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TRENDS IN THE AUTOMATED MASS PRODUCTION

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Abstract: *Rapidly rising requirements for productiveness, an increasing variant variety, diminished batch dimensions and cost pressure in the production require high efficient flexible control and manufacturing systems. There are main focuses and challenges of the future production which are the matter of mastering in the course of the progressive industrial automation. These are a) resources-efficient production as e.g energy, impulses, alternative materials and combined technologies, b) clear production as e.g logistics integration, MES, c) quality and productiveness as new manufacturing processes, innovation, professional forces protection and d) adaptable production as e.g work piece recognition, intelligent robots, gripper technology, security technology with picture processing. Especially in consideration on adaptable production, quality and productiveness, the development of new manufacturing systems and picture controlled robots are essential basic condition for the production in 2020. This paper will give an insight in the trends in production systems as well as of development of the CPS and Industry 4.0.*

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Key Words: ***Adaptable production, Picture processing systems, Industry 4.0, Cyber-Physical-Systems (CPS)***

1. INTRODUCTION

Relating to quality and productiveness which are concerning control of the system integration and new manufacturing processes, innovation and protection , relating to adaptable production which is concerning work piece recognition, intelligent robots, gripper technology and security technology with picture processing and picture guidance, the development of the new manufacturing arrangements, automated assembly technology, application of picture controlled robots and technology of precise measurement is essential basic condition for the production in 2020. Because the production processes must be nowadays realized increasingly accurately and faster, gradually more automatic manufacturing systems, often based on robot applications, are used to face the problem and fulfill the requirements of the production. Camera and picture processing systems as so called „artificial eyes" become indispensable in the automation process. Completely integrated in the control sphere of a manufacturing cell, cameras and scanners lend to modern machines and robots the ability to "see", to recognize, to work autonomous and to make the right decisions based on input information. Nevertheless, the person (human being) cannot be completely renounced in the production, because robots in the today's state of the technology are exact and able to serve repeatedly, but not intuitively. They must be adapted very time-consuming to new applications and new problems in the production procedure. The integration of the most modern security technology is still complicated by the fact that the known robot systems use proprietary computer languages and different coach systems. There is no international standardization in the programming of the robot systems like in the programming of the PLCs (see, IEC 61131). Hence, nowadays robot cells are mostly laid out to work in structured, firmly secured surroundings. They still show a high danger potential for people in their surroundings. Therefore it is a matter of development of innovative security technology which can guarantee a secure and efficient "human-machine" or "human-robot" interaction.

2. DANGER-FREE AND FLEXIBLE HUMAN-ROBOT INTERACTION

Robots are since the 60-s a part of system applications in the production. Since then, robot systems become improved and optimized. Nevertheless, a requirement of the so called "Production 2020" is to create conditions that person and robot can co-operate adaptable and secure in the production sphere with each other, without restrictions. In addition danger areas must be supervised reliably and consistently. The customary methods of the security and supervision of the robot and production systems, disturb not only the production process and work routine, they are often put out to the risk by manipulations and cause, also in the operational practice, higher costs. For example, interrupting of conventionally used light curtains leads to an immediate stop of the movements of a robot. The quick disconnection, abrupt starts and stops are burden for the robots' mechanics, they lead to higher wear and to mostly renewed time-consuming manual starting-up routines after an emergency stop. The application of the camera technology and methods of 3D picture processing in the security and supervision of danger areas opens new possibilities for the secure human robots and human machine interaction. Instead of application of the classical security technology with final counters, backing systems and security control technology based on 3D

picture recognition space supervision is being tested for. An example of such a system is so-called “virtual protective room” as so called "SafetyEYE", designed by PILZ Company. Such a realization of the application for the mass production of fuel cells is introduced in [3].

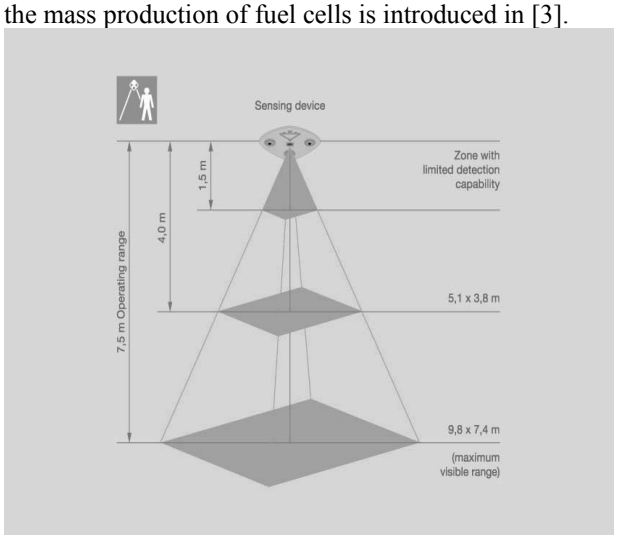

Fig. 1. SafetyEye - Principle

SafetyEye is a 'seeing' security technology for the space supervision which combines intelligent sensor systems with actual control. SafteyEye is laid out according to all relevant norms and standards as Cat. 3 EN ISO 13849-1:2008, SIL2 IEC 61508,- PL d EN ISO 13849-1 or DIN EN 61496. The functional principle is shown in the following picture.

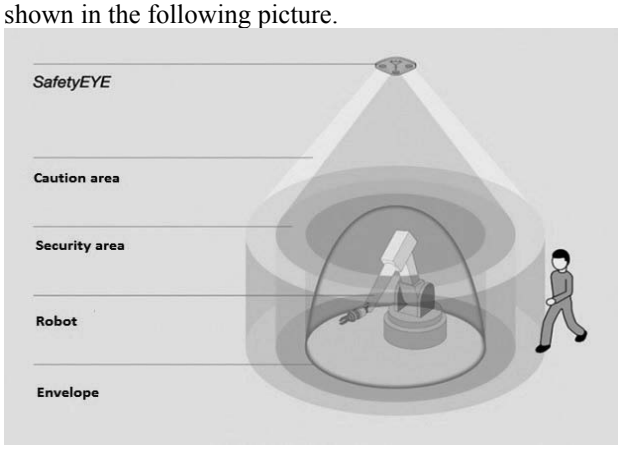

Fig. 2. SafetyEye – Robot cell

Danger areas are surrounded by caution and security areas which can be freely defined in the SafetyEye Configurator. The SafetyEye Configurator offers the possibility to provide different, predefined geometrical forms as well as the option, to design security areas hands-free. It is possible to configure arbitrarily many caution and security areas to which, then with the help of the configuration tool, different actions can be assigned for different danger situations. Caution and security areas can be summarized to complex areas and are still easy to use, because they can be configured intuitively and fast by PC. If different complex areas are necessary for different modes of operation of a robot (T1,T2, AUT), these can be switched during the working cycle of the machine dynamically, by so called secure coach system SafetyBus p or the digital entrances of the PSS control unit. Therefore users can remain adaptable, because once defined, security areas can be adapted by mouse click in the SafetyEye Configurator. The specific feature of the three-dimensional, secure camera system is that injury of the security area (entering the area of danger) does not lead automatically to the emergency stop. Since if an employee violates the virtual security area at a place which the robot would reach only after several seconds, the security area can be deactivated and, instead, a caution area at the same place can be activated. Then, for the fact, the control technology provides that the robot moves further at extremely diminished speed. If the employee withdraws, alarmed by a warning signal, the robot goes on working at normal speed. Only if the employee enters the immediate danger area, an emergency stop occurs. Thus processes can be steered precise and adaptable protected.

3. TRENDS IN THE PRODUCTION – INDUSTRY 4.0

The basic discussion about working forms of the future production becomes discussed today increasingly in the scientific circles [4]. During the last years and decades, new technologies and working forms become a part of the modern production in developed countries. Thus modern supportive devices as computer, mobile devices, social networks and collaborative real time signals are not to be thought of today. But these developments have still passed the production work to the greatest possible extent without a letting trace. The development during the past decades was stamped, above all, by two movements. On the one hand repeatable and automatable tasks with rising complexity become automated. Besides, robust and holistic production systems (HPS) have been introduced. Both developments – automation and HPS – have reached a high market penetration and today they stamp the production processing trade. In the course of an increasingly stronger adjustment of the production in the actual customer requirements (Mass Customization) and by it, the resulting variation creation, processing time and production batches have been reduced [1]. In Germany this development is accompanied by traditionally strong trade unions and in total a productive dialogue for the social partners in one very middle-sized company coined enterprise culture. Derived from the trends in the production in the study made by [5] experts have been questioned, which challenges by their opinion will particular stamp the future production. In the sum three subject fields have been highlighted as very and urgently important. Some quotations by the experts highlight this [5].

1. Contact with complexity

»The competitive advantage will be in the future, the control of complexity and complicated technologies together with the necessary know-how.« Klaus Bauer, head of the system development base technologies with TRUMPF Werkzeugmaschinen GmbH + Co. KG.

»The higher the product variety and the more slightly the production batches, are the higher becomes the expenditure for a central control of the production. By decentralized systems we can reduce the complexity.« Wolfgang Wahlster, chairperson of the management and technical-scientific leader of the German research Centre for artificial intelligence.

2. Innovation ability

»Germany will have no other way, as to always have the innovation nose one inch ahead.« Manfred Broy, Technical University of Munich

»Most people do not recognize the fact, that the technology development runs exponentially and what actually this means. People try to look to the back and then extrapolate linearly: if in the last ten years this and that has happened, this will presumably happen during the next ten years. This is a huge blunder and many industries thereby sleep away what actually, really happens.« Dr. Wieland Holfelder, Engineer Director & Site Lead at Google Germany GmbH.

3. Flexibility

»We will have to react much more at short notice to things which happen. Therefore we have relatively fast to condense our data and process them in order to come to decisions«, Dr. Manfred Wittenstein, board of directors for technology and innovation with the Wittenstein AG.

The progressive development of the information technology and communication technology (ICT) has ensured, that meanwhile also in the area of the production highly competitive and favorable sensor and actor systems are available. These move again the application of real time information in the field of vision of the production. Under the catchword "Industry 4.0" at the moment, developments about the production area become discussed, consisting out of intelligent, self-steering objects. Examples of such Cyber-Physical-Systems (CPS) are arrangements, containers, products and materials. In a vision of the penetration of this approach, the processing machines are becoming to self-steer themselves independently by whole value added chains, they book the material necessary for production process and organize independently the delivery to the customers [2]

5. INDUSTRY 4.0 AND THE MASS CUSTOMISATION

Mass Customization (individualized mass manufacturing) is a production concept in which on the one hand the advantages of the mass production as scale effects, experience curve advantage or automation are used, on the other hand, this concept is dedicated to the growing request of the customer for individualization of the products [7]. According to the opinion of economic experts, demands for the production will also further rise in the future. By Mass Customization and rising flexibility of the products the variation assortment and with it the product variety will rise massively. As stated by M.t. Hompel (Fraunhofer IML) in regard to the challenge for the industrial location Germany »The necessary mutability will not be able to be mastered in the future production with the classical instruments any more. Enterprises will earn money with the fact to be quicker and more changeable as the other« [8]. In addition, almost all experts see in the individuation of products an essential unbroken trend which will also continue in the future. As stated by T.Feld (Scheer Group) »The observable trend, is the turning away from the mass production to the individual production up to the microproduction. We have here more and more autonomous systems which are able to produce also very small lot sizes«. As stated by the K.B. Trumpf, visionary and head of system development at Werkzeugmaschinen GmbH + Co. KG »Industry 4.0 does not address exclusively the mass production, but above all the flexibility of the production. The intelligent factory of the future is highly adaptable, highly productive and resource-saving. Thereby the individualization (lot size 1) to the economic conditions becomes the reality of the mass manufacturers«. The experts agree that the in-flexible automation solutions which have unfolded her productiveness primarily in the mass production, are not economic in the developed industrial nations any more [5, p.37]. As stated by T.Bauernhansl (Fraunhofer IPA Institute) “The adaptable automation plays thereby a very big role and this is possible only in connection with the people«. It means that there is necessity to digitally connect the people with the production process in real time. As stated by W. Wahlster, Director and CEO of German Research Center for Artificial Intelligence »In our Smart Factories we will produce competitive hybrid products: of course no trivial products for the mass market, but complicated, extremely high-quality products in which the IT innovation portion will be very high on account of a huge number of embedded and linked up microsystems« [5, p.121]. Concluding one can say that the Industry 4.0 supports the individualization of a product. However, the trend will be the movement from the mass production to highly productively and resource-saving individual production or micro-production without significant losses which would be otherwise to be compensated by scale effects.

6. INDUSTRY 4.0 HAS NOT YET ARRIVED AT ENTERPRISES

The questioning done by [5] has proved that the concept Industry 4.0 has not reality arrived at enterprises yet. Thus 60.3% of the questioned enterprises have not heard about the core concept of the industrial 4.0 debate and CPS, only 24% of the questioners have incompletely heard about CPS. Just once 15.7 % of the questioned enterprises have been extensively informed about CPS concept and its meaning.

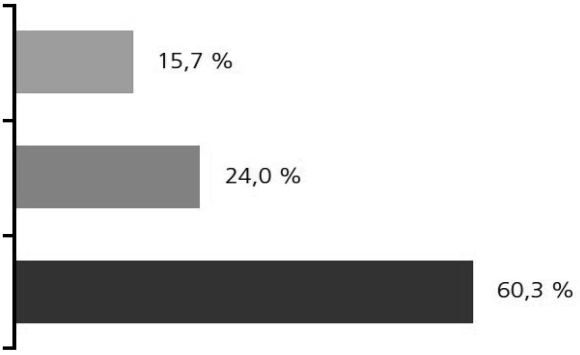

Fig. 3. Knowledge about CPS

Even less spread are enterprises which produce products with CPS. Just once 4.2% of the interviewees produce products with integrated CPS. More than 86.2 % produce

no products with integrated CPS – or according to own information do not know that they do this. 9.6 % are partly using integrated CPS.

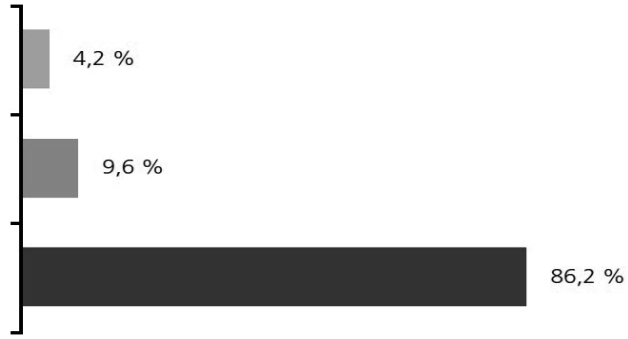

Fig. 4. CPS Production

The one of the basic ideas of the industry 4.0, is to use the new possibilities of the interlinking in the production. Many of the ideas are not new and became a decades before already discussed under the catchword CIM 2.0. An important difference to the CIM 2.0 is the approach realized by distributed, intelligent objects in order to realize decentralized control, which is able to make the local decisions [6]. On this occasion, holistic system is not given by a central system but by decision-friendly decentralized system. An example is given in the following figure.

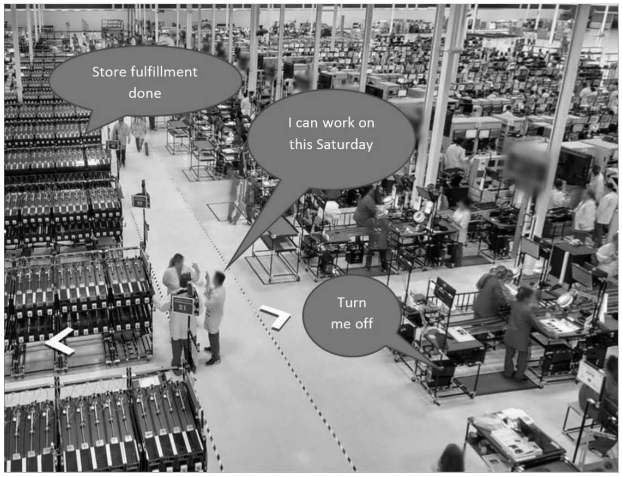

Fig. 5. Inside of Industry 4.0 plant

Industry 4.0 partly exists today. In today's contemporary production plants there are many elements of it. Until the existing and new parts unfold their effect as an entirety, however, it will last a little bit. Of course the subject security also plays an important role within it. However, the security subject is not treated as a real obstacle. As stated by many experts, enterprise must live first with the fact that, like in all IT systems, a hundred percent security in such Smart Factories will not be given. However, a professional protection of the Internet of the Things in the factories is absolutely possible [2].

5. CONCLUSION

Based on example of modern tools for realization of flexible and secure "human -machine" or "human-robot" interaction as a part of the production process today on the one side and the evaluation of the trends in the production by the analysis of the experts statements on the other side, this paper gives a insights about the state of the development of the Industry 4.0. In order to stay competitive, enterprises have to “catch the train” of the development of the production in regard of Cyber-Physical-Systems. The future role of the people in the fully automated production in regard of the development of the information technology is one further topic of research which can meaningfully contribute to this work. The future trend of the Industry 4.0 will be the step forward from the mass production to decidedly productively and resource-saving individual production and microproduction deprived of noteworthy losses which are in regular case compensated by scale effects.

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