TECHNOLOGICAL INNOVATIONS — BASIS FOR INCREASE OF COMPETITIVENESS OF THE U.S. WELDING PRODUCTION

O.K. MAKOVETSKAYA
E.O. Paton Electric Welding Institute, NASU, Kiev, Ukraine

The tasks and problems of materials joining in industrial production are given. The model of development and implementation into production of technological innovations, offered by the Edison Welding Institute (USA), was considered.

Keywords: *welding production, science, innovations, industrial consortium*

The risk of loosing the leadership in the world economy causes ever more anxiety among the state and business spheres of the USA. In the recent years the country has lost its position in the world rating of competitiveness having moved from the first place in 2009 to the fifth one in 2011, and in 2010 the USA let China have the first place as to the volume of industrial production [1].

The sector of industrial production is the corner-stone for the US economy. Its volume amounts 11 % in the GDP of the country, and in the total volume of export the volume of goods of industrial production exceeds 60 %. About 13.4 Million people are engaged in industry which amounts about 9 % of all employees. The labor payment in the sector of industrial production is 20 % higher than that in the other non-industrial sectors of economy.

Since 2008 the crisis remains the main problem for the US economy. However negative tendencies in the economy of the country were revealed as long ago as 2001. By that time in the period of one year more than 2.5 Million working places were reduced in the sector of industrial production. Among the most anxious tendencies in the US sector of industrial production, experts outline the following:

- reduction of output of industrial products. The volume of industrial sector in GDP of the country for the period of 2000–2010 was reduced from 17 to 11 %;
- reduction of number of working places. In the period of 2000–2010, 37 % (6.5 mln) of working places were reduced in industry;
- reduction of volume of foreign trade (the volume of USA at the world market decreased from 19 to 11 % (2000–2010) that resulted in growing of the trade deficit;
- increase in prices on goods of industrial production (increase of costs connected with safety and protection of environment, taxation, labor payment, reclamation, etc. was reflected on the price of ready products which became one of the factors deteriorating its competitiveness at the world market);
- lack of qualified personnel. Only in the field of welding production the lack of qualified welders amounts 500 persons per year [2].

The technologies for materials joining are the indispensable part of industrial sector of economy. Welding and related technologies of joining are closely integrated into the production process of fundamental branches of industry and considered as the key non-alternative technologies for them. Taking into account such a decisive role of joining technologies for the economy, the Edison Welding Institute (EWI) together with the American Welding Society in 2010 initiated the wide-scale study of state-of-the-art and possible ways for growing competitiveness of industrial production where the materials joining is widely applied. In the frames of the project «The future of materials joining in the North America» the survey of goods manufacturers of six leading branches of industry was conducted to determine the basic problems of those branches and their needs in technologies for joining materials. The results of research were studied in 2011 at the final conference «The growth of competitiveness of industry: the future of materials joining in the North America» in the work of which the scientific, governmental and social organizations, leading manufacturers of welding technologies «Lincoln Electric», «Trumpf», «Miller Electric», etc. took part. In the final document the basic problems of materials joining in industrial

Table 1. Problems and priority tasks in the field of materials joining in the USA for the nearest five years (four first ranks on branches of industry are mentioned)

Problems and tasks	Rank on branches of industry					
	Automobile industry	Oil-and-gas industry	Military industry	Aerospace industry	Heavy-machine building	Power engineering
Deficit of qualified engineers and specialists in the field of quality control of joints		1	4			
Deficit of qualified workers-welders and workers of other professions		3			1	
Growth of competitiveness in countries with low payment of labor	3					
Increase of expenses for development and implementation of new processes, products, methods				2		2
Increase of time for evaluation of joints quality					3	
Broadening of application of new materials and their combinations	1	4	3	4	4	1
Implementation of new technological processes			2	1		
Decrease of time from designing to putting technologies into production			1	3		4
Creation of on-line system for informing about innovative technologies and methods, providing access to them	2					3
Increase of requirements to the quality of joints performance	4	2			2	

production and tasks of its development in the nearest five years were defined.

Under the modern conditions of globalization of world economy the only possible way for the growth of competitiveness in industry is innovative development, i.e. improvement of level of developments, reduction of time for implementation of technical innovations into production, improvement of level of education and qualification of personnel. The innovative development of economy implies also a high level of correlation between science, production and personnel training. According to the survey of enterprises of six leading branches of US industry carried out by the EWI, the problems available in the branch of materials joining are closely connected with the solution of namely these tasks. The results of survey are given in Tables 1 and 2 [3].

According to the results of research given above over the recent years the volumes of application of new progressive structural materials and their combinations will grow in all branches of industry (see Table 1). This is the basic task of the branch of automobile industry and power engineering, it is also included into the specified four tasks of other branches of industry. The designers and manufacturers are ever more interested in the application of new materials which improve technical characteristics of products and reduce their cost. For example, the need in reduction of mass of automobile resulted in increase of application of high-strength steels, aluminium, magnesium alloys and composites. The growth of application of new structural materials requires development of the new technologies for joining (see Table 2). It was mentioned by representatives of all the surveyed branches of industry, and for space-aircraft and military industry this problem is the most challenged. According to estimates of correspondents it is also necessary to reduce the cycle period «R&D — implementation of new developments into industrial production», to find the ways of reduction of costs on development and implementation of innovations, creation of on-line system for informing about innovative developments in the field of materials joining. In total, these tasks reflect the need in development of strategy for development of joining technologies (Table 2).

The next important task is involvement of qualified personnel into the field of joining technologies. According to the data of the US Statistics Bureau the number of employees and specialists of all welding professions in the period of 2002–2009 decreased from 1,076,498 to 968,037 people, or by 10.08 %. Nowadays the deficit of welders on long-term contracts amounts approximately 500 people per year. However this number can be higher as far as mastering the professional skills of welder is required else in

Table 2. Necessary industrial technologies of materials joining and other types of works (four first ranks on branches of industry are mentioned)

Required technologies/types of works	Rank on branches of industry					
	Automobile industry	Oil-and-gas industry	Military industry	Aerospace industry	Heavy-machine building	Power engineering
Development of technology for joining the new progressive materials	1	3	1	1	3	3
Increase in number and improvement of level of education of engineers and designers in the field of joining technologies		2	2			1
Development of arc welding process (efficiency, quality, etc.)		1	3		1	
Development of new methods for joining dissimilar materials	2			2		2
Providing the on-line access to the databases on technologies for materials joining		4				
Development of more sensitive, accurate, reliable methods of non-destructive testing	3		4	4		
Development of high-efficient technologies for welding thick-sheet materials					2	
Improvement of methods for education of welders (making them more perfect, purposeful, less expensive)					4	
Development of strategy of development of new joining processes						4
Improvement of resistance welding technology (quality, reliability, etc.)	4					
Development of additive industrial technologies				3		

more than 25 professions. According to the data of survey confirmed by the statistic data, the branches of US industry lack in qualified workers-welders, engineers and also other specialists in the field of welding and quality control. Thus, the main problem in oil industry is the lack of qualified engineers and specialists in the field of quality control of joints, and in heavy-machine building the main problem is the deficit of workers-welders (see Table 1). The lack of qualified personnel is closely connected with modernization of system of personnel training, development and implementation of system of constant improvement of qualification for the specialists of all professions [4].

The main source of innovations is R&D. According to the estimates of American experts the total costs on financing of research and developments in the world will grow by 5.2 % in 2012 and reach 1.4 Trillion USD, among which the volume of USA will amount 36 % or 436 Billion USD. The industry finances 64 %, the federal government 29 %, meantime 71 % of all R&D, carried out in the country, are performed in the industry. Table 3 gives data on structure of distribution of financing of R&D in USA on basic sources of financing and performers.

The field of R&D becomes ever more opened for cooperation in USA as well as in the whole world. The data of Table 3 show considerable growth of finances by the industry of both its own R&D as well as fundamental ones carried out by academic organizations in the interests of the industry. The federal government attracts also considerable investments into the industrial R&D and other organizations. According to the data of survey of «R&D Magazine» 80 % of industrial companies finance joint research with academic organizations and other companies. Not only industry but also federal government shows ever growing interest in obtaining income from the investments into the R&D. If several years ago only 10 % of companies planned and obtained income from investments into R&D, nowadays already more than 50 % of companies consider this value as a key indicator of their activity.

The Act of Bayh-Dole accepted in 1980 laid grounds for the new state scientific and technical policy of USA directed to the growth of competitiveness of the national economy. The Act allowed transferring intellectual property, created at the federal costs, to such non-federal performers of R&D as universities, private companies and other subjects, and also allowed exclu-

Table 3. Structure of distribution of financing of R&D in the USA on the basic sources of financing in 2012, Million USD (percent of changes by 2011)

Financing source	Performer of R&D					
	Federal government	Governmental funds, centers, national laboratories	Industry	National fund and other academic organizations	Non-profitable organizations	In total
Federal government	29,152 (–2.5)	14,666 (–3.69)	37,577 (–2.42)	37,440 (093)	6817 (–2.29)	125,652 (–1.61)
Industry	–	202 (2.20)	237,487 (3.37)	3868 (26.49)	2129 (8.89)	279,685 (3.75)
National scientific fund and other academic organizations	–	–	–	12,318 (2.85)	–	12,318 (2.85)
Other governmental organizations	–	–	–	3817 (2.72)	–	3817 (2.72)
Non-profitable organizations	–	–	–	3491 (2.70)	11,055 (2.70)	14,546 (2.70)
In total	29,152 (–2.51)	14,868 (–2.36)	311,063 (2.63)	60,934 (2.85)	20,001 (1.55)	436,018 (2.07)

sive licensing of inventions which is the key condition for their commercialization. This and another accepted acts and decrees of the government, state programs of USA and stimulated integration of fundamental and applied science, strengthened interest of industry in performance of fundamental research, activated the inter-discipline research, changed the policy as applied to research infrastructure [5, 6].

To stimulate the carrying out of technological R&D in the field of joining technologies, to strengthen correlation among scientific and industrial sector, to reduce significantly the time and broaden the branches of implementation of innovation products, the EWI together with the Institute of Industry (USA) created a model of development and implementation of technological innovations into industry in the field of joining technologies and successfully approbated it in practice. The proposed model is based on the idea of creation of new organizational structures which could promote the closer integration of all participants of innovation process: from the idea to development commercialization and wide implementation of innovations into production, namely:

- focused industry consortia, and
- manufacturing technology application centers.

Consortium is the temporary union of industrial enterprises interested in development of new progressive technology. The members of consortium define the basic technological problems which require attention, form project program and team of performer. As the performers for solution of different specific tasks the consortium can attract centers of development and implementation of industrial technologies, research laboratories, commercial structures and other organizations. The support of innovations development to the stage of commercialization is performed by the state through the state programs. The implementation of innovations into industry implies wide attraction of funds of industrial foundations and other sources. Table 4 shows scheme of interaction of consortium and development centers and implementation of industrial technologies. This scheme demonstrates one of the possible ideas of functioning of consortium, i.e. the possibility of attraction in the course of development of innovation for the solution of definite tasks of specialized centers of development and implementation of industrial technologies and material resources which have available highly qualified personnel and necessary material resources.

The aim of the model of consortium developed by the EWI is to reveal the needs in new technologies of materials joining arising in the branches of industry, to realize the development of these technologies and develop programs of partner cooperation for the creation and wide implementation of new technologies into production. The example of realization of this model in practice is the Consortium of Additive Technologies and the Consortium of Technologies of Nuclear Power Engineering created by the EWI in 2010.

For example, the Consortium of additive technologies combined the efforts of large corporations of US space-aircraft industry, the clients of the EWI and other private, social and state organizations interested in the development and wide implementation into production of ad-

Table 4. Scheme of interaction of the purposeful industrial consortia and centers of development and implementation of industrial technologies

Purposeful industrial consortia	Centers of development and implementation of industrial technologies							
	Automation	Casting	Assembly of electronics	Stamping	Control	Joining	Additive technologies	Treatment
Production of metal for aircraft industry using additive technologies	×				×	×	×	×
Decrease in automobile mass		×		×	×	×	×	
High-speed assembly of batteries	×		×		×	×		
Ecologically clean production of electronics	×		×			×		
Manufacturing of equipment for nuclear power plants		×			×	×	×	×
Automation of process of production of equipment for heavy-machine building	×				×	×	×	×

vanced additive technologies. In total the Consortium united 24 industrial members and partners for performance of research. The industrial members of Consortium are the companies-producers and consumers and investigation partners: five universities and such organizations as Army, Air Force, Navy, NIST, NASA. The development and implementation of this model was supported by the state. The state Ohio allotted the many-million grant for realization of this project.

If the aim of consortia is to solve the strategic and organizational tasks on development of the new technology, the centers of development and implementation of industrial technologies are the basic performers of this project. These organizations should be recognized as the world class leaders in their field, equipped with the innovative equipment and having the highly qualified personnel. The example of such center in the field of materials joining is the EWI. It closely cooperates in the work with research universities and industrial sector which allows realizing of innovation developments and their successful implementation into production. Since 1984 the Institute has a constant state support according to the Ohio Edison Program. The constant development, efficiency of work and high level of return of investments attract private investors. In 2010 the volume of private investments into the developments of the EWI 20 times exceeded the volume of state financing [7].

The innovation model of development and implementation of technologies proposed by the EWI was approved by the government of the USA. The National Institute of Standards and Technologies at the Trade Ministry accepted the new state program on its basis to support the development of technological innovations in the USA «Advanced Manufacturing Technology Consortia» in 2011. The budget of the program for 2012 amounted to 12 Million USD. It envisages the support of development of such innovation directions as robotic technologies, nanomaterials, new progressive materials, new progressive production technologies. In total, the state allotted 75 Million USD to support the innovation programs in 2012 [8].

1. Bucher, K. US competitiveness ranking continues to fall: Emerging markets are closing the gap. *www*.weforum.org
2. (2011) Strengthening manufacturing competitiveness: Report from Conference 2010 on the Future of Materials Joining in North America. EWI, Febr. 2. *www*.ewi.org
3. Conrardy, C. Materials joining and technology. *www*.weldingandgasestoday.org
4. State of the welding industry report: executive summary. In: Weld-Ed. *www*.weld-ed.org
5. 2012 Global R&D Funding Forecast. In: Battelle. The Business of Innovation. *www*.battelle.org
6. Dezhina, I. (2011) Support of fundamental science in USA: Lessons for Russia. *Bytie Nauki*, **94**, 6–7.
7. Revitalizing American's manufacturing innovation infrastructure. Response to the NIST AMTech Request for Information. EWI. *www*.ewi.org
8. President Obama Launches Advanced Manufacturing Partnership. *www*.nist.go