EVALUATION OF MACHINE TOOL PRODUCTION AND MAKING CORRELATIONS REGARDING GLOBAL TRENDS

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Rezumat: *Societățile se bazează foarte mult pe tehnologie și pe beneficiile pe care aceasta le aduce. Era digitală în care trăim pune mare accent pe crearea de facilități care să le îmbunătățească oamenilor calitatea vieții. Însă nu putem vorbi de aceste facilități fără a lua în calcul sectorul industriei de mașini-unelte fără de care o mare parte din aceste schimbări nu ar fi fost posibile. Importanța tehnicilor și tehnologiilor pe care sectorul mașini-unelte l-a avut asupra progresul tehnologic cunoscut de omenire a stat la baza evoluției și a progresului societăților. Digitalizarea și creșterea economică nu ar fi fost posibilă fără aceste instrumente.*

Abstract: *Companies rely heavily on technology and the benefits it brings. The digital area in which we live considers that the creation of facilities that improve the quality of life is very precios. But we cannot talk about these facilities without taking into account the machine tool sector because without it these changes would not have been possible. The importance of the techniques and technologies that the machine tool sector has had on the technological progress known to mankind has been the basis of the evolution and progress of the companies. Digitalization and economic growth would not have been possible without these tools.*

Keywords: production, machine tools, technology, market, industry

1. Introduction

The emergence and development of machine tools is due to the needs and concerns of people to increase the speed and power of the tools. This need has led to the birth of a new science that includes the methods and means of processing materials in order to achieve a product called "Technology". The term "technology" was formed by combining two ancient Greek terms: techne - art, craft and logos - science. In Romanian, the term was introduced in the first part of

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the 19th century by graduates of technical universities from France, Germany, Austria, returned to the country, such as: Gheorghe Asachi, Gheorghe Lazăr, Petrache Poenaru, Alexe Marin, and others [1].

The machine tool is defined as: "equipment with which the surface of the parts is generated by the cutting process, under certain conditions of productivity, dimensional accuracy and surface quality"[4]. The work machine is a construction that performs partial execution works or produced by movements with different parameters and energy transformations. They can be used independently or in groups of machine tools leading to the creation of technological lines with successive correlated operation through a part of the production process [5].

In the historical documents we do not find a date when we can establish their appearance, but only in the middle of the 16th century are working machines with main kinematic chain and advance kinematic chain close to today's notion. According to historians, the development of machine tools occurred with the development of the textile industry and mining, a development that contributed to the evolution of mankind.

Thus, the paper aims to follow the way this machine tool industry has developed, the role that this sector plays globally and the global trends that it can have.

2. Techniques and technologies underlying the machine tool sector

Technical progress transforms the production of various objects. The step taken in the field of production technology, which was completely different in the past, is also called the industrial revolution. Industrial revolutions representing the radical transformation of the structure of an economy by changing the type of energy used, by using new sets of machines and forms of organization in order to produce goods. Thus we can say that new production technologies have fundamentally changed the working conditions and lifestyle of people.

Technologies have evolved disruptively since their inception until now, and four major industrial revolutions can be defined (referred to in the literature Industry 1.0 to Industry 4.0) [2].

The First Industrial Revolution introduced the use of water and steam to mechanize production, beginning in 1784. The Second Revolution began in 1870, with the use of electricity to achieve mass production. And the Third Industrial Revolution used electronics and information technology to automate production, from 1969 to the present [3].

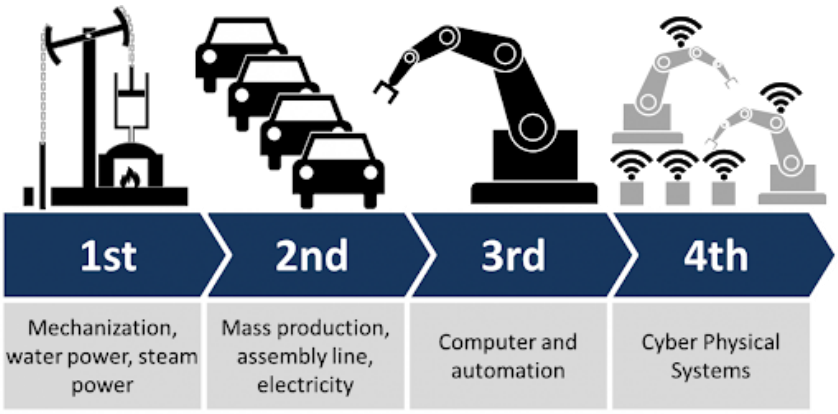

Fig. 1. Industry evolution.

Today we are talking about the Fourth Industrial Revolution, which is practically intertwined with the previous one (Fig. 1). It is represented by the digital revolution, characterized by a fusion of technologies that facilitate the boundaries between the physical, digital and biological worlds [3].

"We are surrounded by artificial intelligence, from autonomous vehicles and drones to virtual assistants and software that translates in real time, makes investments in the stock market and contributes to the discovery of new drugs or algorithms capable of predicting our interests and social behaviors. Digital technologies regularly interact with the biological world, leading to a symbiosis between microorganisms, our bodies, the products we consume and even the buildings in which we live. The Fourth Industrial Revolution has the potential to increase incomes and raise the living standards of people around the globe [3].

New technological developments have revolutionized the world and led to the creation of new products and services that make personal and professional life easier, bringing both efficiency and pleasure. For example, the world can become a more tolerant, interconnected place and a place where good communication can develop through social platforms through interaction, through which people can learn and use to connect and make information transfer [3].

2.1. Technological landmarks in the evolution of machine tools

The first long boring machine was built by Smeaton in 1765. It was perfected by Wilkinson in 1775, and in 1797 Maudsley built the first lathe, the basic structure of which is still valid today [4].

Initially, machine tools were driven from a central unit by belt drive, and later they had their own actuators.

Through their development and innovation, more space was created in the workshops, resulting in a higher productivity [4].

Currently, the pace of development of the machine tool industry raises increasingly complex issues for designers and builders in this field. Thus, they must consider improving productivity, dimensional accuracy, processing quality, operational safety, human operator protection, machine tool cost, in line with current and forward-looking trends in global science and technology progress [5].

2.2. Classification of machine tools

There are many types and types of machine tools, and this makes it difficult to list them and make an updated classification, which will keep pace with the continuous evolution of its science.

In the literature, in order to facilitate the study and analysis of the functional construction of machine tools, the following classification is used:

1. According to the processing used, machine tools are grouped into: turning machines (milling machines), milling machines, drilling machines, grinding machines, planing machines, grinding machines, gear teeth processing machines, grinding machines threading, etc.
2. According to the quality of the processed surface, the following are distinguished: roughing machines, finishing machines.
3. By size, there are: small machine tools, medium machine tools, large machine tools, heavy machine tools.
4. According to the working precision, the machine tools can be grouped into: normal precision machine tools, high precision machine tools.
5. Depending on the type of production for which they are intended, machine tools may be grouped into:
   a. Universal machine tools that can perform various operations used in the production of unique; these are: normal lathes, universal milling machines, universal grinding machines, etc.
   b. Special machine tools for processing parts of the same type but of different sizes; this group includes threading machines, gear machining machines, etc.
   c. Specialized machine tools intended to perform a certain operation on a certain part; This group includes aggregate machine tools and those that make up automatic lines.
6. Depending to the degree of automation, the machine tools are: non-automatic, which require the intervention of the operator, semi-automatic in which the entire processing cycle is performed automatically, and the

supply of semi-finished products is done manually and automatic which automatically performs the function of semi-finished products.

7. After the processing process, the machine tools are divided into several groups, the name of the group coming in most cases from the name of the process. Each group in turn contains several subgroups, in addition the numerical code is presented [5].

The increase in the requirements in terms of precision in the processing process, correlated with that of productivity has led to an evolution both from the point of view of the manufacturer and from the point of view of the user. The technical staff has therefore contributed to the evolution of this industry by developing electronic components and applying industrial informatics.

3. The current stage

The machine tool sector accounts for less than a percentage of total employment, regardless of the country in which it is located, but many innovative downstream industries, which have a high added value, use machine tools, ranging from medical equipment to ship and air construction.

Machine tools are often referred to as "mother machines" because of their impact on any other manufacturing process. This name highlights the significance of the machine tool industry on the world economy.

It is possible that part of the reason why the machine tool industry does not receive the attention it deserves is due to the public's perception. For example, in the United States, as in many other industrialized economies, people very often perceive manufacturing through the prism of the three "D's" - dirty, dangerous, and difficult - that is, dirty, dangerous, and difficult. The same attitude is found in the other part of the world, in Japan, where there are the same conceptions of the machine tool industry.

Despite these misperceptions and lack of public attention, the machine tool industry is a central element of economic and industrial development. For example, in Japan, the famous Ministry of International Trade and Industry (MITI) considered this industry: “as a critical component of its economic renaissance and industrialization processes in the middle and late twentieth century. But Japan is not a singular case in this regard; the same emphasis on the machine tool construction sector was found in South Korea. It is worth noting that the rise of Japan, and now of South Korea, has taken place simultaneously with their remarkable increases in production, gross domestic product and gross per capita income [6].

According to the 2014 Gardner report (Fig. 2), which covers the global machine tool industry, it shows that only twelve countries have a surplus trade in machine tools:

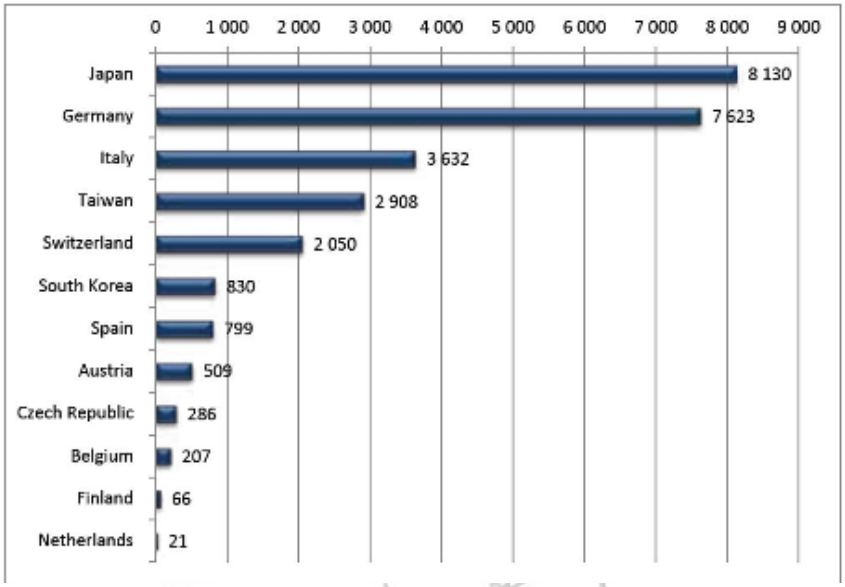

Fig. 2. International Trade in Machine Tools - 2014 report.

The above characteristics indicate the importance of the machine tool industry in the successful economy. It is viable for countries that want to develop economically from an industrial point of view and must be included in priority and support policies. It remains an integral component for cutting-edge manufacturing. [6]

The CECIMO conference on "Advanced production technologies for circular manufacturing" emphasized that new technologies currently being developed contribute to saving resources and contributing to the circular economy. Also here, it is recommended to the political sector, in the future, to support the innovative and state-of-the-art technologies of this industry [7].

The machine tool sector, as explained in the new CECIMO Report on "The European Machine Tool Sector and the Circular Economy", has had to deal with sustainability for some time. Juha MÄKITALO, Chairman of the CECIMO Technical Committee, emphasized that, indeed, “repairs, reconditioning and recycling of products are already a reality in our sector, but the role of machine tools in relation to manufacturing technologies as facilitators of the circular economy is as important as these factors ”[7].

The above-mentioned conference highlighted the fact that innovative technologies in the machine tool sector have made major contributions to sustainable products, technologies that have helped reduce waste, simplify processes and reduce working time.

In this paper I aim to analyze the history of the global market for the machine tool sector. For this purpose, I will mainly use the data published by CECIMO which cover a large part of the industrial enterprises in Europe and collaborate with associations around the world. According to the most recent press release, in which the association presented the figures obtained in 2018, it is announced that CECIMO holds 35% of the market share in the global production of machine tools of 2018 and focuses on artificial intelligence and skills. The percentage of market share means a turnover for 2018 of 27.5 billion euros, which is 9% higher than in 2017.

According to the report for 2018, the turnover of 27.5 billion euros is related to production. Regarding imports, CECIMO reached a market share of 16 billion euros in 2018.

In the Figure 3, is presented the data on the market share of the main machine tool manufacturers in 2018, classified by country [8].

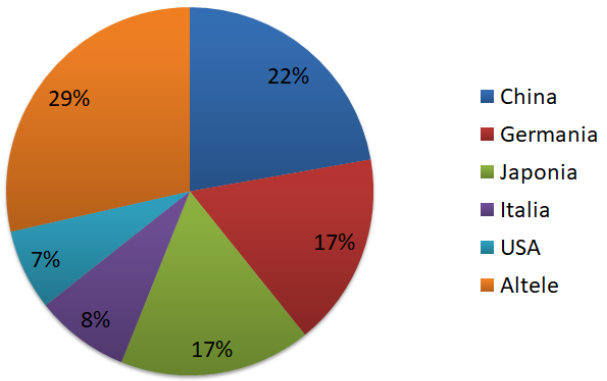

Fig. 3. Machine tool manufacturers market share - 2018 report.

The role of new digital technologies has been highlighted by some of the participating companies who have argued through examples that digitization can also help with remote control machines, meaning a faster solution to problems, reduced downtime and resource savings.

An important conclusion of this event was that research on the use of materials and increased efficiency should be supported to help reduce energy consumption and save resources.

Regarding the leaders of the production of machine tools in 2018 [9], based on the production value (in millions of euros), the official ranking is as follows in the Figure 4.

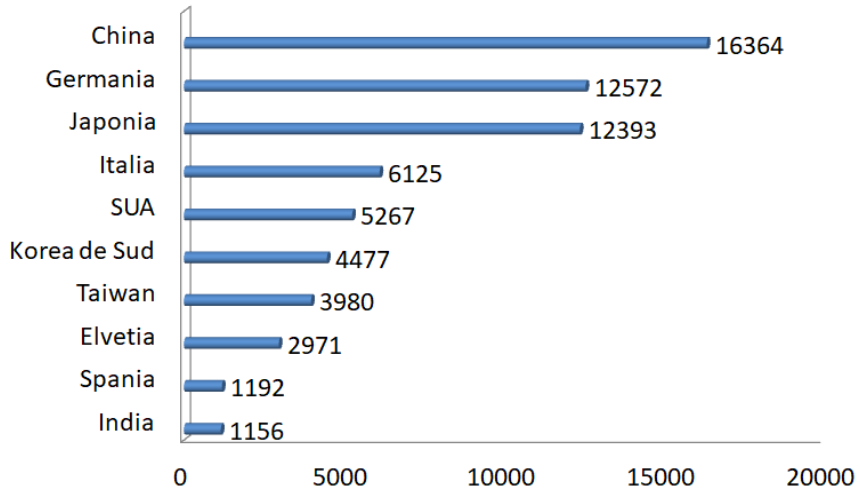

Fig. 4. The value of machine tool manufacturers - 2018 report.

As can be seen, in 2018, China reached the top of the largest machine tool countries in the world. With the production of machine tools worth about 16.4 billion euros, China's market share fell to 22%. China, Germany and Japan were the top three machine tool manufacturers in the world, while the United States (5.3 billion euros) and Italy (about 6.1 billion euros) accounted for seven and eight percent, respectively. from the global production of machine tools.
Among the largest machine tool companies in the world are China's Shenyang, Germany's Trumpf, Germany's DMG Mori Seiki and South Korea's Hyundai. Overall, Asian countries accounted for more than 50 percent of global machine tool production. Asian machine tool countries include China, Japan, South Korea, Taiwan and India [9].

4. Case study

Conventional or CNC machine tools - both for mechanical machining and for sheet metal deformation and machining are the stars of any manufacturing process in industries around the world.

Throughout technological evolution, there have been simple machines, driven by a human operator, machines programmed to behave in a certain way and, finally, machines with sensory properties, with the ability to plan, recognize shapes, navigate, learning, which is called intelligent systems.

Intelligent production systems are able to make decisions based on parameters and what distinguishes them from the previous ones is the ability to get out of the environment of repetitive operations and to connect with the environment. It is said that the only constant is change. It is also said that we live in exponential times, in which we advance in leaps and bounds. We all feel that the world is changing at an accelerated pace, we can even observe the phenomenon on different levels of collective and individual life [10].

We are already surrounded by artificial intelligence, from autonomous vehicles and drones to virtual assistants and software that translates in real time, invests in the stock market and contributes to the discovery of new drugs or algorithms capable of predicting our interests and social behaviors. Digital technologies regularly interact with the biological world, leading to a symbiosis between microorganisms, our bodies, the products we consume and even the buildings in which we live. The Fourth Industrial Revolution has the potential to increase incomes and raise the living standards of people around the globe. Technology has already made possible new products and services that make our personal and professional lives easier, bringing both efficiency and pleasure. Over 30% of the world's population currently uses social media platforms to learn, connect and transfer information. This interaction should create the opportunity for inter- and multicultural cohesion and understanding, transforming the world into a more tolerant, interconnected and less problematic place [10].

At the same time, one of the biggest challenges facing new information technologies is maintaining privacy. Governments will gain new technological means to increase their control over populations, based on ubiquitous monitoring systems and the ability to coordinate digital infrastructure. At the same time, the revolutions that take place in biotechnology and artificial intelligence (AI - Artificial Intelligence) and that redefine what it means to be human, pushing more and more the boundaries of our physical and mental capabilities, will force us to reconsider our moral and ethical limits. So whether all this progress will do us good or bad depends only on us and how mature the human species really is [10].

4.1. The 4th industrial revolution

The phrase "The Fourth Industrial Revolution" was first introduced by Klaus Schwab (Executive Chairman of the World Economic Forum) in 2015 in an article in Foreign Affairs.

The term represents the fourth major industrial era since the initial industrial revolution of the eighteenth century. And it is characterized by a fusion of technologies that blur the lines between the physical, digital and biological spheres [11].

The Fourth Industrial Revolution is a concept with its own technical standards, which everyone should follow, and Industry 4.0 is a strategy to improve technology, created by Europeans to the standards of the Fourth Industrial Revolution. In other words: "The Industry 4.0 Movement is a strategic and intentional approach to shaping the future, while accessing an industrial revolution helps us understand what has already changed and what are the trends in industrial change" [11].

Today, behind the "scene" of global industry, large companies in manufacturing are undergoing a profound digital shift, designed to streamline increasingly complex production processes, through new technological solutions, in order to meet customer needs [12].

4.2. Trends in the machine tool sector that will shape our future

There are many technologies that promise to revolutionize the industrial sector, but the most important directions of this sector are the following:

- *Artificial intelligence for precise metal cutting*

Artificial intelligence-based processing performance will be the future in the machine tool sector, says Jagannath V, Sr. Vice President of Sales, FANUC India.

At the same time, tracking the cutting results of each part entering the engine would be extremely important to assess performance and take corrective action if necessary in the future, Jagannath points out.

According to him, some of the AI technologies that will become predominant would be adaptive intelligent control and intelligent thermal control together with the connectivity of machine tools. [13]

- *CAD/CAM is the future for SMEs*

The machine tool industry is the backbone of industrial development for a country. It directly reflects the health of the manufacturing industry. The machine tool industry strives to develop the best technology to meet the expectations and productivity of users. In the last two decades, almost every machine tool manufacturer has been busy supplying higher or higher speeds. Before that it was

more for accuracy. Certainly these are very important features of any machine tool to produce quality parts as well as higher productivity. However, there are different challenges for SMEs and the mid-range or large industries, notes Nitin Wakode, PSG Associate Vice President, Onward Technologies Ltd.

This segment is expected to have a lower cost of the machine tool, a longer life, a higher speed and a fairly good accuracy.

The medium and large industries that CAD / CAM / DNC have already been implementing in recent decades face different challenges. The major challenges are the greater number of machines for managing and obtaining data in real time, managing suppliers' deliveries, exchanging data for collaborative production or concomitant technique. Many large industries have over 100 machines in their stores. It is a great challenge to maintain real-time scheduling, downtime, productivity, quality, preventive maintenance programs, consumable stocks, workforce scheduling. Here, the challenges do not end with the development of the plan, but the monitoring of each piece of equipment in real time is the biggest challenge towards controllers and Industry 4.0 compatibility [13].

- *Selective Laser Melting*

With a consistent development in the field of processing by laser deposition, through the techniques of the powder nozzle and the powder bed, DMG MORI has combined the most important generative production processes under one roof.

- The construction volume of the LASERTEC 30 SLM is 300 x 300 x 300 mm with a maximum load capacity of 200 kg. Changing the powder takes only two hours.
- The powder nozzle and milling head of the LASERTEC 65 3D hybrid can be replaced at any time, so that areas with complex geometries can be milled, areas that can no longer be accessed later on the finished side.

DMG MORI has already been successfully operating in the field of laser deposition processing with powder nozzle technology for 4 years. With the recent acquisition of a majority stake in REALIZER GmbH in Borchen, DMG MORI has expanded its portfolio to include powder bed technology. [14]

- *The Power of Fibre Laser Tools*

Fiber technology has proven to be a lifesaver for all of humanity since it was invented.

Contrary to existing applications, this technology was invented to improve the communications sector.

Over the course of several years, she experimented with other procedures, such as modeling and cutting metal. After many attempts, an Indian researcher managed to cut the metal using the same fiber technology that was later named as fiber laser technology.

When it comes to meticulously processing metal, fiber laser technology proves to be excellent, with the possibility of pulse control. It offers the possibility to control the power and concentration of laser beams, thus performing tasks for such small processes up to the level of microprocessing.

Metal cutting, marking, engraving, welding, microprocessing are procedures that fiber technology has taken to another level. [13]

- *Industry 4.0: The fourth industrial revolution*

According to Wakode, Industry 4.0 is considered to be the fourth industrial revolution, which we can also call the Internet of Things (IoT).

The idea of achieving everything with a minimum of human intervention was the basis for the development of the concept of Industry 4.0.

Today, the use of IT and networks has led to the evolution of businesses, factories and machines, through real-time data usage systems. Devices are "smart", like smartphones. The equipment uses smart grids that help them to self-analyze and self-detect, which was not possible in the past. The idea is to connect each piece of equipment to a network to transmit its own information and receive information and commands so that it works as required.

Industry 4.0 will offer equipment the opportunity to make decisions based on data / information received via the Internet. They can plan, re-plan to adapt to real conditions and scenarios. [12]

5. Conclusions

Technical progress has undergone an extraordinary evolution over time. We started from completely manual creations and we arrived at a mass production in which human intervention is minimal and the emergence of new jobs.

While Industry 4.0 is constantly evolving, we may not have a complete picture until we look back 30 years.

While many organizations may still be denying how Industry 4.0 could affect their business, other companies are already implementing changes and preparing for a future in which smart cars will improve their business.

According to researchers, "Technology is becoming more and more personal. Computers have gradually moved from desks to standing, into pockets, and will be integrated into our clothes in the future". [10]

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