary: SC Automobile Dacia Group Renault SA

3.15. Intelligent mechatronic technology and equipment for oil carter tightness control

Fig. 18. Intelligent mechatronic technology and equipment for oil carter tightness control

Technical features:
- Power: Electricity 220 V AC /50 Hz; Pressur air 6 bar;
- Working pressure (set to machine controller): 5 bar;
- Pressure Control:
  + 0.98 bar – for low /high pressure circuit;
- Highest loss allowed: 25 cm^3 / min;
- Cycle time: 60 sec.

Beneficiary: S.C. DACIA RENAULT S.A

3.16. Intelligent mechatronic technology and equipment of tightness control for assembled cylinder head of F8Q engine

Fig. 19. Intelligent mechatronic technology and equipment of tightness control for assembled cylinder head of F8Q engine

Technical features:
- Supply voltage: 220V / 50 Hz;
- Air Supply pressure: 6 bar;
- Working pressure 5 bar; (adjusted on the controller):
- Leakage control pressure: 1 bar;
- Loss tightness admitted: 25 cm^3 / min;
- Cycle time: 30 sec.

Beneficiary: S.C. DACIA RENAULT S.A

3.17. Equipments for functional parameters control of oil pumps

Fig. 20. Mechatronic equipment for NISAN lubricating pump control

Technical features:
- Controlled piece: lubricant pump built into the crankcase
- Control parameters: the flow rate and pressure in relation to the speed of rotation of the sprockets
- Oil flow range 2 ... 100 l / min
- Maximum oil pressure: 7 bar
- Speed range: 450 ... 4500 rev / min
- Oil -Temperature 50 ° C ± 2 ° C
- Air pressure range: 0 - 0.1 Bar
- Operating mode: manual / automatic

Beneficiary: S.C. DACIA RENAULT S.A

4. THE CHALLENGE OF MECHATRONIC SYSTEMS DESIGN AND EXECUTION

Developing mechatronics and mechatronic products and technologies is a logical and practical step in the evolution of science and technology, while the electronics has become a component that cannot be separated from mechanical systems.

The evolution from the mechanical systems to mechatronic system is shown in fig. 4.

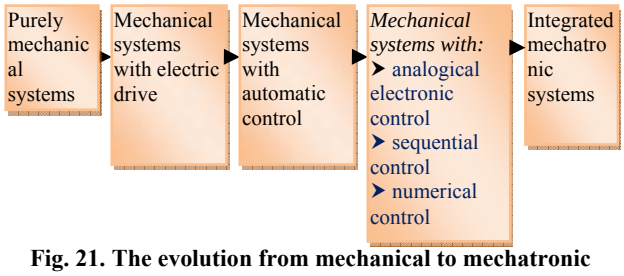

Fig. 21. The evolution from mechanical to mechatronic systems

Keywords for mechatronics concept are:
- ➢ Integration
  - architectural integration (provided by design);
  - functional integration (ensured by the software);
- ➢ Intelligence (relating to command and control functions and characterized by an adaptive behavior);
- ➢ Flexibility (the ease with which the system can be adapted, or one can adapt to new conditions).

One of the most important decisions in the initial phase of designing a device with automatic cycle of operation is the selection of the control system.

For measurement and control equipments automation two technologies are used:
- Automation systems based on programmable logic controllers (PLC)
- Computer-based automation systems.

Following the standardization of programming modes and communication protocols in the last two decades there has been a trend towards replacing automation systems based on PLC with computer-based automation systems. However, PLCs still play an important role with programmed logic equipment market due to the following advantages:
- Are guaranteed for use in adverse industrial conditions: voltage variations and temperature, noxae, vibrations;
- Programming is simple and consists of writing directly to a terminal of a series of instructions, according to some signal diagrams, cyclograms, organization or a set of logical equations
- Modular construction.

With all these advantages, however PLCs have limited functionality. The central unit is specifically designed to interpret a narrow set of instructions characteristic to process control. They express basic functions as: evaluating expressions, logical sequence or timing counting, simple mathematical calculations etc.

Due to competition between the two technologies, PLC and PC, they are in constant evolution. To meet the demands and requirements of the industrial environment modern industrial computers developed, type all in one box, enabling the use of resources and advantages of a PC to obtain a specific functionality PLC, both hardware and software. In addition, performances of industrial PC allow addressing complex, high performance applications. These computers are integrated solutions consisting of an industrial PC and an operating unit, providing a way of displaying on a display with high brightness and optimal size to ensure good visibility.

Using an industrial computer, despite the considerably higher price than that of a normal PC, is justified because:
- All components of the structure of an industrial PC are available in the market on long-term, have superior strength and durability of the PC;
- Have motherboards with long-term availability
- Contain components with high tolerance to shock and vibration, with extended temperature range, non-stop operation, are protected against hostile environment (humidity, dust, vibration, electromagnetic fields, etc.);
- Enables safe and long lasting data storage.
- Compact design ideal for industrial automation applications where installation space is critical.

The following are some of the units of the acquisition, processing and display of data used by INCDMTM for the construction of the mechatronic equipment with applicability in automotive industry, depending on the parameters of controlled and beneficiaries needs.

- Programmable Display unit ESZ 800

  (HOMMEL-ETAMIC)

Fig. 22. Programmable Display unit ESZ 800

  - No. of sensors: max. 32 (max.8 modules, 4 inputs per module)
  - Compatible inductive sensors: HB, LVDT, 2 mm
  - Transducer inputs: 4

- Simatic S7 - 300 PLC

Fig. 23. Simatic S7 – 300 PLC Module

It has a modular construction adding only those modules strictly necessary to working task:

  - Power Module
  - Display mode
  - Central unit module
  - Memory card
  - I / O digital module
  - Analog modules
  - The adaptation inductive transducers signals module (4 channels)
  - RS 232 serial modules - 2 pieces.
  - The TCP / IP

- Industrial Measuring Computer for acquisition, visualization and statistical processing of dimensional measurements supplied by displacement transducers - Etamic CMZ 200.

Fig. 24. Industrial computer Etamic CMZ 200

It operates in Windows environment and provides parametric software for measurement and statistical control functions.
Features:
• maximum 200 measurement functions with the following data:
  - data acquisition unit with 1 or 4 channels (up to 16 analog sensors)
  - maximum 8 measuring satellites (SDM)
  - digital interface RS485 (up to 62 digital transducers)
  - compatible with Axom, Heidenhain, National Instrument, Sony, Solartron

• Real-time statistical control, trends, histograms
• Count the number of parts, good, scrap
• CPK calculation, CAM etc.
• Development display mode
• Export SESAME, QS-STAT, SUMEQ data;

- SIMATIC 677 Industrial Computer

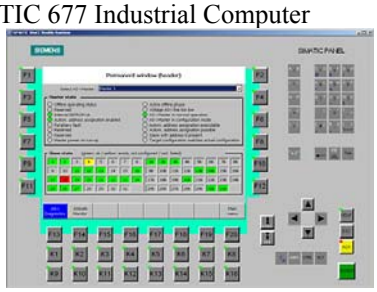

Fig. 25. SIMATIC 677 Panel Industrial Computer

Computer specific to industrial environment with a high degree of protection (IP65) conducted in an open architecture. It operates under Windows and Linux operating systems. Unlike CMZ 200 does not contain pre-loaded software. It is compatible with USB acquisition boards or PCI with National Instrument, Sensorey. It also requires signal inductive sensors conditioning modules, LVDT or HB.
Main features:
- Monitor 15”, 17”, 19” touch type,
- Main memory: 512 Mb / cover. Maximum memory: 4096 Mb
- Processor: Intel Celeron M 440, 1.86GHz, 533MHz FSB, 1MB SLC Drives
- Optical driver: DVD ± R /- RW, HDD: 80GB

- Interfaces:
  - Free slots - 2xPCI, 1 flash card slot
  - Graphical interface: DVI-I
  - Connection for keyboard / mouse: USB - USB
  - Serial interface: COM1: V.24
  - USB: one on the front panel, 4 on the rear, USB 2.0

5. CONCLUSIONS

By developing and enhancing the adaptivity of mechatronic systems and technologies there are achieved the premises for optimizing control and manufacturing processes and products.

Mechatronics, as a multi-disciplinary science offers new possibilities for the design, construction and implementation of innovative products and systems, in a new approach for monitoring and coordinating complex manufacturing processes.

Manufacturing technologies in the automotive industry, characterized by high productivity benchmarks families and their assembly and control in terms of quality / price ratio increasingly larger, require continuous development and optimization of mechatronic systems, integrated manufacturing flow for increasing processing accuracy, increase productivity, ensuring operator safety and equipment safety in exploitation, reducing manufacturing costs.

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