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THE ROLE OF INDUSTRIAL ROBOT IN THE PROCESS OF WELDING IN THE AUTOMOTIVE INDUSTRY

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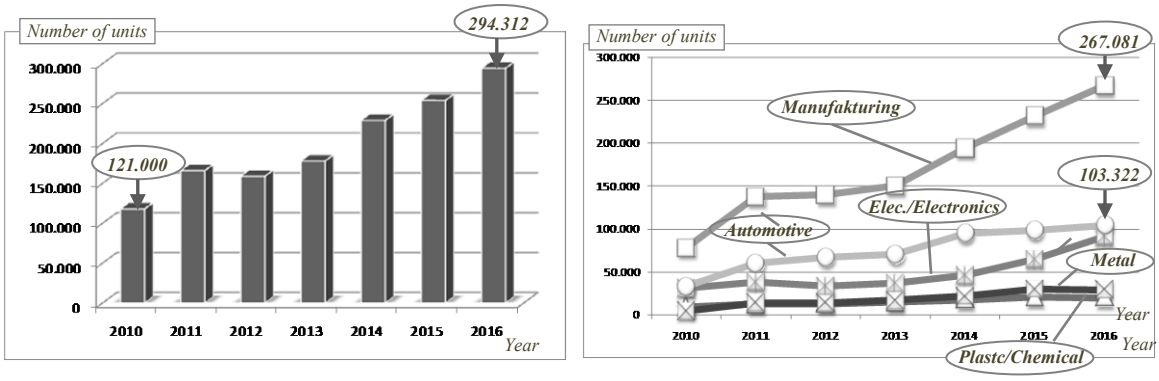
ABSTRACT
Automation in the automotive industry can not be imagined without the use of industrial robots. Today we are in the fourth industrial revolution, which the Germans like to say "Industry 4.0", thanks to digital and communication technologies whose aspirations to fully automate and modernize production processes in all industrial branches. The industry's first branch is the automotive industry, so in the future we come to the "intelligent automation" or "intelligent factories" that will produce vehicles in the future. All this is impossible to do without the complete application of industrial robots, of new generation. The paper analyzes the representation of industrial robots in Europe in all industries, with particular reference to the automotive industry. An analysis of the representation of industrial robots in various welding processes in the automotive industry , and by countries where the automotive industry is developed in Europe is given. The dependence of vehicle production on an annual basis was made from the number of installed robots in automotive manufacturing processes.
Keywords: welding process, arc welding, spot welding, robot, vehicle, intelligent automation.

1. INTRODUCTION
Automation and modernization of production processes in all industrial branches has begun in the 1970s with the introduction of the first industrial robots in the industry. Industrial robots were first introduced in vehicle production processes, which reduced the number of workers who were engaged in monotonous and boring jobs as well as jobs that were harmful to their health.In the automotive industry, these were the jobs of welding of vehicle chassisand vehicle painting, so that the largest number of industrial robots were used in these jobs. The first generation of industrial robots at the time had to have workspace separated by fences during operation, in order to avoid potential injuries of anyone who would enter. The disadvantage of the first generation of industrial robots is that they were rigid, robust, took up a lot of space, rigid when conducting other tasks, and ultimately expensive to implement. The development of digital technology, IC technology and sensor technology leads to the development of robotic technology, which is already slowly applying the second generation of industrial robots. These robots are not separated by fences, they work alongside with workers and occupy smaller space. They are also less expensive, easy for programming, because they can be

reprogrammed by accustomed worker.The development of robotic technology aims for industrial robot to become intelligent, to make independent decisions, to maintain itself and communicate with the environment in which it operates. The development of robotic and other technologies is moving towards the fourth industrial revolution that aims to create intelligent production processes or intelligent factories of the future [1,2,8,9,10].

2. THE REPRESENTATION OF INDUSTRIAL ROBOTS IN WELDING PROCESSES IN THE AUTOMOTIVE INDUSTRY

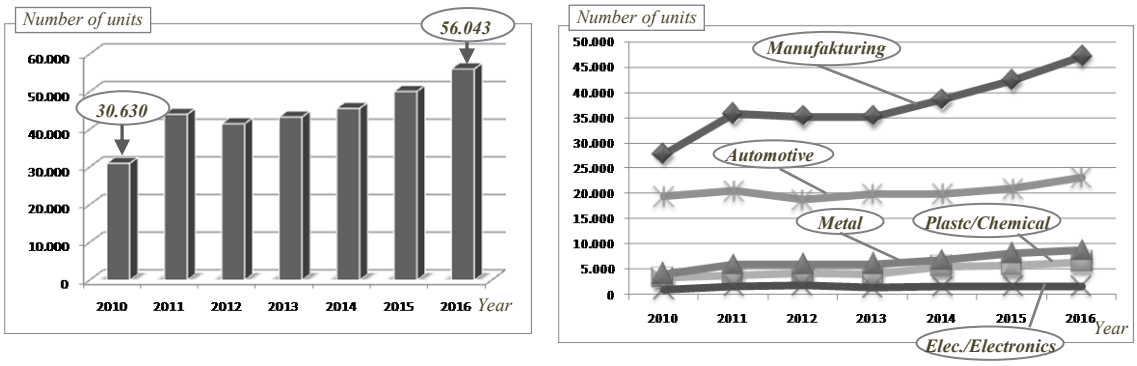
In the analysis of the representation of industrial robots we used data adopted from the International Federation of Robotics (IFR), UN Economic Commission for Europe (UNECE), and Organization for Economic Co-operation and Development (OECD) [3-6], which are shown in Figure 1 and Figure 2.



a –annual application of industrial robots *b – application by industrial branches*

Figure 1 The representation of industrial robots worldwide, as well as application in production: automotive, electric, metal andchemical (plastics)industry in the period 2010-2016 [3-6]

The worldwide representation of industrial robots was increasing annually in the period 2010-2016, so that from around 121.000 robots in 2010, the number of robots increased to around 294.000 robots in 2016. This means that in only seven years the increase was two times higher, as shown in Figure 1.a)[12]. In regard to the application of industrial robots in production processes, the first place is held by automotive industry with around 40%, second place is held by electric/electronic industry, and the third place is occupied by metal industry.The annual representation of industrial robots in Europe was mildly increasing in the period 2010-2016, so that the representation of around 30.630 robot units in 2010 increased to around 56.043 robot units.

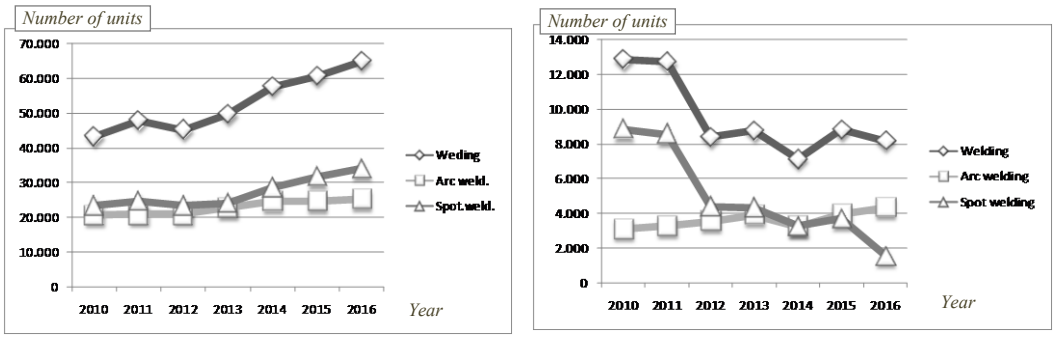


a – annual application *b – application by industrial branches*

Figure 2 Annual representation of industrial robots in Europe, and the application in production: automotive, electric, metal and chemical (plastics) industry in the period 2010-2016[3-6,9,10]

In regard to application of industrial robots in Europe, as well as worldwide, the first place is occupied by production processes in the automotive industry, which amounts to around 50% annually and is far more than other industrial branches. The reason for this kind of application lies in the fact that Europe has successfully developed automotive industry, including companies such as BMW, Audi, Mercedes, Sab, Peugeot, Skoda, Opel, etc., all in involved in vehicle production. The second place in industrial

robot representation is held by metal industry, which is also related to the automotive industry, whereas electronics industry holds the second place in the world. Finally, the third and fourth places are held by plastics/chemical industry and electric/electronic industry, as indicated in Figure 2.b). The representation of industrial robots in welding processes in the world had a growing tendency in the period 2010-2016. In 2016 it reached amount of around 65.000 robots, presenting about 22% of the total representation, as shown in Figure 3.a). Two of the most common processes are spot welding and arc welding. First place is occupied by spot welding, as it is mostly used in the automotive industry, whereas second place is held by arc welding. They both have increasing tendency, as indicated in Figure 3.a).



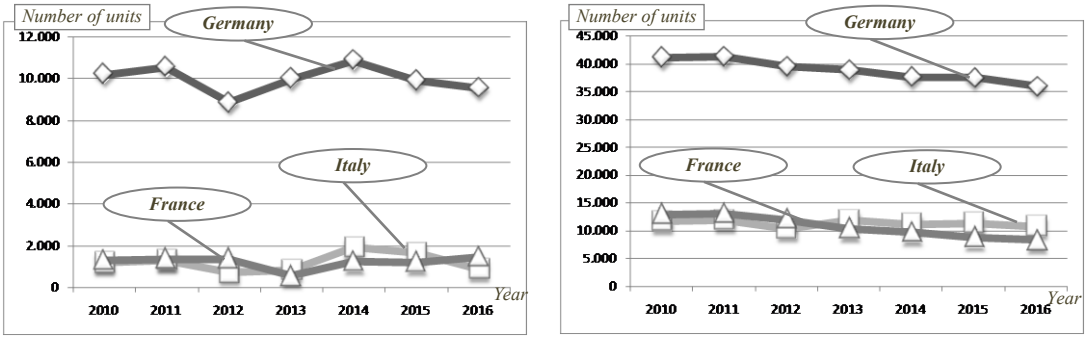
a – application in the world *b – application in Europe*

Figure 3 The representation of industrial robots in the welding processes (arc welding, spot welding) in the world and Europe in the period 2010-2016[3-6]

Europe has somewhat different tendency of representation of industrial robots, Figure 3.b). The representation of industrial robots in the welding process has a decreasing tendency of around 13.000 units in 2010 dropping to 8.000 units, representing about 17.5 % of the total number of applied robots in Europe in the same year. Spot welding process was decreasing, whereas arc welding process demonstrated mild increase in the same period.The justification of such tendency of industrial robot application in Europe lies in the fact that European companies are transferring parts of the automotive industry's production to other continents, which in return display growing tendency of application.

3. VEHICLE PRODUCTION AND REPRESENTATION OF INDUSTRIAL ROBOTS IN GERMANY, ITALY AND FRANCE

In order to analyze the impact of industrial robots on vehicle production in the automotive industry, we have conducted an analysis of representation of industrial robots in the automotive industry and vehicle production in three European countries that have the most developed automotive industry: Germany, Italy and France, as shown in Figure 4.



a – automotive industry *b – total number of robots in welding process*

Figure 4 The representation of industrial robots in the automotive industry and total number of robots in welding process in Germany, Italy and France for the period 2010-2016 [3-6,8,9,10]

Based on Figure 4.a) we can see that Germany is in the first place in Europe in regard to the representation of industrial robots in the automotive industry. In the period 2010-2016, the average representation of industrial robots in the automotive industry was 10.000 robot units on annual level.

If we compare this amount with the total representation of industrial robots in the welding process in all industrial branches in Germany, Figure 4.b), where average representation on annual level in the same period is 40.000 robot units, we can conclude that Germany installs around 25 % of robot units in the automotive industry. The representation of industrial robots in the automotive industry in France and Italy is far less than in Germany, as shown in Figure 4.a). During the period 2010-2016 itwas almost identical, with around 1.800 units, whereas the total representation of industrial robots in the welding processes in both countries on annual basis isaround 12.000 units, which is far less than in Germany.

4. CONCLUSION

It can be concluded that the largest number of industrial robots is applied in the production processes of the automotive industry, which amounts to around 40% on annual level worldwide. In regard to welding processes, this amount is around 22% on annual level, with two dominantwelding processes: firstly, spot welding and secondly arc welding. In the past six years there has been a decrease in the application of robots in Europe in both processes. The reason lies in the fact that many companies have moved their vehicle production processes to non-European countries with cheap labor. Three countries in Europe that are dominant in the application of industrial robots are Germany, France and Italy, which are also dominant in the vehicle production, as shown in Figure 5. Germany holds the first place in Europe in the application of industrial robots in welding processes of the automotive industry, which indicates that Germany is also the first in vehicle production in Europe. In the forthcoming period, the development of sensor technology, IC technology and robotic technology will shift towards the development of the second generation of industrial robots that will operate with workersin common workplaces without fences. This cooperation will take the key role in advancing the vision of "intelligent production", which is first implemented in the automotive industry.

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