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The Role of Industrial Robots in the Development of Automotive Industry in China

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***Abstract*—** The world's largest user of industrial robots in production processes is automotive industry, because global competition in the market requires continuous automation and modernization of production processes in the automotive industry. The use of robots in the world is continuously increasing year by year, so it is expected that about 414.000 robot units will be used in 2019. China is the first country in the world in the application of industrial robots, and is increasing the use every year, so that we can say that the annual trend in the application of robots in China is exponential by function. The leading countries in the application of industrial robots, in addition to China, are: Republic of Korea, Japan, North America (USA) and Germany. The tendency of application of industrial robots in the automotive industry in the world is growing on annual and total level. High application of industrial robots in China has resulted in the development of the automotive industry. The estimate is that in the future China will become the largest user of industrial robots, meaning that China is planning to implement the modernization and automation of production processes in the automotive industry, but also in other industries including electronics industry, metal industry and plastics and rubber industry. The development of new technologies and innovations is leading to the development of robotic technology which has been increasingly used in the automation of production processes. This will, in return, lead to the development and application of "smart automation" or "smart factories" in the future that will, besides vehicles, also produce other high quality products in short time period and with large varieties.

***Keywords*—** automotive industry, vehicles, automation, China, industrial robots, application.

I. INTRODUCTION

We have to admit that today not a single production process is conceivable without automation and modernization, i.e. application of industrial robots, because without them there is no automation.

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The reason is very clear because we have continuous growth of production in the automotive industry, and in addition very often we have to make changes in regard to the product variety. As an example we can mention automotive industry (various models of vehicles, e.g. Toyota Corolla I, II, III ..... XI), as required by the market, with high competition of different companies in the industry. Production of the new models requires such manufacturing process that is flexibly automated so that it can rapidly adapt to the production of new vehicle models. High flexibility of the production process in the automotive industry is essential for reducing the production time of vehicles, since today vehicles have shorter life span and higher varieties. In order to meet these demands, we introduced collaborative robots in the production processes, which have the ability to work side by side with workers. The highest praise in the development and application of a new generation of robots belongs to the constant development of new technologies, especially information technology and sensor technology. The new generations of industrial robots in comparison to former classic industrial robots have lots of advantages such as: industrial robots do not have to be separated from workers by compartments during the production process (nowadays they work together with workers), they are lightweight and flexible so that they can be easily moved, and just as easily and simply reprogrammed to perform new tasks. With these robots automation becomes easier to use, flexible, cheaper and is leading towards "smart automation". So far, automation was too complex and expensive, because the installation of one industrial robot costs about two years' salary of one worker, and the use of collaborative robot about half the annual salary of one worker. In many industries there is a public fear that with the application of robot the workers will lose jobs, which is quite contrary to the opinion of reality. The use of robots and automation is necessary because robots are used for the improvement of quality of work, to take on the dangerous, dirty and boring jobs that man is not able to perform due to hazardous health issues or due to their complexity require flexibility, precision and reliability that man does not possess [1, 2, 3, 4, 12, 13, 14, 15, 16-23]. The development of new technologies, new methods and innovations, as well as progress in the industrial production stemming from those trends, present new challenges for the robotic industry. We expect full cooperation of robots and workers, greater application of industrial robots that will lead to "smart

optimizations" and "smart machines", and in the end to "smart factories" that we can expect to grow in the near future.

II. THE TENDENCY OF APPLICATION OF INDUSTRIAL ROBOTS IN CHINA

Prior to the analysis of the application of industrial robots in China, it is necessary to conduct the analysis of the application of industrial robots in the world on annual basis. Statistical data on the application of robots worldwide were taken from the statistical department of *IFR – International Federation of Robotics*, which provides global statistics for about 40 countries worldwide, which were analized by application areas [1, 9, 10, 11]. The tendency of application of industrial robots in the world annually is shown in Figure 1.

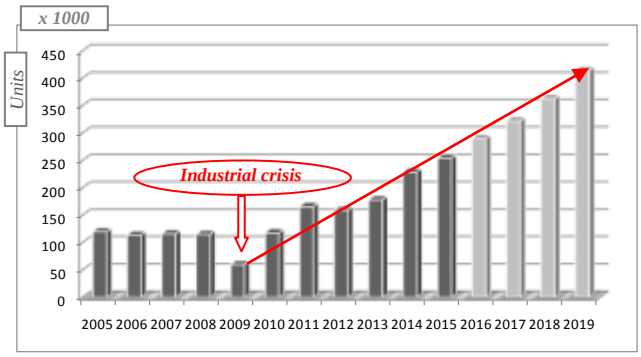

Figure 1. The tendency of application of industrial robots worldwide in the period 2005 – 2015 and the predicted application tendency for the period 2016-2019 [1, 9-11]

By analyzing the tendency of application of industrial robots worldwide for the period 2005-2015 we came to conclusion that in the past five years the trend of application had linear growth, so that in 2015 about 254.000 industrial robot units were applied. In period 2005 – 2015, we must emphasize year 2009 in which the least robot units were applied, around 60.000 units, the reason of which was high economic and industrial crises that occurred in the world. When it comes to estimating the application of industrial robots in the world, we see that a prediction for each year is the increase in applications so that in 2019 the expected application of industrial robot units is approximately 414.000. It is necessary to conduct the analysis of the application of industrial robots in China, because it is interesting for several reasons. One of the reasons is that China has recently become the first country in the world in the application of industrial robots, and the second reason is that China is the world's leading country in the production of vehicles. The tendency of application of industrial robots in China in the period 2005-2015 is shown in Figure 2, as well as predictions from 2016 to 2019. We can conclude that the trend of application of industrial robots is continuously growing, so that it was increased from 14.978 robot units in 2010 to 69.000 robot units in 2015, which is the increase of 4.6 times or 460 %. If we compare the application of industrial robots on the continent of Europe in 2015 [9], where around 50.078 robot units were applied, we come to the conclusion that in the same year China applied around 19.000 industrial robot units more All this speaks in favor of the fact that China wants to catch up with developed countries, in regard to the automation of production processes in question, and in particular the automotive industry. This tendency of application of industrial robots in China was to be expected, since China adopted 10 years national plan "*Made in China 2025*", which aims to make China one of the countries with the best technology industry in few years.

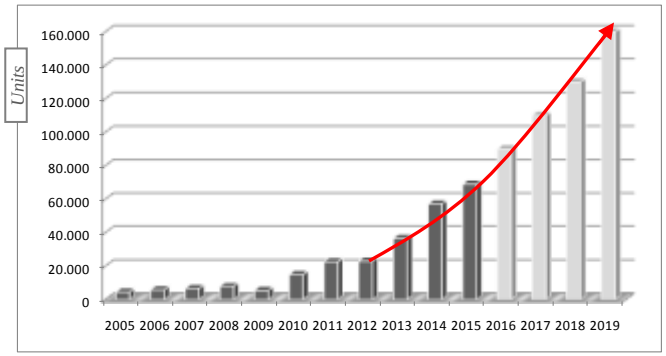

Figure 2. Annual tendency of application of industrial robots in China for the period 2005-2015 and predicted application tendency for the period 2016-2019 [1, 9-11]

In 2015, of the 69.000 robot units installed in the China, around 20.400 robot units were actually produced in China, as reported by the Robot Industry Alliance (CRIA). Also, having in mind the prediction of application of industrial robots in China and the growing tendency, it is estimated that in 2019 they will reach the amount of 160.000 robot units.

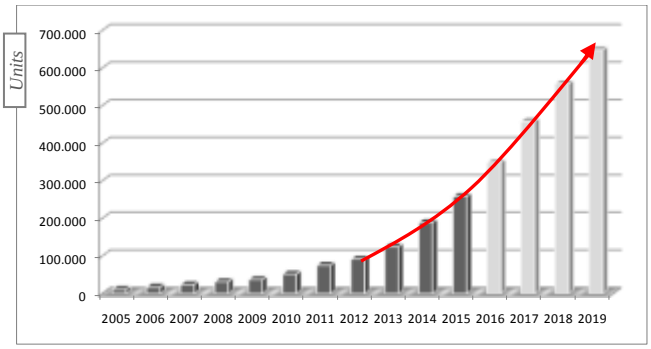

Figure 3. Total tendency of application of industrial robots in China for the period 2005 – 2015 and predicted application tendency for the period 2016-2019 [1, 9]

Figure 3 illustrates the overall trend of application of industrial robots in China and predicted application to 2019. It is expected, according to this prediction, [9] that in 2019 China will install a total of around 600.000 to 650.000 units of industrial robots. This tendency of application of industrial robots in China in the future is quite logical, as global competition in the market requires continuous modernization of production processes. The growing market demands

requires the expansion of production capacities, which can be achieved by developing new generations of industrial robots and their application in production processes. The introduction of a large number of industrial robots in the new generation of manufacturing processes and reduction of "product life cycle" enable us to increase the variety of products and introduce flexible automation. Application of industrial robots in all production processes, as well as in the automotive industry, will increase the production and improve the quality.

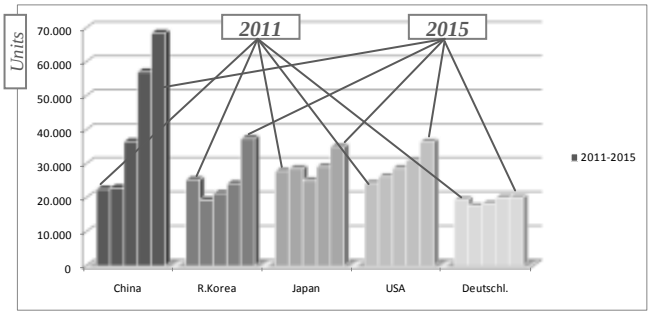

Figure 4. The tendency of application of industrial robots in China, Republic of Korea, Japan, North America (USA) and Germany in the period 2011-2015 [9]

We have conducted the analysis of the application of industrial robots in the following countries: China, Republic of Korea, Japan, North America (USA) and Germany in the period from 2011 to 2015, as shown in Figure 4. As can be seen in Figure 4, in all these five countries the tendency of application of industrial robots is increasing, but China is the first in the world in the application of the robots in the past three years and significantly stands out from other mentioned countries. For example, in comparison to the developed Germany, China applied three times more robot units in 2015.

III. THE TENDENCY OF APPLICATION OF INDUSTRIAL ROBOTS IN THE AUTOMOTIVE INDUSTRY

The largest portion of the installation of industrial robots is ran by the automotive industry. Since 2010 countries which produce vehicles had significant investments in new production capacities, as well as modernization and automation of existing production capacities which resulted in an increase in the application of industrial robots in the world in years to come. Figure 5 illustrates the tendency of application of industrial robots in production processes of the automotive industry.

If we are to observe the tendency of annual application of industrial vehicles, we see that it is growing so that in 2015 we have 98.500 robot units installed, which represents approximately 38.7% of the total installed robots in the world.

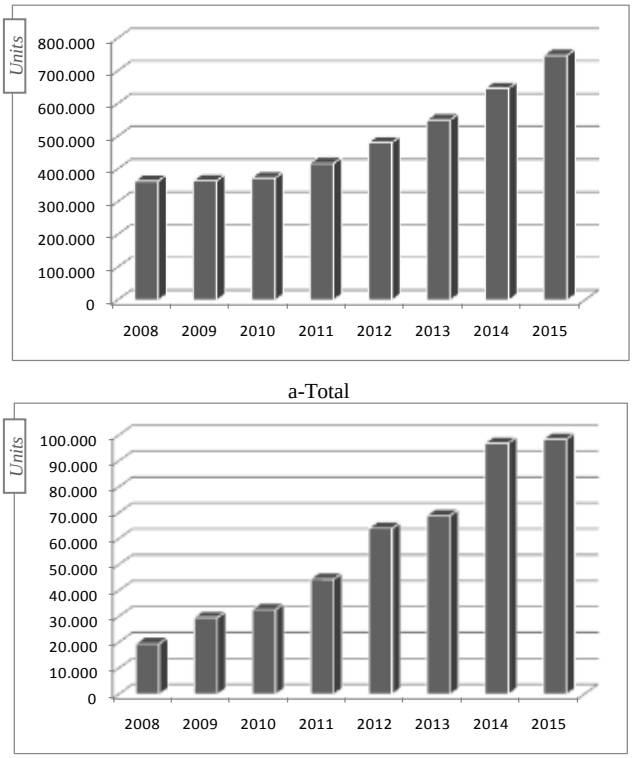

Figure 5. Annual and total tendency in application of industrial robots in the automotive industry worldwide for the period 2008 – 2015 [9-11]

Likewise, as of 2010 we have increasing tendency of application of industrial robots concerning the overall application in the automotive industry. Overall application of robots in the automotive industry in 2015 reached the value of over 700.000 robot units, which represents approximately 43.45% of the total installed industrial robots in the world [1, 9].The automotive industry is in first place in regard to the application of industrial robots in the world, which is logical, since in order to stay competitive in the market the companies that produce vehicles must conduct continuous automation of their production processes. With regard to this, China is in the first place in industrial robots installation in the world, therefore being also the first in the production of the vehicles, as shown in Figure 6.

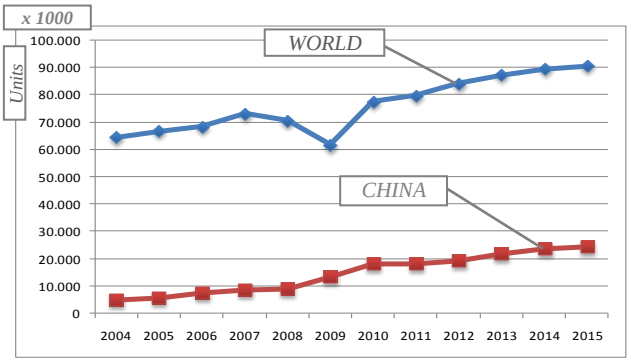

Figure 6. Production of vehicles in the world and China for the period 2004 - 2015 [5-8, 24]

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The analysis of Figure 6 brings us to the conclusion that the production of vehicles in the world is increasing every year, except in 2009 when due to economic world crisis industrial world crisis occurred, causing the lowest production of vehicles in the past eleven years, about 60 millions. By comparing Figure 6 to Figure 1 we see that in 2009 a minimum of industrial robots were applied throughout the world, around 60 000 robot units. With the increasing application of industrial robots in the world, the vehicle production is increasing as well. Figure 6 shows vehicle production in China, and we can see the increasing tendency in vehicle production, as well as the tendency of application of industrial robots, so that China produced about 24, 5 millions of vehicles, which represents about 27% of world vehicle production. In the period to come, this tendency will continue and China will increase its participation in the vehicle production in the world.We come to the conclusion that China is developing the automotive industry and conducting the automation of production processes in the automotive industry. The ratio of application of industrial robots in China compared to other countries can been seen in the analysis for 2015. Figure 7 shows the application of industrial robots in 2015 by the countries in the world.

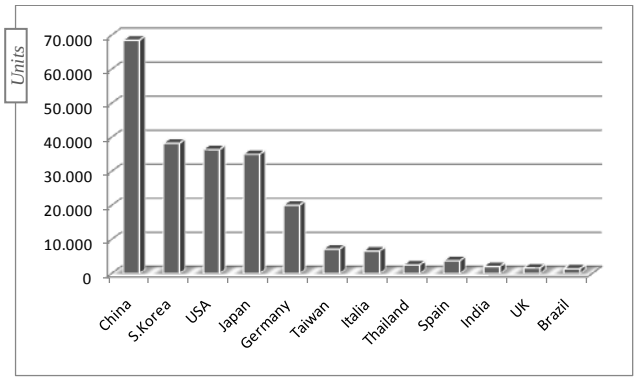

Figure 7. The application of industrial robots in twelve top countries in the world in 2015

As seen in 2015, China has far greater application of industrial robots in comparison to other countries. The second place in application of the industrial robots is held by North Korea with around 38.300 robot units, although in 2014 the second place was occupied by USA. The third place is held by USA with application of around 36.500 robot units, the fourth place is taken by Japan with around 35.000 robot unitsand the fifth place is occupied by Germany with around 20.000 industrial robot units. We can determine that these five countries are leading in the application of industrial robots in the last five years. Countries such as Taiwan, Italy, Thailand, Spain, India, UK and Brazil apply in between 1.400 to 7.200 industrial robot units, as given in diagram 7 according to level of application. All other countries in the world applied less than 1.400 robot units in 2015. The answer to the question why the tendency of application of industrial robots in the world in 2015 is growing is illustrated by the analysis of application of industrial robots by industry branches, as shown in Figure 8.

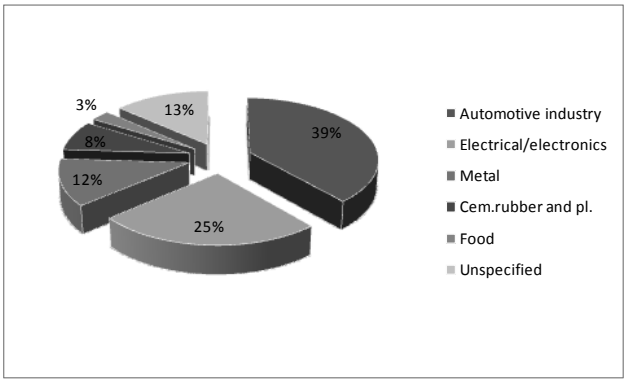

Figure 8. Percentageof application of industrial robots in 2015 by industry branches

Based on Figure 8 we come to the conclusion that in the application of industrial robots in the world, the first place goes to automotive industry with 39% of the total application of industrial robots in 2015, which amounts to about 98.961 industrial robot units of total applied 253.748 units in the world. The second place held by electrical/electronic industry with 25%of applied industrial robots, the third place is taken by metal industry with 12% of applied industrial robots, the fourth place is occupied by chemical (rubber and plastics) industry with 8% of applied industrial robots and in the fifth place in application of industrial robots in 2015 is food industry with 3%. The last 13% includes the use of industrial robots in other industries that are not specified. As can be seen, the first place in the application of industrial robots is held by the automotive industry, and as China is by far the leader in the application of industrial robots in 2015,this means that China is conducting automation of production processes in the automotive the industry. The proof to this statement is given in the analysis of vehicle production by countries in the world in 2015, as shown in Figure 9.

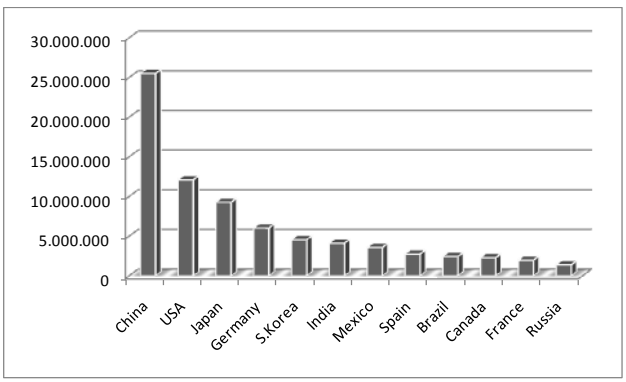

Figure 9. Production of vehicles in twelve top countries in the world in 2015

China is the first in the world in the production of vehicles in 2015, producing around 25.5 million of vehicles, which means that the statement that China is implementing the

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modernization and automation of production processes in the automotive industry is correct. Following China, in the second place is USA with around 12.1 million produced vehicles, and in the third place is Japan with around 9.3 million vehicles. Though North Korea is in second place in the application of industrial robots, it takes the seventh place in the production of vehicles with around 4.5 million of vehicles. This brings us to the conclusion that North Korea is applying less robots in the automotive industry, hence focusing the application on electrical/electronic industry. China is the first in the world in the application of industrial robots and the first in the world in the production of vehicles, and predictions are that in the period 2016-2019 China will still be the first in application of industrial robots. This is not happening by chance, as can be concluded from the fact that China is implementing a national 10-year strategy entitled "Made in China 2025", which aims to make China one of best technological and industrial nations in the world in a few years.This is the reason why China is increasing the use of industrial robots every year, i.e. conducting modernization and automation of production processes in all industrial branches, with automotive industry being in the first place.

CONCLUSION

Based on the presented analysis and facts of the application of industrial robots in the world and China, as well as the production of vehicles, we can make the following conclusions:

- Automotive industry uses industrial robots in their production processes predominantly.
- Global competition in the automotive industry requires continuous automation and modernization of production processes.
- The life cycle of the vehicle is being decreased, which requires expansion of production capacities in the automotive industry, whereas at the same time market demands the increase of variety (new models of cars), which requires flexible automation in the production processes.
- Experts are continuously seeking to improve the quality in the automotive industry, which results in the application of sophisticated robotic systems.
- China is number one in the world in terms is of application of industrial robots, so that in 2015 about 69.000 robot units have been installed.
- China is the first in the world in the production of vehicles, so that in 2015 they produced about 24.5 millions of vehicles, or 27% of world production.
- Production processes in the automotive industry have already been using collaborative industrial robots that are working together with people; they are improving the quality; they are lightweight and mobile, easy to program for performing other tasks.
- There is a projected growth of application of industrial robots in the world; it is estimated that in 2019 around 414.000 robot units will be installed.
- China is the main initiator of the application of industrial robots, and it is estimated that by 2019 they will apply about 40% of the global use of industrial robots, which in return will result in growth of vehicle production in China.
- In the coming period there will be a sudden development of industrial robotics (new construction of collaborative robots), where there will be a development of "intelligent automation" or the development and application of "smart factories", so that "Industry 4.0" will play a major role in the global production concerning the automotive industry.

REFERENCES

[1] Karabegović I.;Husak E.;2016. China as a leading country in the world in automation of automotive industry manufacturing processes, *IV International Congress Motor Vehicles & Motors 2016, "MVM-2016"* , 06-08. October 2016.Kragujevac,(in Serbia)

[2] Karabegović I.; Husak E.;2014.Significance of industrial robots in development of automobile industry in Europe and the World, Journal Mobility and Vehicle, Vol.40., No.1., 2014., University of Kragujevac, Faculty of Engineering, Kragujevac, Serbia, ISSN 1450-5304, pp.7-16.

[3] Doleček V., Karabegović I.;2008.Roboti u industriji", Tehnički fakultet Bihać, Bihać, (in Bosnia)

[4] Doleček V.; Karabegović I.;2002. Robotika, Tehnički fakultet Bihać, Bihać,(in Bosnia)

[5] Verband Deutscher Verkehrsunternehmen-VDA: „AutoJahresbericht 2010", 2010.,Koln, Deutschland,

[6] Verband Deutscher Verkehrsunternehmen -VDA: „AutoJahresbericht 2012", 2012., Koln, Deutschland,

[7] Verband Deutscher Verkehrsunternehmen VDV: "AutoJahresbericht 2014", 2014., Koln, Deutschland,

[8] Verband Deutscher Verkehrsunternehmen VDV:"Jahresbericht 201472015, Koln, Deutschland,

[9] World Robotics 2015, United Nations, New York and Geneva, 2015.

[10] World Robotics 2012, United Nations, New York and Geneva, 2012.

[11] World Robotics 2009, United Nations, New York and Geneva, 2009.

[12] Bakšys B.; Fedaravičius A.; 2004. Robotu Technika, Kaunas Technologija, Kaunas, (in Lithuania)

[13] Rogić M.; 2001.Industrijski roboti, Mašinski fakultet Banjaluka, Banjaluka, (in Bosnia)

[14] Karabegović I.;Doleček V.; 2016, The tendency of application of industrial robots in the automotive, electrical engineering and metal industries worldwide, *3rd International Scientific Conference "COMETa 2016"*,07-09. December 2016.University of East Sarajevo, Bosnia and Herzegovina

[15] Karabegović I.; Karabegović E.; Husak E.,2011. Application analyses of industrial robot in World automobile industry in 2010, Journal of international scientific publications:Material,Methods & Technologies, Vol.5, No.2,.Sofia,Bulgaria, ISSN 1313-2539, : pp 336-345.

[16] Freund E.; Stern O.;1999. Robotertechnologie I, Institut für Roboterforschung, Dortmund, (in Deutschland)

[17] Karabegović I.; Karabegović E.; Husak E.;2011. Comparative analysis of the industrial robot application in Europa and Asia", International Journal of Engineering & Technology IJET-IJENS Vol.11, No.01, (in Pakistan)

[18] Karabegović E.; Karabegović I.; Hadžalić E.;2012. Industrial robots application trend in world metal industry", Journal Engineering Economics,Vol.23, No.4, Lithvania, 2012,: pp.368-378.

[19] Karabegović I.; Doleček V.; Husak E.;2011. Analysis of the Industrial Robots in Various Production Processes in the World", International Review of Mechanical Engineering, Vol.5, No.7, 2011., Napoli, Italy, :pp.1272-1277.

[20] Wolka D.W.;1992.Roboter sisteme, Technishe Universität des Saarlandes im Stadtwald, (in Deutschland)

[21] McKerrow P. J.;1991. "Introduction to robotics", Addison-Wesley Publishing Company, Sydney,(in Australia)

[22] Sciavicco l.; Siciliano B.;2000.,Modelling and Control of Robot Manipulators, 2nd Edition, Springer-Verlag Advanced Textbooks in Control and Signal Processing Series, London, UK, 2000; 1st Edition, McGraw-Hill, New York, NY, 1996. Also in Italian as Robotica Industriale – Modellistica e Controllo di Manipolatori, McGraw-Hill Libri Italia, Milano, I, 2nd Edition, 2000; 1st Edition, 1995.

[23] Shimon Y. Nof.;1999. Handbook of Industrial Robotics, 2nd Edition,Library of Congress Cataloging –in- Publication Data,USA

[24] http:/www. worldometers.info7cars/(05.11.2016.)

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