ACTUAL PROBLEMS OF MODERN SCIENCE

Edited by

Matiukh Serhii
Khmelnytskyi National University, Ukraine

Skyba Mykola
Khmelnytskyi National University, Ukraine

Musial Janusz
Bydgoszcz University of Science
and Technology, Poland

Polishchuk Oleh
Khmelnytskyi National University, Ukraine

Bydgoszcz – 2021

Actual problems of modern science. Monograph: edited by Matiukh S., Skyba M., Musial J., Polishchuk O. – 2021. – 758 p.

Monograph is prepared at the Khmelnytskyi National University in cooperation with Bydgoszcz University of Science and Technology, Poland.

Article in monograph are presented in the author's original version. Authors are responsible for materials and interpretation.

ISBN: 978-83-938655-5-0
DOI: 10.31891/monograph/2021-10-1

CONTENT

INNOVATIVE TRENDS IN INDUSTRIAL MACHINERY ENGINEERING AND EDUCATION

Berezin L.[1], Oliinyk O.[2] , Rubanka M.[1]

[1] Kyiv National University of Technology and Design, Ukraine

[2] National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Ukraine

DOI: 10.31891/monograph/2021-10-65

1. Introduction

Given the dynamics of changes in production, mankind has experienced three industrial revolutions [1]. The fourth Industry 4.0 is a revolution of the near future, which is based on the latest information and communication technologies (Cyberphysical systems, Internet of Things, Physical Internet, Internet services, etc.), which form a high level of flexibility of production from mass to individual, increasing productivity by connection of production systems, their monitoring and diagnostics with the use of digital engineering and in real-time.

The transition to Industry 4.0 in the field of industrial machinery engineering on the example of knitting equipment is in its infancy and requires appropriate adaptation of engineering education in preparation for Industry 4.0. Thanks to the latest advances in science and technology, and especially in data processing, communications and digital integration of concepts and processes, innovative solutions for automation, digital visualization, computerization and electronics are being tracked in the field of industrial machinery engineering, aimed at expanding technical and technological potential of the latest equipment, which is confirmed by information from the exhibitions ITMA ASIA + CITMA-2018 [2], ITMA-2019 [3], the work of the European Committee of Textile Manufacturers [4] and sites of well-known manufacturers.

In recent years, a significant amount of work has been published on education in the context of Industry 4.0 [5-7], which examines the inconsistencies of the competencies of graduates of higher education institutions to the new qualification requirements "headhunters" and disparate concepts for their elimination. Therefore, the aim of the work is to analyze competitive technical innovations in knitting equipment according to the requirements of the transition to Industry 4.0 and to consider the adaptation of industry engineering education to the new qualification requirements in the era of Industry 4.0.

2. Research results

Digital engineering as a set of services of digital organizational and technological design, production and logistics chains and modes of operation of equipment is the key to the successful introduction of Industry 4.0 in knitting production. This allows you to develop new concepts of equipment management and expand technological capabilities on the demand of increasing individualization of knitwear. Digitization of the manufacturing sector using embedded sensors allows you to create closed digital images of both product components and processes and production equipment through cyber-physical systems and analysis of data sets. This expands the capabilities of electronic control systems and control of knitting processes, provides high reliability of equipment, limiting the intervention of service personnel, extreme accuracy and stability of positioning of executive mechanisms, expanding technological capabilities, implementing a rapid transition to a new range of patterns, sizes, weaves. For example, the use of digital technologies for sock machines allows you to implement non-standard technical solutions in the design of drives, control systems and needle selection, which reduces the number of mechanical components by 35… 40% [8], in particular using stepper motors. It also changes the amplitude of rotation of the needle cylinder to a given angle, which reduces the idling of the cylinder on the reverse when knitting heel pockets and the manufacturing time of the product as a whole. Digital support on the Ange 14 W model from Uniplet allows you to implement electronic knitting of the heel and bowl without the use of devices to change the number of needles, which increases productivity by (15… 25)% compared to the traditional approach. Manufacturers of sock machines are mainly inclined to electronics of their own production, which allows you to choose non-standard self-sufficient solutions in both hardware and software for production needs. Examples are the development of electronic technologies by Dinema for Lonati Group machines [9], electronic control system 2900SL on Rumi machines from Stäubli [8], an improved version of Art-Gen software on Busi Giovanni machines, Deimo microprocessor devices on Nova D knitting machines. and Lucia D, etc. A typical computerized control system for modern knitting machines is the SEVEN-R machine model from RUMI, which is equipped with a UPS device to support program memory and knitting process in case of power outages, a device for forming a heel due to knitting density

adjustment, Dream Box Solis pneumatic device for product orientation, high-speed modern WAC drive made in Japan, electronic adjustment of elastic thread feed and movement control of cams of the locking system, etc. An integral part of modern knitting equipment is the presence of electronic needle selection and switching thread carrier, which provides a quick change in the range and helps to expand the color scheme, patterns and weaves on the socks. In addition to independent developments of manufacturers, a wide range of high-speed electromagnetic needle selection units (actuators) and pneumatic systems from a specialized company Matrix [10]. On the example of Ange and Dera machines, the innovative Matrix technology provides high dynamic performance (extremely fast switching time), stable reliability, reduced energy consumption and a high level of accuracy even in adverse production conditions. Compactness, the highest level of reliability and performance at high knitting speeds are guaranteed by piezoceramic boxes for selection of knitting needles from WAC, Siemens and Matrix. A completely innovative solution is the device for selecting needles on the principle of a monomagnet, which is presented by Lonati on DC88 and GX series machines.

An example of the evolutionary advancement of computing capabilities on knitting equipment is the XT Machine from Santoni [11]. The equipment is equipped with a new automatic system, which is controlled by a microcomputer and a revolutionary needle selection system, which allows you to knit unprecedented three-dimensional weaves with the original 3D Intarsia technology. The main uniqueness of the XT Machine is the ability to knit the top of sports shoes in a pre-selected shape and with a perfect fit to the foot with unlimited patterns and color combinations. The footwear which is made on XT Machine automatic machines, in comparison with traditional, differs in ease, convenience, a possibility of creation of special individual characteristics and the highest quality. The main strategic advantage of the Santoni innovation is the ability to efficiently and quickly design and manufacture footwear, which significantly reduces the overall production time and production waste. Sock machines on the way to Industry 4.0 are equipped with software, systems for product development and related manufacturing automation technologies. As an example, Rumi machines model Seven-R [12] implemented a version of SD software based on the well-known graphics program Rudidraw for image creation and program preparation and management editor, which is implemented in the Windows 95/98/2000 / IU /

XP operating system, has specific control functions to simplify the work of operators (quite intuitive creation of drawings, the ability to work with multiple open drawings, high bit size with convenient scaling for viewing small details), allows remote operation of the scanner and printer when transmitting images in different graphics formats. On Lonati Group products, product creation and knitting process control is performed by the Digraph 3 Plus software package, which contains a complete collection of styles and helps the operator to combine them to achieve the desired results. On the machines of Uniplet A.S. the graphic design system is composed of two programs Stayler 4, Stayler 5 (developer Deimo) and SuperGraphic (developer Sunrise) based on PIC and BMP formats. S-Paint and SKMon software for sock product design and production monitoring are used on Busi Giovanni's Idea Terry machine models, respectively. The updated version of the Art-Gen software of this company provides customers with the implementation of individual programs of knitting socks of their own design on the basis of intuitive functions, with subsequent sending and installation on the equipment via the network. Lonati offers an operating system that allows you to remotely control the control of machines using mobile devices (smartphones, tablets, smart watches).

The use of electronic systems on advanced machines allows for full automation of knitting socks with a closed bowl without the use of sewing operations. Suturing of socks with closing of fingers is carried out on models of automatic machines Seven-R (manufacturer Rumi) by the D4S device from the Swiss company Stäubli [8] which provides high efficiency thanks to minimization of idle time at independent operation of the device and the automatic machine. Among others, Lonati Group's GK line machines stand out, which use the SbyS automatic bowl sewing system (Stitch-by-Stitch) [13], the Toe Closer system, which is presented by Matec on the HF Super 4.7 PBT [14] and Star-D models, a device Lin-Toe® machine Jumbo company Sangiocomo SpA, a number of machines from Uniplet. A fully automatic connection with the "Classic kettle bowl of socks" function is provided on Busi Giovanni machines with the Rimaglio automatic device, which is located next to the machine and works separately [15]. It is obvious that in the near future, fully automatic knitting of socks will become a global standard in the industrial machinery engineering, given the high cost-benefit ratio and rapid return on investment. Autotex equipment is designed to automate

the final operations of packing socks, including: turning the sock on the front side, sewing a label, high-quality thermal printing, marking products with programmable radio tags, applying an adhesive sticker, which eliminates the need to organize a sewing department and manual operations in continuous production.

In the long run, knitting machines should be flexible in the use of additional devices and accessories, especially to tension control and yarn speed control. Innovative solutions for yarn feeders include embedded intelligent systems for noise suppression and erroneous operation. There are Yoyo devices from Dinemo Electronics, which control the supply of yarn in knitting machines (round knitting, sock, flat knitting, etc.) using highly efficient sensors and stepper motor, which are programmed by adjusting and maintaining different tension in the yarn depending on specific knitting process and type of raw material. BTSR International S.P.A. [16] proposed microsystems of active supply of yarn feeding Ultrafeeder 2 with the function of accumulating yarn on the drum and anti-twist system with built-in knot detector, universal device EFS 920 with integrated feed system for both elastic and conventional threads, from the market leader in yarn feeders Memminger-IRO. BTSR offers Smart Matrix 64H terminals with IS4F HTS electronic sensors, which allows programming and control of yarn consumption for real-time production monitoring and, according to the developers, is able to eliminate at least 80% of raw material waste.

With the use of electronic control unit there are possibilities to control the system of vacuum selection of products, pneumatic switching of thread guides, system of automatic change of product density based on stepper motor, anti-twist system, pneumatic device Dream Box Solis for product orientation, independent stepper motors for cam control, position sensors such as Honeywell and Lesikar, etc. One of the latest solutions to increase the durability of machines is the unique Pulsonic 6 lubricator, which provides optimal dosing and distribution of oil through both computer control and a local network of interconnected controllers (Controller Area Network).

Advances in automation, computerization and technology of production and logistics processes together with advances in e-commerce in the near future will create digital enterprises that will produce individual products based on consumer demand and without the need for traditional production and logistics chains, i.e. to implement trends Industry 4.0. Therefore, the movement of knitting machine

manufacturers is obvious regarding the possibility of adapting the product range or developing machines for modular factories, which could be easily modified according to specific customer requests. Smart production facilities are formed by combining production with information and communication technologies that allow manufacturers to seamlessly integrate various intelligent products and processes. An example is the SDS-ONE APEX4 system. SDS-ONE APEX4 from Shima Seiki, which provides integrated support for knitting production from planning to production and sales promotion, i.e. is a Total Fashion system. This ensures the transition of production from mass to "on demand", which eliminates the need for traditional production and logistics chains and maximizes profits from zero losses from stockpiling and lost sales opportunities, timely response to rapid and flexible fashion trends and more. The possibility of making knitwear in networks is a reality. For example, Busi Giovanni is implementing a concept that allows its customers to create individual sock knitting programs with a number of intuitive functions, followed by remote loading on the equipment.

Obviously, adapting to Industry 4.0 increases the need for time, dynamic, flexible and at the same time integrated networks. Large-scale data processing and artificial intelligence networks support the self-organization of machines and autonomously determine the range and quantity of products ordered, i.e. connect all technological and organizational chains from yarn to the final product. Modern information and communication technologies are shaping the business models of future knitwear production using new forms of organization, including virtual ones, in which product development, production and sales are networked in different locations and companies. Concepts, methods and IT systems are being developed that support both the management of global development and production networks and regional players. It provides shared access to data, information and knowledge, coordinates processes and expands the boundaries of cooperation.

One of the important tasks for Industry 4.0 is to create "green" technologies in accordance with the requirements of environmental standards. In the knitwear industry, it is the reduction of production waste, promotion of its reuse, automation of waste sorting by type of fibers and color, recycling of plastic containers, use of solar panels, windmills, clean gas, environmentally friendly dyes, etc. as energy sources.

It is obvious that the consistent implementation of Industry 4.0 requires the latest educational system Education 4.0, which will eliminate the mismatch of competencies of employees to the requirements of the future in the labor market and promote the development of future engineers in the digital world of the future. In [5, 17] consider new requirements, including: Interdisciplinary thinking, decision and problem solving, cultural and intercultural competency, and lifelong learning, etc. and identify the main problem of employees regarding the implementation of cyberphysical systems.

Innovations in the services of higher education institutions and other educational providers include on-line and interactive learning, which provides access to on-line learning, open learning systems, e-learning offers on free access courses at "open" universities, including intersectoral networks in in the spirit of Industry 4.0, regardless of location and time. This allows you to gain knowledge individually with the help of special tools and digital media that regulate the levels of complexity of the material in accordance with the abilities of the consumer of knowledge. Flexibility of learning is manifested in the transition from a traditional education system with the same methods for each to individualization of approaches. In the context of digitization and integration into the Internet, the idea of lifelong learning, for example in the workplace, is being considered. Important are the elements of project-based learning with the ability to apply theoretical knowledge to real projects, which allows you to focus on the end result, collaboration in teamwork and time management. As information technology is a reality of the future, an important competence is the interpretation of data, including the management of virtual systems, the collection and processing of information. One of the key changes in engineering education is the implementation of projects at the interdisciplinary level with the cooperation of teachers of various specialties, cooperation between universities and industry. The role of hybrid teams, which include people and machines working together in a virtual and decentralized (or international) production environment Industry 4.0, was reported in [18,19]. With this perspective, there are requirements for engineering education of the future, such as cooperation in the virtual environment and human teams and robot. Smart machines, machine-to-machine communication (M2M), data security, big data, support systems such as mixed reality systems are areas where the emphasis is on changing learning technologies [20] using virtual

AR modeling and complementary VR realities, remote labs. In [21] an example of a virtual laboratory in an integrated learning environment for students of computer science and automation engineering with the ability to access and control devices via the Internet, in [22] - a modification of teaching students of industrial machinery engineering in conventional simulation games to reproduce key aspects of Industry 4.0. By drawing on real industrial technologies such as ERP systems and barcodes / RFID chips, students can create an Industry 4.0 environment. In [23] methods of teaching industrial networks and their application in production are discussed. The role of mentoring and mentoring in relation to students in their professional development and adaptation to market requirements is reported in [24].

The paper [7] provides information on training programs in a number of engineering specialties, which summarizes the developments of leading foreign universities, related specialties Machinery Engineering and Industrial Engineering - a list of additional disciplines in accordance with Industry 4.0. This primarily applies to artificial intelligence and robotics, the Internet of Things (IoT) and 3D printing, virtual AR and augmented VR realities, statistical methods of data analysis, database systems, IT security, bio- and neurotechnology, etc. - the latest trends in production and society.

Given the trend towards digitalization, there is a growing demand for digital literacy, which is necessary to work in a digital environment, such as virtual AR and augmented VR realities, which will have significant application in future corporate training methods and strengthen their skills in the professional sphere. The shift from low-level programming languages to those related to databases and artificial intelligence (Python and R) is obvious. Disciplines Statistical Methods of Data Analysis and Database Systems lay the foundations for understanding the subjects Machine Learning and Artificial Intelligence. In addition, there is a need to analyze and evaluate data flows between production resources and network systems based on Big Data, databases without SQL no-SQL databases, MapReduce and data management in the cloud, because conventional programming is not able to analyze large volumes of information.

At the same time, issues of information protection system are becoming relevant. To do this, it is advisable to expand the training of students in the areas of Intelligent systems, IT security and hardware systems (industrial applications). In

the area of IT security, security system issues are proposed for consideration and protocols, cryptology, network security, data privacy and security, and security management.

The future era according to the principles of Industry 4.0 is also characterized by mass automation of processes and productions, robotics, introduction of new digital and biotechnologies and renewable energy in industry. Therefore, the required courses Embedded systems, Industrial automation technologies, Industrial robotics and Real time systems. The introduction of the provisions of these disciplines in the production environment will allow you to work independently and autonomously in accordance with the analysis of their own condition and the environment.

An important component of promoting various aspects of Industry 4.0 through intermediary activities between student and production projects are student clubs [25].

3. Conclusion

Priority trends of machine-building companies producing knitting equipment in accordance with the conditions of transition to Industry 4.0 are aimed primarily at production flexibility in setting technological parameters and individualization of product range, improving productivity, quality and efficiency of resources through collection, control and analysis of production information in real-time. The main means of achieving the goal include digitization of information, use of computerization, automation, electronics, organization and support of production processes with the involvement of global electronic networks, taking into account the wishes of customers. This will allow the implementation of business models of future knitwear production using new forms of organization, in which development, production and sales will be combined in a network for joint corporate cooperation of enterprises and consumers of products. Also listed are the requirements for the Education 4.0 education system in the light of Industry 4.0 implementation and relevant innovative solutions from leading foreign universities and other educational providers to provide competencies that will meet the requirements of the future labor market.

References

1. Shvab, K. (2019). *Chetvertaya promyshlennaya revolyutsiya* [Fourth industrial revolution]. Moscow: Fors [in Russian].

2. Technology/Machinery Swedish machinery at ITMA Asia + CITME 2018. URL: https://www.innovationintextiles.com/swedish-machinery-at-itma-asia-citme-2018/ (Last accessed: 05.10.2021) [in English].

3. Transforming the World of Textiles. URL: https://itma.com/ (Last accessed: 05.10.2021) [in English].

4. Industrial Knitting Machines Market: Global Industry Trend Analysis 2013 to 2017 and Forecast 2018. URL: https://www.persistencemarketresearch.com/market-research/industrial-knitting-machines-market.asp (Last accessed: 05.10.2021) [in English].

5. Abramov, A. (2018). *HR v obrazovanii Soft skills. Samoobrazovanie Samorazvitie Lyudi budushchego* [HR in Education Soft skills. Self-education. Self-development. People of the future]. Moscow: Focus [in Russian].

6. Navyki budushchego: chto nuzhno znat' i umet' v XXI veke [Skills of the future: what you need to know and be able to do in the 21st century]. URL: https://trends.rbc.ru/trends/education/5e728cbc9a79476476f6eb4e (Last accessed: 05.10.2021) [in Russian].

7. Coşkun, S., Kayıkcı, Y., & Gençay, E. (2019). Adapting Engineering Education to Industry 4.0 Vision. Technologies, 7(1), 10. doi:10.3390/technologies7010010

8. Stäubli Flash. URL: https://www.staubli.com/en/file/22860.show (Last accessed: 05.10.2021) [in English].

9. Dinema electronics. URL: https://www.dinema.it/uploads/2019-9-6/brochure%20textile_LR.pdf (Last accessed: 05.10.2021) [in English].

10. Matrix technology for textile industry. URL: http://www.matrix.to.it/pdf/textile_dep.pdf (Last accessed: 05.10.2021) [in English].

11. ISPO Munich. URL: https://www.ispo.com/en/munich (Last accessed: 05.10.2021) [in English].

12. Rumi Seven-R Socks Machine Use RUMIDRAW Graphical Program. URL: https://ar.pinterest.com/pin/647181408924422932/ (Last accessed: 05.10.2021) [in English].

13. GOAL SINGLE CYLINDER GK725H - GK625H - GK525H. URL: https://www.lonati.com/uploads/pdfgenerati/LON-GK-GK725H%20-%20GK625H%20-%20GK525H%20-ENG.pdf (Last accessed: 05.10.2021) [in English].

14. Santoni URL: https://www.santoni.com/ (Last accessed: 05.10.2021) [in English].

15. Busi Giovanni. URL: http://www.busigiovanni.com (Last accessed: 05.10.2021) [in English].

16. Constant tension feeders. URL: http://www.btsr.com/products/constant-tension-feeders (Last accessed: 05.10.2021) [in English].

17. Götting, M.; Gosewehr, F.; Müller, M.; Wermann, J.; Zarte, M.; Colombo, A.W.; Pechmann, A.; Wings, E. Methodology and case study for investigating curricula of study programs in regard to teaching industry 4.0. In Proceedings of the 2017 IEEE 15th International Conference on Industrial Informatics (INDIN), Emden, Germany, 24–26 July 2017; pp. 533–538.

18. Luo, X.; Störmer, M. Chancen und Herausforderungen der Organisations- und Personalentwicklung im Zeitalter der Industrie 4.0–Bestandsaufnahme und Ausblick. In Kommunikation und Technik; Springer: Berlin/Heidelberg, Germany, 2018; pp. 191–209.

19. Richert, A.; Shehadeh, M.; Plumanns, L.; Groß, K.; Schuster, K.; Jeschke, S. Educating engineers for industry 4.0: Virtual worlds and human-robot-teams: Empirical studies towards a new educational age. In Proceedings of the 2016 IEEE Global Engineering Education Conference (EDUCON), Abu Dhabi, UAE, 10–13 April 2016; pp. 142–149.

20. Huba, M.; Kozák, Š. From E-learning to Industry 4.0. In Proceedings of the 2016 International Conference on Emerging eLearning Technologies and Applications (ICETA), Vysoke Tatry, Slovakia, 24–25 November 2016; pp. 103–108.

21. Konak, A.; Clark, T.K.; Nasereddin, M. Using Kolb's Experiential Learning Cycle to improve student learning in virtual computer laboratories. Comput. Educ. 2014, 72, 11–22.

22. Zarte, M.; Pechmann, A. Concept for introducing the vision of industry 4.0 in a simulation game for non-IT students. In Proceedings of the 2017 IEEE 15th International Conference on Industrial Informatics (INDIN), Emden, Germany, 24–26 July 2017; pp. 512–517.

23. Schlechtendahl, J.; Kretschmer, F.; Lechler, A.; Verl, A. Communication mechanisms for cloud based machine controls. Procedia CiRp 2014, 17, 830–834.

24. PRITsKER, A. (2019). Puteshestvie v mentoring. Rukovodstvo po raskrytiyu vnutrennikh resursov [Travel to mentoring. Internal Resource Disclosure Guidelines]. Samara: Filin" [in Russian].

25. Faller, C.; Feldmüller, D. Industry 4.0 learning factory for regional SMEs. Procedia CIRP 2015, 32, 88–91.

ALPHABETICAL INDEX OF AUTHORS

Technical editors*: Serhiy Horiashchenko, Robert Polasik*

ISBN: 978-83-938655-5-0
DOI: 10.31891/monograph/2021-10-1