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Robotisation – Global Trends

Abstract: Higher quality, lower costs, shorter order processing times belong to requirements increasingly commonly set for manufacturers. Presently, progress mainly consists in the automation or robotisation of single processes or of complete production lines. The article presents statistical data and trends concerning the development of robotisation in Poland and worldwide as well as provides examples of robotisation and automation in industrial companies.

Keywords: robotisation, automation, robot applications, robotisation development trends

Higher quality, lower costs and short order processing times are tasks increasingly often faced by producers. Presently, development primarily depends on the automation or robotisation of single processes or whole production lines. This trend, always present in technology, is now taking new shape. Industrialised and developed countries witness a decrease in the profitability of manually performing simple and repeatable operations; therefore, physical work, not only in difficult and health/life hazardous conditions, is being replaced by that performed by robots and automated machinery. Due to their numerous applications, robots can be divided into welding, painting, assembly, lifting and loading as well as special application robots. Among all industrial robots a significant group is composed of robots intended for welding applications. Robotised welding stations equipped with state-of-the-art solutions enable increased process-related efficiency, velocity and quality. The article presents recent changes taking place in the market of industrial robots and shows new technological solutions based on the robotisation of welding processes in particular.

Statistics

The year of 2013 witnessed the greatest robot sales ever. As can be seen in Figure 1, in comparison with 2012, sales increased by 12%. The greatest demand for robots is generated by companies of the automotive, electric engineering and chemical industries. A significant interest in robotisation can also be seen in the food and plastic industries.

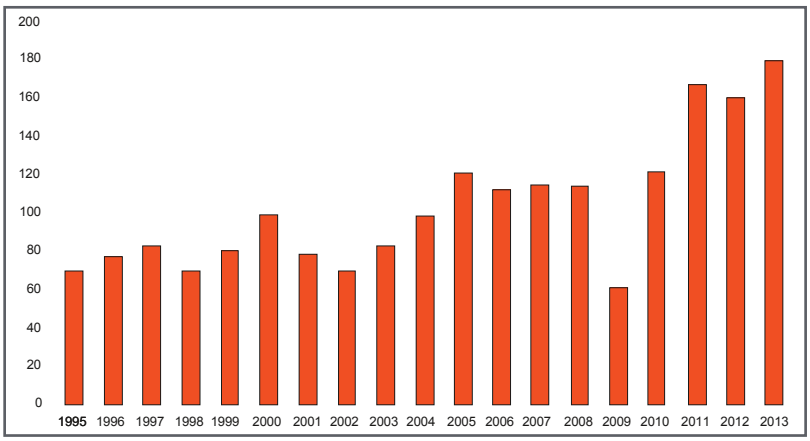

Fig. 1. Global annuals purchase of industrial robots (source: IFR)

According to the most recent data of the International Federation of Robotics (IFR), today, after several years of fighting for the leading position, China is the largest robotisation market worldwide with a 20% share in the total sales of

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robots. In 2013 the Chinese market saw sales of approximately 36,560 industrial robots, making the total sales volume almost three times as big as in 2012 and giving China its leading position in the global rating. In 2008-2013 the total sales in China grew on average by approximately 36% [10].

The second largest demand for robots worldwide is generated by America. The results of 2012 increased by 8% to reach the number of 30,300 industrial robots in 2013. The increase was mainly due to demand from car part suppliers. In 2010-2013 an increase of 18% was generated by the USA, 29% by Canada and 30% by Mexico. In 2013, Asian countries, along with Australia and New Zealand, saw a 17% increase in sales if compared with those of 2012 [10].

In 2013, the sales of industrial robots in Europe stood at 43,400 units, almost equalling the highest sales of 2011 (43,800) and exceeding the result of 2012 by 5%. Similar to America, the main part of this increase was generated by car producers having a 17% share in the total sales volume (14,000 units).

Other industries saw a continuous purchase of robots in 2011-2013. Between 2008 and 2013, the annual rate of increase in robot supplies to Europe amounted to 4.5%. The greatest market of industrial robots was that of Germany, which in 2013 bought almost 18.5 thousand units, being 4% more than in 2012. In the same period, a significant increase in terms of figures was also seen in the Italian market (by 5 thousand units) and in the Spanish market (by 3 thousand units).

Situation in Poland

Although the Polish robotisation market is growing, Poland is still one of the least developed countries in Europe. In 2003-2013 the robotisation density in Poland increased from 2 to 14 robots per 10 thousand workers employed in industry (Fig. 2). The increase of this indication is undoubtedly an advantageous tendency, yet in relation to Europe as a whole, or in comparison with the leaders, i.e. Germany or Italy, the increase is overly slow [4].

The figures above are also confirmed by IFR data, according to which the Czech Republic reached a 14% robot density indicator as early as 2004, whereas Slovakia reached the same density in 2007. In addition, in 2011 the Czech Republic increased its indicator by 60% in relation to the previous one, Slovakia by 54% and Poland by 16%. However, according to data of the Central Statistical Office, Poland has great potential in terms of production robotisation, and the number of automated equipment, such as robots and manipulators, is continually increasing. Figure 3 presents the structure of automated equipment in Polish production enterprises. The greatest share is that of computers for controlling and adjusting technological processes (38%); automated production lines

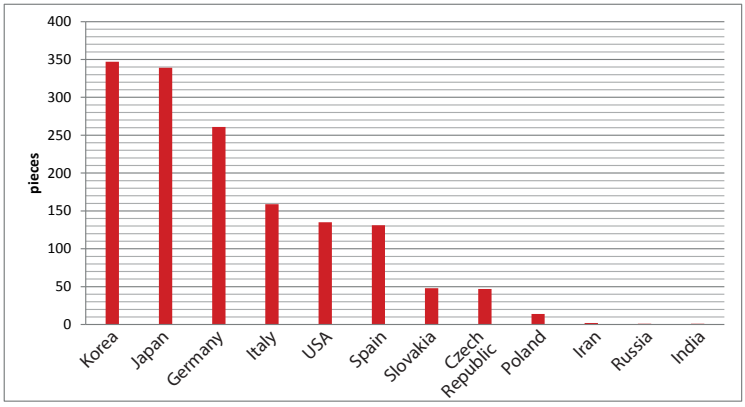

Fig. 2. Number of industrial robots per 10 000 workers employed in processing industry (source: own study developed on the basis of a report by Institute for Market Economics)

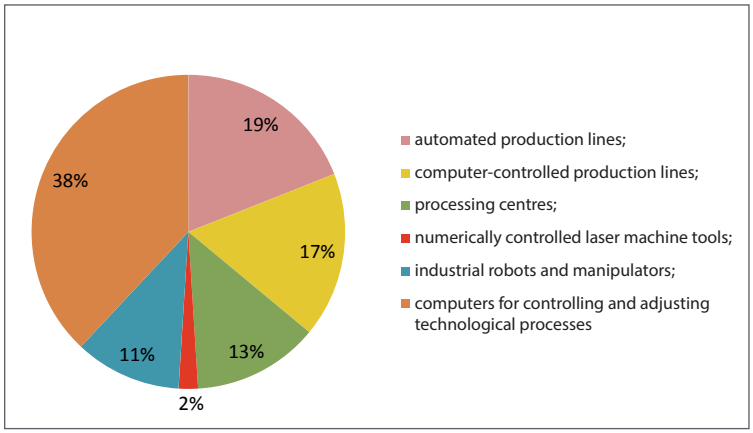

Fig. 3. Structure of production process means of automation in industry in 2012 (source: Nauka i Technika 2012, GUS)

with a 19% market share come second, computer controlled production lines with 7% are third, and robots and manipulators with a 11% market share are on the fourth position [4, 5].

However, taking into consideration an increase in the number of individual automated equipment units, the greatest increase on an annual basis (10%) was that of robots and manipulators. The number of computers for controlling and adjusting technological processes grew by a mere 0.2% if compared with that of the previous year (Table 1) [5].

Table 1. Number of industrial robots and manipulators according to the number of workers (own study developed on the basis of data provided by Central Statistical Office for Poland)

Description		Number of enterprises being in possession of industrial robots and manipulators	Number of industrial robots and manipulators (units)
Public sector		-	84
Private sector	In total	1250	11 127
	10-49 workers	270	773
	50-249 workers	554	2938
	≥ 250 workers	427	7500

Presently, there are 11,211 robots in Poland with more than 11,100 installed in 1250 companies connected with private sector industry. In terms of company size, 773 robots are used in 270 small enterprises (less than 50 workers), 2938 robots are operated in 554 medium enterprises (51-249 workers) and 7500 robots are installed in 427 big industrial companies (over 250 workers) (Table 1) [5].

Robot Application Areas

Factors affecting the development of robotisation in individual industrial sectors can be divided into three basic groups, i.e. technical, economic and social. Frequently identified technical factors include the necessity of flexible automation due to a shorter product active life and the number of product varieties manufactured, high quality of products imposed by specific standards and regulations, noxious and hazardous work conditions, increased competition as well as the development of mechanics and control systems. Economic factors mainly include savings obtainable thanks to industrial robots working 24/7 on expensive and technologically advanced products, growing labour costs, short production cycles, mass-scale production as well as the possibility of easily adjustable programmable production of a given product range related to available work area and transport. Social factors mainly include the shortage of manual workers caused by increasingly high education and more restrictive safety-related standards for human work. The factors enumerated above determine the directions of industrial robotisation development and indicate sectors which most willingly take advantage of possibilities offered by robotised production [11].

As can be seen in Figure 4 and according to data collected by IFR, the increase in the purchase of sales observed both globally and in Poland is dominated by orders from the automotive industry. The industrial sector occupying the second position is the widely defined production of electric and electronic equipment. In 2011 this sector saw a 20% increase in robot installations

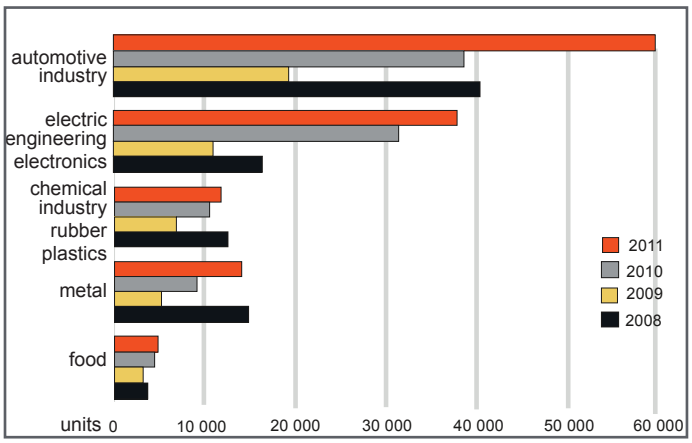

Fig. 4. Global sales of industrial robots according to industrial sectors in 2008-2011 (source: FANUC Bulletin, Poland; February 2013)

if compared with 2010. The percentage share of global sales for the electric industry stood at approximately 23%. The metal industry, including the manufacturing of metal products, is the third largest group in terms of the number of industrial robots used [3, 10].

Examples of Implementations and New Applications

Automotive Industry

The types of processes and robotic solutions are strongly related to a given industrial sector. For instance, in the food industry robots are used for packaging or palletisation, whereas in the automotive industry robots are utilised for making and mechanically processing car elements, assembling, welding, painting and manoeuvring bigger and heavier car fragments. The use of a robotised production line makes a production cycle faster and enables the standardisation of production. The WISS company from Bielsko-Biała, a manufacturer of specialist vehicles, produced mainly for fire brigades, has implemented an ABB IRB 800 robot in the company's production line. The robot was made by special order connected with the individualisation of manufactured vehicles. A 10-axis machine for special applications is capable of making 100 welds within 12 minutes. The same activity performed by a human would last three times longer. Apart from welding, the station is also used for assembling, cleaning and spraying. An equally complex solution is exemplified by the implementation of a robotised system in the Austrian car muffler manufacturing company Roth-Technik, where in one production line 10 welding and manipulating robots produced by KUKA have been integrated. In addition to increased flexibility and efficiency as well as production cost reduction, the most important factors encouraging robotic investments include high productivity and precision, repeatability and relieving humans of work considered monotonous and dangerous. An unquestionable advantage is the improvement of process quality. Robotic applications make it possible to extend the range of services offered. An example of such an outcome can be observed in the Spomasz Żary production company in Bolesławiec, where a fully automated BMW 2000-800 line for producing I-sections has been implemented. The line equipped with DC 1000 thyristor power sources, automatic welding heads, NA5 controllers and torches, among other things, has enabled the steel structure producing company to extend its product range [1, 9, 12].

Electric Industry

Advantages related to robotisation are significant not only in the automotive industry. The industrial electronics sector, characterised by labour-consuming assembling processes, also seeks to reduce costs through robotisation and automation. Normally, these processes are performed manually in regions of lower production costs. Quickly increasing salaries entails higher overall production costs, particularly in such processes, which in turn, leads to an increased interest in robotisation. In the electric and power industries, robotised welding technologies are used, e.g. for surface regeneration. One of the robot installations performed by Lincoln Electric can be seen in the production facility of the ZRE company in Katowice, where an electric arc surfacing process has been used for regenerating power shafts. Specialist software has enabled the synchronisation of motor-reducer/positioner and extension arm movements. In addition to surface regeneration, the main application of such robots in the sector includes the precise assembly of electric appliances. Robots and manipulators are also used in the production of TV sets, DVDs and household equipment [9].

Metal Industry

The metal sector also belongs to important sectors generating demand for robots. In Poland

Table 2. Industrial robots and manipulators used in industrial production processes according to sections and departments – 31.12.2011 r. (source: Central Statistical Office, Statistical Annual Volume for Industry 2012)

Sections and departments	Industrial robots and manipulators			
	In total		robots alone	
	Units	Value in %	Units	Value in %
In total	9285	100	6024	100
Industrial processing	9272	100	6016	100
Metals	187	2	135	2
Metal products	877	9	645	11
Electric appliances	454	5	198	3
Equipment and machinery	345	4	175	3
Cars/vehicles	3962	43	2873	48
Other means of transport	127	1	20	0

in 2011 (Table 2) 11% of industrial robots were used in this sector making this industry one of the production robotisation leaders if compared with other sectors.

One of the very quickly developing applications involving the robotisation of processes connected with metal element processing is welding. The purposefulness of such applications is justified by the specific character of welding technologies, where robotised work increases efficiency as well as ensures the obtainment of high quality and repeatability of production. Thanks to robots, humans do not have to perform tasks in areas of harmful conditions such as high temperature, noise or toxic vapours.

An example of a slightly different approach is a robot-based solution present in the metal industry in the form of a complex robotic production chamber involving a Kuka-manufactured kr125 robot with an arm reach of 2.4 m, intended for the production of steel cabinets. The station, also referred to as a welding chamber [12], enables welding of variously sized cabinets. The average element preparation time is approximately 5 minutes. Increased work efficiency is ensured by two tables enabling the simultaneous work of humans and robots.

Welding Chambers

Welding chambers are complex and interesting solutions used for integrating many activities in one production process. The solution is present not only in the automotive industry, which proves the demand and purposefulness of such stations. An enterprise purchasing welding chambers expects and receives the quick implementation of proposed solutions. Due to their modularity, chambers can be easily adjusted to individual needs.

One of more interesting examples of welding chamber applications is a solution designed especially for Wytwórnia Okuć Meblowych Wom /Furniture Fitting Factory/ in Brodnica. The company was established in 1991 starting with a toolmaker's shop and an office. In the years to follow the company invested in modern plastics. It was then that the idea of production automation came into existence. Among other things, the concept included four independent robotised Abb-manufactured FlexArc welding stations. The Abb-proposed solution included stations with two welding robots and a control system utilising an irc5 controller with the MutliMove function. Work on the station is performed in a parallel manner. On one hand robots join elements, whilst on the other hand robots prepare elements for a welding process. Several welding chambers ensure the continuity of production in cases of large orders or technical problems affecting one of the stations. Wom started the production of complete frames, hoists and rollers. Presently, thanks to new solutions, the company is the greatest supplier of elements for the Ikea furniture producer [13]. Another example of a robotised solution of a similar type is the integrator of welding

systems developed by Valk Welding. This project was primarily focused on the reduction of area used. In this solution a welding robot works on the basis of an E-type frame intended for applications in confined areas with little room for a welding station. The rotating table applied requires 30% less utility area than that needed by a classic station. A complete chamber is delivered to the customer's premises and ready to work at once. This advantage makes it possible to move the station freely to various locations without the necessity of carrying out the labour-consuming calibration of the whole system [15].

The examples for applications of welding chambers are numerous. A Yaskawa-manufactured flexible and automated system for welding chassis installed in the Cosma company in Austria or a chassis welding station produced by Valk Welding and operated at Etc Rotterdam are but examples of several thousand implementations of these complex solutions. Based on the number of applications of quick implementation integration systems, it can be stated that the market welcomes such new solutions. Their great advantage is the possibility of adjusting and connecting appropriate modules combined individually as needed. In spite of many existing applications, solutions for new technological processes continue to appear.

Robotisation Development Trends

Experts anticipate that in the next two years the demand for industrial robots will amount to 190 thousand units. Therefore, on the basis of the examples provided above and taking into account the aforementioned forecasts, it can be concluded that industrial robotisation is a

Table 3. Annual sales of industrial robots in selected countries along forecasts for 2012-2017(source: data provided by IFR)

Continent/ Country	2012	2013	2014*	2015*	2016*	2017*
America	28.137	30.317	33.700	35.500	38.500	40.000
Brazil	1.645	1.398	2.000	2.300	3.000	3.500
Canada, Mexico, USA	26.269	26.668	31.500	33.000	35.000	36.000
others	223	251	200	200	500	500
Asia/Australia	84.645	98.807	120.000	144.500	165.000	186.00
China	22.987	36.560	50.000	70.000	85.000	100.000
India	1.508	1.917	2.500	3.000	4.000	5.000
Japan	28.680	25.110	28.000	30.000	31.000	32.000
South Korea	19.424	21.307	23.500	24.000	25.000	26.000
Taiwan	3.368	5.457	6.000	6.500	7.500	9.000
Thailand	4.028	3.221	4.200	5.000	6.000	7.000
others	4.650	5.235	5.800	6.000	6.500	7.000
Europe	41.218	43.384	46.000	47.000	49.000	55.000
Czech Republic	1.040	1.337	1.800	2.000	2.300	2.600
France	2.956	2.161	2.300	2.400	2.600	2.800
Germany	17.528	18.297	19.500	19.500	20.000	21.000
Italy	4.402	4.701	4.800	5.000	5.200	5.500
Spain	2.005	2.764	3.000	3.500	3.600	3.800
Great Britain	2.943	2.486	2.500	3.000	3.200	3.500
others	10.344	11.538	12.100	11.600	12.100	15.800
Africa	393	733	800	850	900	1.000
the rest of the world	4.953	4.991	4.500	5.000	5.500	6.000
In total	159.346	178.132	205.000	232.850	258.900	288.000

worldwide trend dictated by global competition, increasingly high quality-related requirements set for products and the necessity of reducing production costs. According to forecasts, the development of robotisation will create favourable conditions for integrating robotic and human work [10].

The greatest increase (of 21%) will also be recorded in Asia, particularly in China, Taiwan and South Korea. Expert forecasts also include North America (an increase of 11%) and Europe (6%). The sales will grow even in highly robotised Germany, Italy and Spain. It is anticipated that in 2015-2017 these countries will see an average annual increase in robot installations of 12% (Table 3) [10].

According to IFR data, the first two quarters of 2014 saw a high two-digit robotisation increase. However, according to forecasts, the second half of this year will see the reduced dynamics of the market caused by the present state of the economy. The expected global increase in robot installations stands at a minimum of 15%. The number of robot installations in 2014 should amount to 205,000 units. If the global economic situation improves, this increase can be even higher [10].

The greatest risk, as regards the forecasts in the next two years, is the situation in Europe. The geopolitical turmoil of the Ukraine-Russia conflict could affect the global economy. This risk also includes the insufficient implementation of structural reforms in European countries [10].

Investments in robotic equipment will continue among car part producers. In some countries a decrease in supply might be observed. Increased investments in production automation will be visible in the electric and electronic industries, mainly due to the retooling and preparation of production lines for new technologies. Robotisation will also grow in the plastics, metal and rubber industries as well as in the pharmaceutical, food and machine-building sectors [10].

Summary and Concluding Remarks

According to IFR reports, the robotic market is developing dynamically all over the world. Apart from the Ukraine-Russia situation, the forecasts are optimistic and encourage further research and implementation of new applications in terms of industrial robotisation. The development of automation and robotisation will mainly depend on the following factors:

- global competition,
- greater energy-saving and utilisation of new materials, e.g. carbon composites requiring, among other things, the exchange of tooling,
- new applications enabling human–machine integration. In the era of industrial development, a significant emphasis is given to the collaboration of humans with machinery, which is reflected in research works conducted by the Robot Safety Standard Committee,
- shorter active life of products and the expansion of product variety, requiring "flexible" automation and robotisation,
- technical improvements in robots,
- improvement in the quality of complicated and advanced production processes – robots taking over work in places hazardous to human life and health, mainly dictated by changes and uniformisation of safety-related standards.

According to forecasts, the years to come should mark a period when Poland also will develop in terms of robotisation as it is an EU country with the greatest robotisation potential. However, it is necessary to bear in mind that a robotisation density coefficient should grow in direct proportion to increasing awareness related to advantages offered by the automation and robotisation of production processes.

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