# USING SENSORS FOR SUPPORTING STRUCTURAL ELEMENTS OF MACHINE TOOL IN THE CONTEXT OF INDUSTRY 4.0

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**Rezumat**: *Lucrarea prezintă avantajele implementării Industriei 4.0 în domeniul mașinilor-unelte Industria 4.0 reprezintă a patra revoluție industrială, care are un impact important asupra cercetării, tehnologiilor, proceselor de fabricație și a oamenilor, prin conectarea multor produse la internet. Prezența senzorilor, expansiunea comunicațiilor de tip wireless, dezvoltarea roboților industriali și a mașinilor inteligente, analiza datelor în timp real, au rolul de a regândi cercetarea în domeniul mașinilor-unelte. Industria 4.0 reprezintă transformarea intensivă în informații a producției (și a proceselor conexe) într-un mediu conectat de date, oameni, procese, servicii, sisteme și active industriale bazate pe IoT, cu generarea, utilizarea datelor și a informațiilor ca mod și mijloace de realizare a industriei inteligente și a ecosistemelor de inovare și colaborare industrială.*

**Abstract**: *The paper presents the advantages of implementing Industry 4.0 in the field of machine tools. Industry 4.0 represents the fourth industrial revolution, which has a major impact on research, technologies, manufacturing processes and people by connecting many products to the Internet. The presence of sensors, the expansion of wireless communications, the development of industrial robots and intelligent machines, the analysis of real-time data have the role of rethinking machine tool research. Industry 4.0 is the information-intensive transformation of manufacturing (and related industries) in a connected environment of data, people, processes, services, systems and IoT-enabled industrial assets with the generation, leverage and utilization of actionable data and information as a way and means to realize smart industry, innovation ecosystems and industrial collaboration.*

**Keywords:** Industry 4.0, sensors, machine tool, structural elements.

## 1. Introduction

The term Industry 4.0 was coined to describe a system that evolved from an automated computer-controlled installation (Industry 3.0) to a system that gathers and analyzes data to make smart decisions automatically. In this context,

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Industry 1.0 corresponds to the first step in industrialization, in which steam engines replaced human-powered equipment in production facilities in the eighteenth century. The emergence of mass production in the nineteenth century, with its harsh automation, is called Industry 2.0. The convergence of new technologies with affordable sensors, with the increasing capacity for storing and analyzing large amounts of data, are key elements in using this concept. At the heart of Industry 4.0 is the ability to measure and record parameters, data, from electrical, mechanical, chemical and magnetic phenomena in industrial processes. In this paper we conducted a current case study based on the implementation of Industry 4.0 and sensors for the load-bearing structural elements of machine tools as well as a perspective for their use [1...4].

## 2. Technologies and methods

This section reviews three major advanced manufacturing technologies: Smart Manufacturing, IoT Manufacturing, and Cloud Manufacturing.

Smart Manufacturing presented in (Figure 1) is a broad manufacturing concept in order to optimize production and product transactions, making full use of the most advanced information and manufacturing technologies. It is considered a new manufacturing model based on science and intelligent technology that greatly improves the design, production, management and integration of the entire life cycle of a typical product. The entire product life cycle can be facilitated using various smart sensors, adaptive decision making models, advanced materials, smart devices and data analysis so the production efficiency, product quality and service level will be improved.

An example of IMS is the cyber-physics factory Festo Didactic, which provides technical training and qualification to large suppliers, universities and schools, as part of the German Government's Industry 4.0 Strategic Initiative Platform.


**Fig. 1.** Smart manufacturing.

IoT (Internet of things) presented in (Figure 2a) refers to an advanced principle in which typical production resources are transformed into intelligent manufacturing objects (SMOs) that are able to perceive, interconnect, and interact with each other to make automatic and adaptive synchronization with manufacturing. Therefore, their on-demand use and efficient distribution, resources can be activated by applying IoT technologies in manufacturing. IoT is considered to be a modern manufacturing concept under Industry 4.0 and has adopted recent advances, such as state-of-the-art information technology (IT) infrastructure for data acquisition and sharing, which greatly influences the performance of a manufacturing system. IoT has real-time data collection and distribution between various manufacturing resources, such as machines, workers, materials, and jobs. Real-time data collection and sharing is based on key technologies such as radio frequency identification (RFID) and wireless communication standards. By using RFID technology (Figure 2b), physical manufacturing flows, such as material movements and associated information flows, such as the visibility and traceability of different manufacturing operations can be seamlessly integrated.

RFID tags and readers are sent to typical manufacturing locations, such as assembly lines and warehouses, where smart objects are created by equipping them with RFID devices. This allows any disturbances to be detected and returned to the manufacturing system in real time, thus improving efficiency.

This manufacturing system is used in Loncin Motor Co., Ltd to collect real-time production data from raw materials, workpieces(WIP) and personnel, so that interest in terms of visibility, tracebility and tracking.


**Fig. 2 a** Internet of Things(IoT).

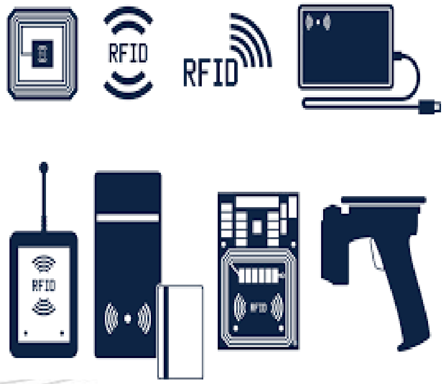


**Fig. 2 b** RFID Readers.

Cloud manufacturing (Figure 3) refers to an advanced manufacturing model under the support of cloud computing, IoT, virtualization and service-oriented technologies, which transforms manufacturing into services that can be comprehensively distributed. It covers the entire extended life cycle of a product, from its design, simulation, manufacturing, testing and maintenance, and is therefore usually considered as a parallel, networked and intelligent manufacturing system ("manufacturing cloud") where production resources and capacities can be managed intelligently.

This can ensure the on-demand use of manufacturing services in the manufacturing cloud for all types of end-users. In cloud production, various resources and production capabilities can be intelligently sensed and connected in the cloud. The Internet of Things such as RFID and barcodes can be used automatically, the latter manage and control resources so that they can be digitized for sharing.

German associations such as the Association of Electrical and Electronic Equipment Manufacturers (ZVEI) have developed an advanced approach; not only created a reference architecture for Industry 4.0 products and services Industry Model Architecture Reference (RAMI), but also described a multi-device administration to allow consistent use of data and resources (Figure 4).

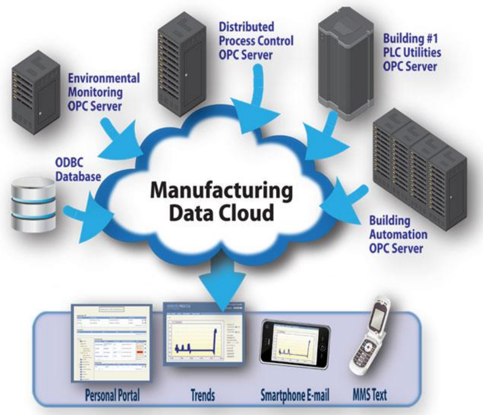


**Fig. 3.** Cloud Manufacturing.

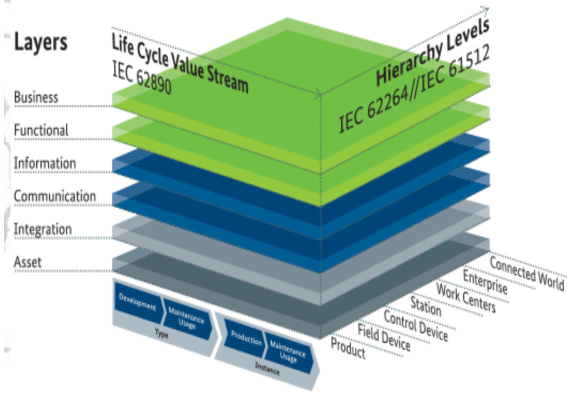


**Fig. 4.** Industry Model Architecture Reference.

IoT refers to an inter-network world in which various objects are embedded with electronic sensors, actuators or other digital devices so that they can be connected to the network and connected for the purpose of data collection and exchange. In general, IoT is able to provide advanced connectivity of objects, physical systems and services, which allows communication and object-to-object data sharing. In various industries, control and automation for lighting, heating, processing, robotic vacuum and remote monitoring are performed by IoT.

Manufacturing companies want manufacturing flows to have a high level of automation and high flexibility. This also includes the close interaction between man and machine. Tomorrow's factories are configured from now on to blur the line of boundaries currently drawn between man and science.

This concept requires the adoption of security solutions that respond with absolute efficiency and a high degree of flexibility, even in unforeseen situations.

It is already possible to adopt industrial safety solutions precisely in the current processes operated by current machines. The intelligent algorithms integrated in this type of product make it possible to switch from digitally activated security technology in favor of a continuous response of the machine based on the position at a given time of the operator. This means that approaching the operator in the vicinity of the machine no longer activates a complete stop but involves reducing the operating speed or changing the direction of movement accordingly. This ensures the safety of the operator without the need to interrupt the production process, increasing the efficiency and availability of machines and production facilities [5...8].

A fully programmable security controller, accompanied by the necessary software, which can be combined with a series of cascade of security sensors makes it possible to protect access for a large number of dangerous points. The new generation of security laser scanners reliably protects dangerous areas or dangerous access points. High-performance safety light curtains can be used as alternatives to conventional solutions with muting sensors, with integrated function (Figure 5).


**Fig. 5 a.** Controller FlexiSoft.


**Fig. 5 b.** FlexiLoop.


**Fig. 5 c.** MicroScan3 Core.


**Fig. 5 d.** C4000 Fusion.

As they move into inclusion in the new Industry 4.0, companies face challenges such as the interconnection of machines and equipment and the integration of these IT systems into all production processes. The purpose of this concept is to acquire an overview for all production and logistics processes on the entire technological flow, from order to actual delivery to the customer. The interconnection of individual protection steps ensures traceability during complex products and logistics. Track-and-trace tracking solutions provide very accurate information about the location of each product and its status. This optimizes production and concerns the global distribution network. Intelligent detection solutions generate data and information that allow complete detection, identification and tracking across the entire chain of interconnected processes (Figure 6)


**Fig. 6 a.** RFU65.


**Fig. 6 b.** Inspector P65x.

Custom-made products, depending on the customer's application, in small quantities, representing one of the advantages offered by the new type of Industry 4.0. To make this a reality, the machine or institution must be flexible enough to allow for variable production and to be able to adapt to various formats. This is the only way to ensure that the goods can be produced individually and in accordance with the specific requirements of the customer. Intelligent detection technologies work in tandem with the new standards of quality and flexibility. These technologies make it possible to collect data in real time. Intelligent algorithms adopt data processing tasks by using intelligent processing functions that can evaluate the data measured directly by the sensor and by using user-relevant data in the form it needs (Figure 7).

**Fig. 7 a.** W4S-3.


**Fig. 7 b.** IMC.


**Fig. 7 c.** KTX Prime.

**Fig. 7 d.** Encoder AFS.


**Fig. 7 e.** Timxx.


**Fig. 7 f.** PAC50.

The possibility of extended diagnosis with high gateway (Figure 8) reads the complete topology such as communication history and possible error messages. The system graphically complements all the information, it can be used very easily through a dedicated web interface, from any mobile device that can run a browser.

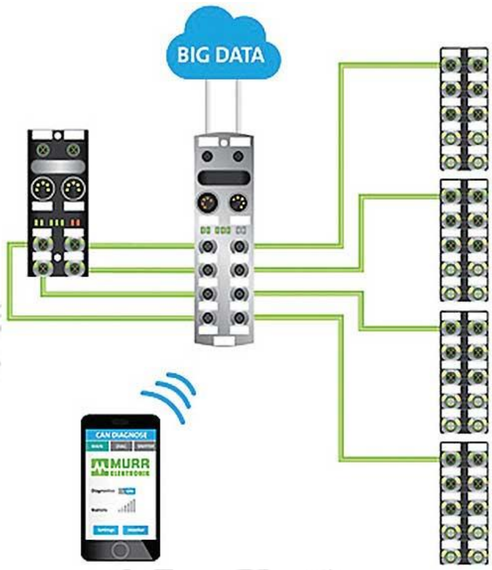


**Fig. 8.** Cube 67 MURR System.

In the future, the implementation of a vibration control monitoring system by placing uniaxial and triaxial accelerometers on the load-bearing elements of the equipment (frame, sledge, tool holder) with the role of increasing operator safety and achieving predictive maintenance of equipment.

The Figures 9 and 10 show two examples of CNC machines models with very high sales requests in recent years, which have a high degree of sensor integration [9...11].

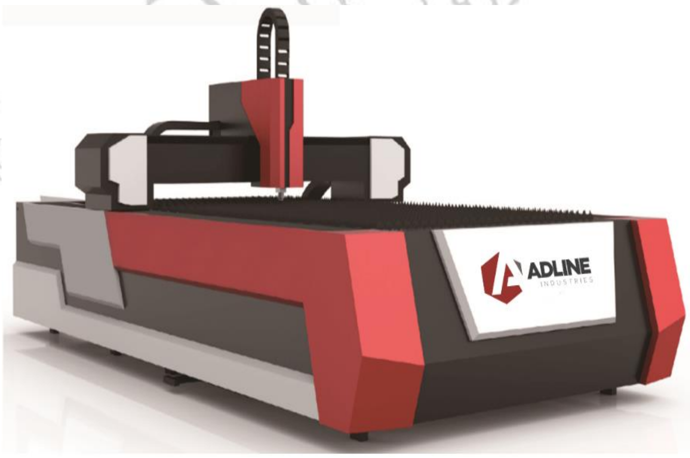


**Fig. 9.** CNC Laser.


**Fig. 10.** CNC Okuma LU35II.

## 3. Conclusions and proposals

Future research perspectives for intelligent manufacturing in Industry 4.0 is considered to be in the following areas: a generic framework for intelligent manufacturing, based on experimental and manufacturing model data, IMS, human-machine collaboration and its application.

Given the deep integration of Industry 4.0, a generic framework for intelligent manufacturing is important, because the production science and technology, sensor technology will be highly integrated in the future. This generic framework will cover large areas that will be used in different enterprises, so that the implementation of smart manufacturing can be guided and standardized. Typical technologies such as advanced sensors, standard wireless communication, models and algorithms for big data processing and applications will be placed in this framework. Thus, a smart hierarchy will be developed as a basis for Industry 4.0.

In conclusion, the purpose of this paper is to implement with the help of current sensors and CNC equipment data and simulations on their interconnection, in safety conditions, low vibrations and easy diagnosis.

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