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Collaborative Robots Innovate Automation in Metal and Car Industry in the World

Edina Karabegović, Isak Karabegović, Ermin Husak

Department of Technology and Robotics,Technical fakulty Bihać, University of Bihać, 77000 Bihać, Bosnia and Herzegovina

Abstract Technological success implies the improvement of technical solutions in the field of automation of the technological process and application of the intelligent system in various branches of industry, together with the metal industry. A large number of robotic applications exist today in the metalworking industry, industrial, first generation robots, however the development of new technologies has led us to collaborative Robots are the advantages of writing in the paper. Their application is motivated by technical and economical reasons such as: improving the quality of finished products (machining, etc.), reducing the falls (in the assembly process), increasing the homogeneity rate - constant quality (in all processes related to robotic application repeatability), increasing the speed security (in aggressive, flammable, explosive and other areas with high robot protection rate), reducing the necessary workforce of a routine and reproducible process, minimizing production costs and overall maintenance, meeting demands that require competition and stricter quality standards. In addition to the technical advantages that due to the use of robots, it is necessary to emphasize that the rationality of the robot application in certain operations is mainly conditioned by the volume of production and the working character that the robot (or more robot) should perform. This work provides an analysis of industrial robot applications in the metal processing and automotive industry around the world, with a detailed analysis of the years and process of production. The analysis was carried out on three continents: Europe, Asia / Australia and America, as well as countries: Japan, Germany, North America (USA, Canada, Mexico), Republic of Korea and China, where the metal and automotive industry was developed. At the end of the paper an example of the use of collaborative robots in the metalworking industry is shown.

Keywords robot, collaborative robot, production process, metalworking, automotive industry

Introduction

Metal industry, that is, the production of metal processing implies the process of metal processing to obtain the final product or semi-product. In the metal industry, industrial robots are used as an integral element of new production lines, which are designed with a high level of automation, with characteristics of flexibility. Applications of robotic systems in the metalworking industry, whether it is a complete automation system or a highly automated production line, is reflected in the following operations: transport of materials or finished elements, machine servicing, processing operations, and product control. The application of industrial robots in the metalworking and automotive industry is very important and important from the standpoint of the flexibility of production processes. In the manufacturing processes of the metal and automotive industries dominated by fixed automation with first-generation industrial robots that are separated from workers by barriers because of their safety. The world is currently located in the fourth industrial revolution, namely, "Industry 4.0" (the German prefecture for the fourth industrial revolution), which is credited with digital technology, information and communication technologies, sensor technology, robotic technology, in one word new innovative technologies that have substantially deflated performance of robotic systems and new solutions are offered for the automation of production processes in the metalworking and automotive industry with the use of collaborative robots or second generation robots working together with workers and not enclosed by fences. By using second generation robots or collaborative robots, the automation of production processes becomes flexible, which is the goal of every company in the metalworking and automotive industry. The companies continuously invest in the development and modernization of production processes with the aim of reducing labor costs, improving product quality, reducing the production time of products with contingency and increasing the output speed of the finished product. Automation of production processes must be flexible and can only be feasible if the diversity of robot use increases, as products on the market are increasingly individualized, meaning multiple versions or variants of finished products available to consumers (for example, different models of vehicles). A growing interest in production processes is low quantities of different types, instead of linetic production systems for mass production (which represent the past), the concept of the production cell system for the production of small quantities of small volume is currently present. In linear production systems, machines and workers are arranged along the transport line to perform only one specific task, industrial robots perform a continuously identical programmed task, and rarely a change in their workflow occurs. However, in the production cell system, the production cell is an independent unit responsible for a part of the tasks, and the robots in the cell system are able to deal with various tasks, depending on the production plan, because they are programmed for several processes and can easily be transferred to another generic process [1-5]. Collaborative robots quickly integrate into the existing production system, take up less space than first-generation industrial robots, are cheaper, easy to program, so they can be applied in small and medium-sized companies, which was not the case so far, so that they will be able Use effectively for automation in the field of metalworking and automotive industry in an area such as welding, cutting, flexible assembly, packing and palatizing, which will result in the increasing use of robots and the increasing spread of the same within the production process.

Benefits of Collaborative Robots in Relation to First-Generation Industrial Robots

The founding advantage of collaborative robots in relation to industrial robots of the first generation is that they do not need to separate them from workers in the production process, but work together with workers without any risk to workers. In the work itself, a person can perform different fields of work, very complex operations and analytical tasks, while a collaborative robot is easy to operate, performs monotonous repetitive operations, can handle dangerous matter, and raise difficulty. In other words people have flexibility, readiness and ability to solve problems, while collaborative robots are durable, have the power of constant, precision and sensitivity. Collaborative robot has high sensitivity because it has built-in advanced sensors such as integral force and torque sensors, as well as visual sensors that provide safe working space and protection zones Figure 1, safe collision detection, safe tool detection, safe force control, etc. A collaborative robot can easily be programmed to use different tasks, giving it greater flexibility. The automated working cycle of a collaborative robot is flexible to easily adapt the robot's performance to individual task execution. Collaborative robots provide worker safety in the workspace that defines the standards "ISO 10218" and "ISO 13849", where fukcionalna sigurnost must be provided, ie must be a zone of safe protection. By monitoring the speed of the robot operation, a zone of secure protection is provided, depending on the distance of the worker from the robot itself, as shown in Figure 1. For the joint work with workers within a commonly defined work space, collaborative robot detects sensors, such a system of double checking (DSC-dual check safety) was developed by the company "FANUC" which is shown in the following figure 1. [15].

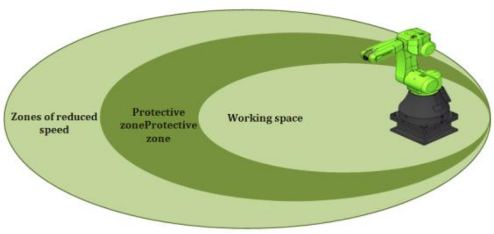


Figure 1: Dual check security system of "FANUC" (DSC)

The DSC system based on the laser sensor monitors additional security, and accordingly controls the robot in the following manner. When a worker is not in these three zones, the robot works at the full design speed of his work. By entering workers in the speed reduction zone, the sensor gives an indication to the PLC that gives the command to reduce the speed of the operation, if the worker continues to move in the entrance to the protection zone, the speed of the operation is continued, and then "Contac stop" is entered if the worker enters In the working proctor the robot switches to the collaborative mode, the reduction of the operating speed is still included "Contac stop". When a worker touches a robot, a receptacle or a work piece, the robot stops performing tasks (stops working) when the worker moves away from the robot it continues to operate at a speed that is dependent on the zone in which the worker is located. Collaborative robots are coated with a soft coating that is sensitive when the contact exceeds the force of 150 N robot stops. Since sensitive sensors are the contact force, we can alter the software (so it can be less than 150N or greater). An example of a robot and worker's contact is given in Figure 2.

Figure 2: Collaborative robot sensitivity that causes the robot to stop [15]

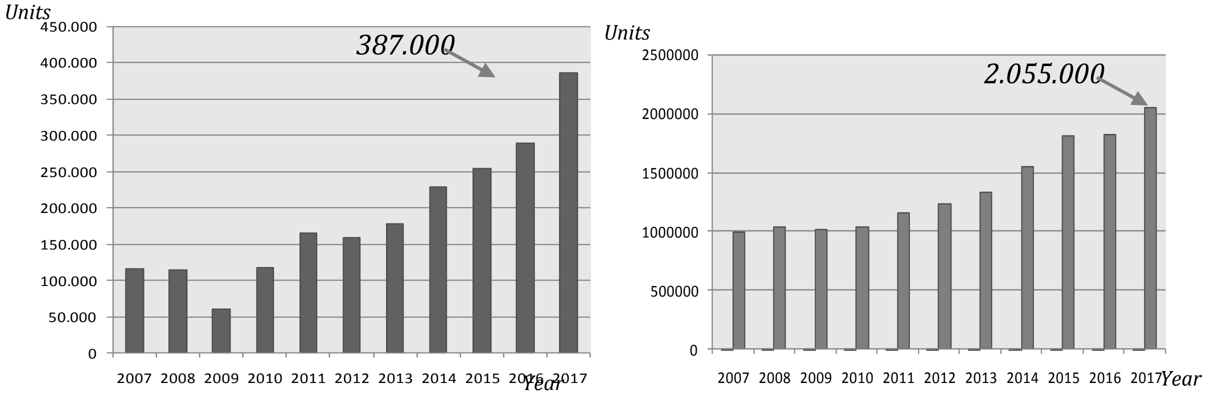
The system has provided an automatic repetition of the robot movement after the robot is stopped, and at that speed depending on the worker's location, in order to avoid stalling. It also provides security when it would happen that the hand of the worker is located between the axes of the robot, so that the workers will not get caught and injured. The benefits of using collaborative robots are enormous to list only some:

- featured simple and fastening tasks for handling,
- significantly improved performance, in the division of operations between workers and robots,
- about the possibility of various levels of automation in the production process so that we can partially automate tasks in those cases where complete automation is too complex or not economical,
- Collaborative robots have the most significant role in Industry 4.0, which connects the virtual reality factory with virtual reality, opening up future perspectives in global production,
- We can significantly improve non-ergonomic workstations with collaborative robots, where we must keep in mind that worker safety is an absolute precondition,
- Increasing product diversity and reducing the product life cycle require flexible automation, which will result in increased use of collaborative robots,

When applying collaborative robots, companies have the following motives: reducing operating costs, reducing capital costs, improving product quality and consistency, improving work quality for workers, respecting health and safety rules, increasing production rates, increasing flexibility in product manufacturing, space saving, etc. . It is expected that in the future the trend of application of collaborative robots will be increasing.

Application of industrial robots in the metalworking and automotive industry in the world

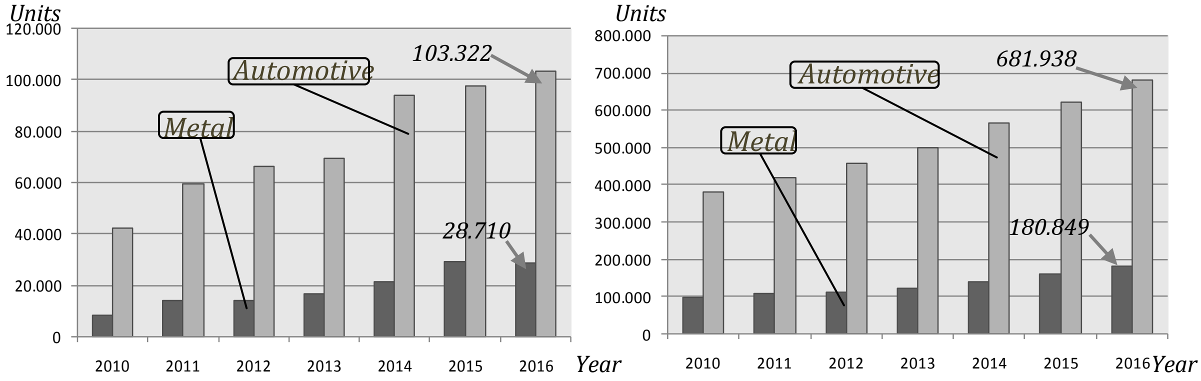
The trends in the application of industrial robots worldwide (on annual and overall levels) are shown in Figure 3. Statistical data are taken over by the International Federation of Robotics (IFR), the UN Economic Commission for Europe (UNECE) and the Organization for Economic Cooperation and Development OECD) [1-3, 6-9].



a-per ye *b-total*

Figure 3: Application of industrial robots in production processes in the world in the period 2007-2017. year [6-9]

Applications of industrial robots in the Period 2005-2017. Year in the world is growing year by year (if we do not take into account the year 2009 in which the global industrial crisis occurred), so in 2016 it reached a value of about 290,000 units, while for 2017 it is envisaged to apply around 387,000 units of robots, and the trend of total industrial robot application in manufacturing processes in the industry is also a rising trend in Figure 3a, so that in 2016 1,826,000 units of robots were applied, while for 2017 it is expected to apply about 2.055. 000 units of robots, and the biggest predictions are applied to the automotive industry [9]. Let's analyze the application of industrial robots worldwide in the metalworking and automotive industry in the world over the past seven years. Statistical data of application are shown in Figure 4.



a-per year *b-total*

Figure 4: Application of industrial robots in the metalworking and automotive industry in the world in the period 2010-2016. year [6-9]

The diagrams in Figure 4 show the trend of application of industrial robots in the metal industry and automotive industry in the world in the period 2010-2016. Based on them, we can conclude that the trend is growing both on an annual and overall level in the metalworking and automotive industry. In the metallurgical industry in 2016, approximately 28,710 robot painters were used in the painting4a. While in the same year in the automotive industry, around 103,322 robot units were used. The automotive industry is the first industry by industrial robots, and in 2016, 35.6% was estimated from the total robots applied this year in the world. Also, the growing trend is the application of industrial robots when it comes to the total application of industrial robots in the two industries, in 2016 a total of about 180,849 units of robots were applied in the metalworking industry, while in the automotive industry, a total of about 681,938 units of robots were suitable, representing about 37 , 3% of the total robots applied in all industries in the world. We can conclude (based on research [9]) that the trend applied to industrial robots in these two industries will increase every year, and the reason for this conclusion is the fact that it is currently in the fourth industrial revolution, with the goal of achieving fully intelligent production processes, that is, a factory that can not be realized without applications of industrial robots. The second reason lies in the fact that the production process is implementing a collaborative robot with scientifically improved performance, with the possibility of various levels of automation in the production process, so that we can partially automate the tasks in cases when complete automation is too complex. We analyze the application of industrial robots in the metal processing industry across continents and in the technologically developed countries in which the metal processing and automotive industry has been developed.

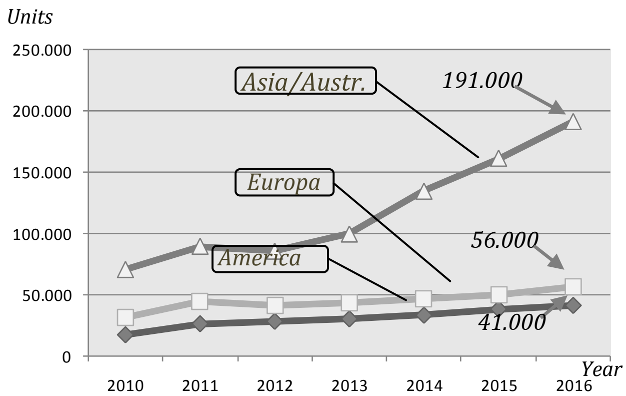


Figure 5: Annual application of industrial robots in America, Europe and Asia / Australia for the period 2010-2016 [6-9]

The trend of application of industrial robots on the continent of Ai / Australia, Europe and America in the period 2010-2016 is rising, with Asia / Australia growing in Europe and America a slight increase in primary industrial robots. In Asia / Australia in 2016, a total of 191,000 units of robots were achieved, followed by about 56,000 robot units in Europe in the same year, and finally in the United States with around 41,000 robot units. We come to the conclusion that the most important is the industrial robot in the automation of production processes in all industries in Asia / Australia, then in Europe in the United States. An analysis was carried out of the application of total industrial robots in the metalworking industry according to the contours of Figure 6.

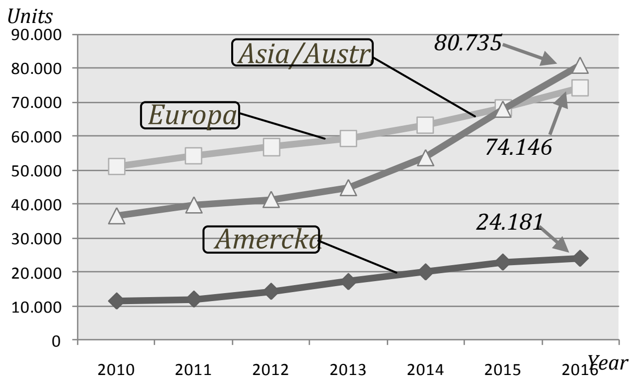


Figure 6: Total use of industrial robots in the metalworking industry in America, Europe and Asia / Australia for the period 2010-2016 [6-9]

The overall trend in the application of industrial robots in the metal processing industry on continents. America, Europe and Asia / Australia is growing, but we have to isolate Asia / Australia where the trend of robot application in this area was until 2013 almost the same as in Europe and America, but afterwards there is a sudden increase in the application where it comes to the first a site in 2016, employing about 80,735 units of robots, followed by Europe with a total of about 74,146 units of robots and the United States closing with 24,181 robot units. The reason for this trend change in Asia / Australia has been the increased use of industrial robots in China that is implementing the national strategy "Made in China 2025" where it wants to become the world's first technologically developed country by 2025. Bearing in mind the fact that industrial robots first began to apply in the automation of production processes in the automotive industry, an analysis of the use of industrial robots in this.

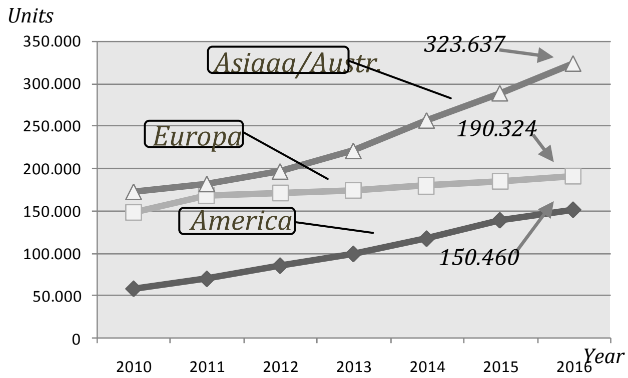


Figure 7: Total application of industrial robots in the automotive industry in America, Europe and Asia / Australia for the period 2010-2016 [6-9]

The trend in the application of industrial robots in the automotive industry on the continents of Aiya / Australia, Europe and America is rising, with Asia / Australia and America there is a more pronounced increase, while in Europe, there is a slight increase in the use of robots. In Asia / Australia in 2016, the application reached the value of about 323,637 units of robots, then about 190,324 units of robots were used in Europe in the same year, and at the end of America, with around 150,460 units of robots applied. We come to the conclusion that most industrial robots are used in the automation of production processes in all industrial branches in Asia / Australia, then Europe and eventually in America. An analysis of the robust application of industrial robots in the countries of Japan, Germany, North America (USA, Canada, Mexico), the Republic of Korea and China in which the metal-processing and automotive industry was developed, as well as shown in Figure 8.

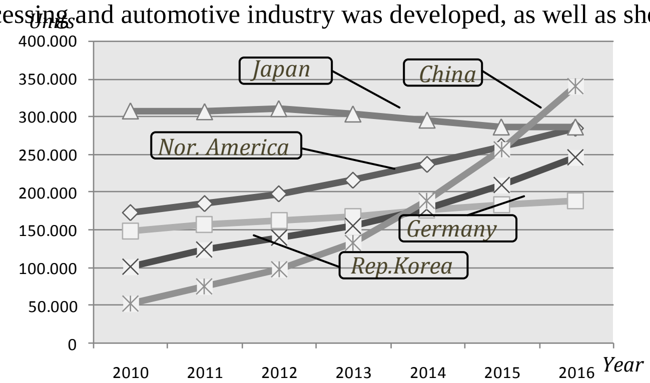


Figure 8: Total use of industrial robots in the countries of Japan, Germany, North America (USA, Canada, Mexico), Republic of Korea and China for the period 2010-2016 [9]

Comparing the use of industrial robots for the period 2010-2016 in the countries of the countries: Japan, Germany, North America (USA, Canada, Mexico), the Republic of Korea and China, we note that the trend is growing in all of these countries except in Japan, the last four years a downward trend. We must keep in mind that China has been the last in terms of the use of industrial robots in 2010 compared to the aforementioned countries; in the last six years, it has an exponential fuction of industrial robots, and in 2016 comes first in terms of application to those countries. The top three countries in the use of industrial robots are China, Japan and the Republic of Korea, which are from Asia, while the first country in the use of industrial robots in Europe is Germany, where the developed metalworking and automotive industry is the last in relation to Japan, North America , Canada, Mexico), the Republic of Korea and China. In order to get a real picture of the use of industrial robots in the metalworking industry in these countries, an analysis of the application for the period 2010-2016 was made, and the same is shown in Figure 9.

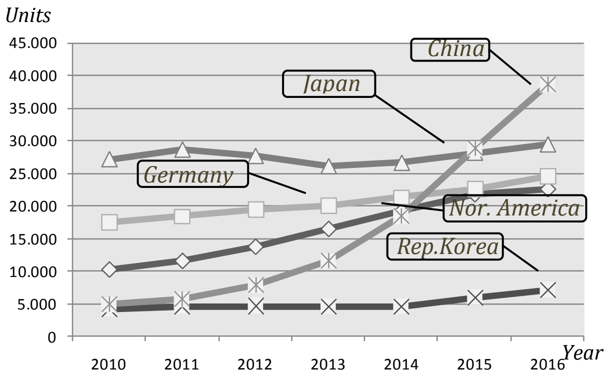


Figure 9: Total application of industrial robots in the metal-processing industry in countries: Japan, Germany, North America (USA, Canada, Mexico), Republic of Korea, China for the period 2010-2016 [9]

Based on the diagram of Figure 9, we can conclude that the trend in the application of industrial robots in the metal-processing industry in countries such as Japan, Germany, North America (USA, Canada, Mexico) and the Republic of Korea are rising slightly, and here we have to distribute this to China in which the use of industrial robots according to the non -ponential function in the metalworking industry and is in the first place, and even six years ago was the last one compared to the other countries mentioned. The reason for this trend (and already mentioned) is the implementation of the "Made in China 2015" strategy, and the second is the continuing application of the fourth industrial revolution of "Industry 4.0" in China, and here we must mention that China is the first country in the world by number applied patents when "Industry 4.0" is concerned. An analysis of the total application of industrial robots in the automotive industry in these countries was made, and the same is illustrated in Figure 10. By analyzing the diagram shown in Figure 10, we conclude that they are in the trends in the application of industrial robots in the automotive industry in Germany, North America (USA, Canada, Mexico), the Republic of Korea and Germany are growing, only in Japan the trend of robot application is declining.

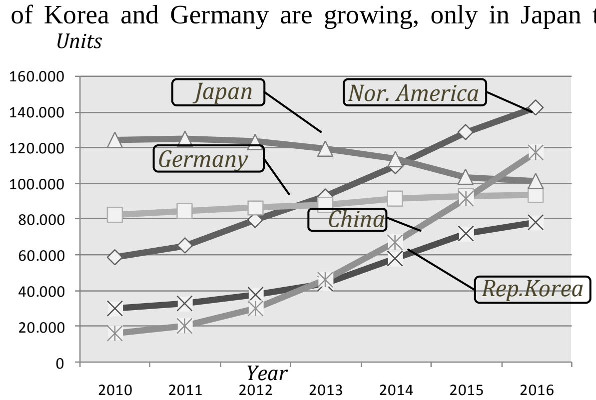


Figure 10: Total application of industrial robots in the automotive industry in countries: Japan, Germany, North America (USA, Canada, Mexico), Republic of Korea, China for the period 2010-2016 [6-9]

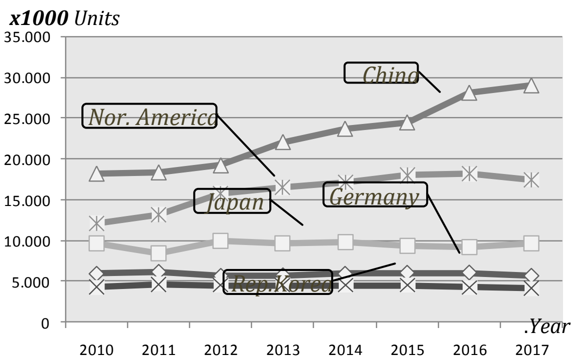


Figure 11: Production of vehicles in countries: Japan, Germany, North America (USA, Canada, Mexico), Republic of Korea, China for the period 2010-2017 [10]

The first applications of industrial robots in the automotive industry since 2014 are North America (USA, Canada and Mexico). Only six years ago, China was in the last place, and in 2016 comes second in the use of industrial robots in the automotive industry. In order to get a more complete picture of the application of industrial robots in the atomic industry, we analyzed the production of vehicles for the period 2010-2016 in the mentioned countries and the same is shown in Figure 11.

The trend in the production of vehicles in these countries for the period 2010-2017, shown in Figure 11, shows that China is in the first place with a growing trend, while in Japan, Germany, North America (USA, Canada, Mexico) and the Republic of Korea , in the last four years, it can be concluded that the production of the vehicle is constant regardless of the trend of application of industrial robots in the automotive industry. Based on this, we can conclude that the companies that manufacture vehicles are modernizing production processes in order to increase the quality, increase the different production models dictated by the market, which requires a flexible automation of production processes. In order to get a real picture of the distribution of robots in these countries, we analyzed the representation of industrial robots in the production processes of the industry, as well as in the automotive industry shown in Figure 12.

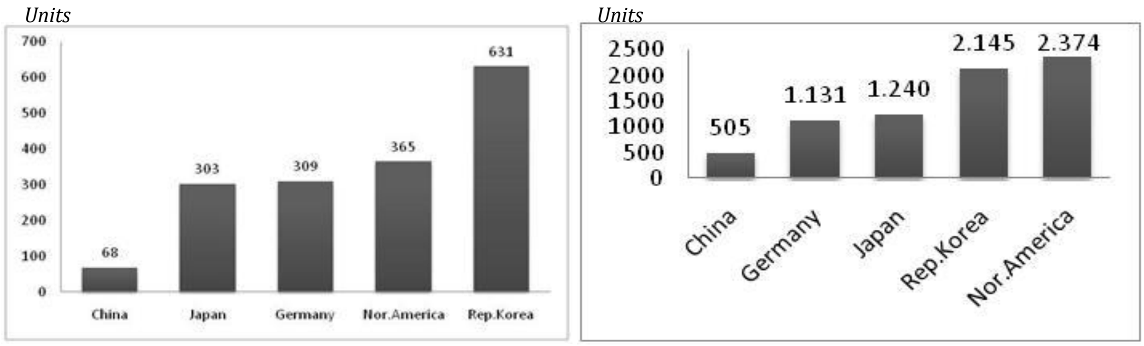


Figure 12: Estimation of the number of industrial robots in the countries of Japan, Germany, North America (USA, Canada, Mexico), Republic of Korea, China in 2016 on 10.000 employees

Comparing the estimation of the number of industrial robots per 10,000 employees in manufacturing industries, Figure 12a), we conclude that the Republic of Korea is the first place with 631 robot units, followed by the following countries: North America (USA, Canada, Mexico) with 365 units, Germany with 309 unit, Japan with 303 units and the last China with 68 robot units. All countries are above the world average, which is 74 units of robots per 10,000 employees in manufacturing industries, only China is below the world average. By analyzing the representation of industrial robots per 10,000 employees in the automotive industry, Figure 12.b), we conclude that North America is the first with 2.374 units of robots, followed by Korea with 2.145 robot units, Japan with 1.240 robots units, Germany with 1.131 robot units and the last China with 505 units of robots. In conclusion, we can conclude that the industrial robot is the smallest in China, and if China annually places the most industrial robots in the world, the majority of world vehicle products, but the production processes are not automated enough, but the production process is mostly represented by workers and performing jobs that can to run a robot. In the first place is the Republic of Korea, where the most automated production processes in all industrial branches, in addition to metalworking, automotive, there is also the electrical industry [6,11-14]. This trend of increasing the use of industrial robots will continue in the future with the increasing possibility of carrying out various operations using collaborative robots in the metalworking and automotive industry. An example of the use of collaborative robots in the metalworking industry for serving machine tools is 13.

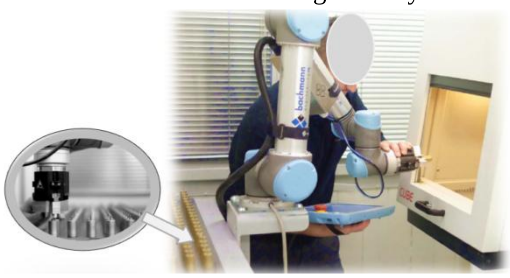


Figure 13: Vaporization of the machine tool by a collaborative robot [6]

The collabative robot shown in Figure 13 puts threaded sleeves into the machine tool every 13 seconds, the operation of the operation takes out a finished piece and replaces it with others, in this way using collaborative robots we make the automation flexible, we replace workers who perform monotonous, unpleasant, stressful and difficult jobs through three shifts in the production process. Reprogramming the robot shown in Figure 13. It takes 15-30 minutes to perform standard other machine tool servicing operations, and can be used for servicing and communication (M2M) of more than two machine tools which reduces the time of product manufacturing, reduces cost of cost, increases the quality and productivity itself, which is the goal of each company. The above example shows that there will be an increase in the use of industrial robots of the second generation, that is, collaborative robots in the future.

Conclusion

The use of robots in the production processes of all industries, especially the metalworking industry and the automotive industry, is increasing every year. The development of new technologies such as information-communication technologies, sensor technologies, robotic technologies leads to the fourth industrial revolution, namely, "Industry 4.0", as well as second generation industrial robots, that is, collaborative robots that work with workers, are simple, easy to program, occupy less space and no need for a fence like the first-generation industrial robots. All these advantages give us the opportunity for greater use of robots in automation in metalworking and automotive industry, and by their application automation of production processes in these industries becomes flexible and gives a series of improvements such as:

- reduction of capital costs,
- Continuous improvement of product quality,
- Improving the quality of work for employees, respecting health and safety rules,
- Increasing production and profitability,
- increase flexibility in the production of products,
- Reduction of material waste and increase of yield,
- save space in production areas, etc.,

which is the goal of every company that must be on the global market today. In the coming period, there will be an increase in the use of second-generation industrial robots - collaborative robots in the metalworking and automotive industries, and their development application will lead us to completely "intelligent" production processes which are the goal of the fourth industrial revolution that is largely implemented by technologically developed countries in to the world.

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Edina Karabegović ,
Qualification: Doctor of Technical Sciences
Professional Academic career: Associate professor at University of Bihać
Competitive research or professional awards received: Author and coauthor of more the 21 scientific papers published in international journals, 86 papers published proceedings in international conferences. Sketch biography (200 words): Edina Karabegović is a associate professor at University of Bihać, Technical Faculty in Department of Mechanical engineering. He received doctoral degree from Faculty of Mechanical Engineering, University of Bihać in 2009, his Master of Science degree from Faculty of Mechanical Engineering, University of Bihać in 2005, and bachelor degree of mechanical engineering from Faculty of Mechanical Engineering, University of Bihać in 2000. He publishes more then 100 papers of different type in international journals, conference proceedings and book chapters.

Full name: Edina Karabegović
Date of Birth: 21.03.1960
Nationality: Bosnian
Department: University of Bihać, Technical faculty
Area of teaching: Technology
Email: edina.karabeg@hotmail.com, Tel : ++38737226273
Bosnia and Herzegovina