Chapter

Stabilization of Digitized Processes

Felicita Chromjakova

Abstract

Stabile production processes are oriented on flexible production process; they enable implementation of digitized concepts in real production technologies. The presented chapter describes research results oriented on actual state mapping in selected industrial companies, with core orientation of people engagement in core processes connected with production digitization. Quantitative and qualitative research by selected industrial companies was realized in combination with hypothesis testing and verification. Core research problem of the presented chapter is the compatibility between employee and cobot by workplace from the ethical point of view. Based on analyze of selected workplaces in industrial companies were identified crucial decisive parameters of effective cooperation between human and cobot with subsequent formulation of conclusions for setting the rules of ethical mutual cooperation "human-robot" by production workplace. Radical innovations in industrial companies connected with the integration of cobot technologies in the production processes are strongly connected with the aim, to give the stability in the mutual connection between employee and cobot. A model of standardized co-operation between human and cobot will be presented; it is based on the key elements of the standardization process. This is a new point of view on the ethics of the workplace, where the "human-machine" cooperation replaces the cooperation model "human-cobot."

Keywords: process, stability, Industry 4.0, performance, standardization, efficiency, human, cobot

1. Introduction

Radical innovation of industrial companies, connected with the integration of human-cobot technologies are strong connected with the requirement to give the stability in the mutual cooperation. Cobots are playing an important role in the process performance, productivity and efficiency of production process. A lot of industrial companies' architects are oriented on the ethical workplace conditions, the vision is to develop the "right" cooperation climate by production human-cobot organized workplace. Already in 1921, the Czech author Karel Čapek mentioned the term "robot" for the first time. His vision was to replace complicated human work with technology that can perform well-chosen work performance while replacing a person with equal work performance. The first consideration was frustration of a worker who began to compare his work performance with the cobot performance. Second, an important vision, it was important to begin use the cobots for dangerous production jobs or for routine production workplaces with extreme physical or psychological stress on the person and body at work—something in the sense of effective and flexible replacement of human by production workplace. Human should cooperate with cobot (or intelligent machine) only by exactly defined technology interconnections. Basic assumption of this interconnection is standardized human intelligence and digital technology intelligence.

In modern industrial company's we face daily the problem of responsibility for the implementation of standardized workplace performance. The crucial research question is, how to deal the ethical aspect of production process stability and responsibility for the required process output. Is the responsible person responsible for the output assigned to perform the performance, or it is the cobot, who is responsible for the output assigned?

The sensitivity on productivity and quality of work performance is therefore on of the cornerstones of stability of digitized processes. An important phenomenon in this context is how we look at the complexly production process productivity and the process stability of human and cobot.

Crucial questions of today's production processes in industrial companies can be summarized as follows:

- how can we analyze the production workplace according the standardization of mutual cooperation between human and cobot?
- are we able to identify core pillars of effective and ethical cooperation by workplace given as a combination of human and cobot?
- it is possible to design the optimal standard of production workplace according the ethical human-cobot cooperation?
- can we apply the same rules to assessing compliance of job or workplace standards for human and cobot?
- which type of competencies and responsibilities are identified by human and cobot in the stabile digitized processes?

2. Theoretical background of digitized process stability

An important part of today's standardization procedures in industrial companies is the accent on the optimal human—cobot interaction, controllable sensors by human and cobots, flexible jobs layout organization between human and cobot and at the end the requirement on the optimal level of emotions given by process realization on the site of human and cobot. A lot of authors published interesting facts according organization of combined assembly processes oriented on achieving flexibility by defined production volume and product tolerances [1]. Some interesting research studies were made according to the multidimensional computing integration by production workplaces. Implementation of Industry 4.0 concept changed radically the requirements on the level of digital literacy, skills and cooperation possibilities by human and cobot. Used qualification matrix and other layout shop floor design tools were transferred in autonomously working digital managed systems. Ethical consideration of this change is now the design drivers with the limit of design space. We can see in theoretical studies, that the interconnected cyber-physical systems have integrated the new complex software and knowledge systems, oriented on the intelligent human and cobot automation, connected with digitized performance monitoring [2]. Many enterprises are working toward the goal of work optimization, in which human and cobot work together and automation is achieved through the development of intelligent machines. These intelligent self-learning systems are driven by cloud computing, breakthrough in sensor technology and the algorithms that hammers the power of bit data. Progress in robotics and artificial intelligence will change the workplace and employment law.

Important part of research contributions in this area is oriented on the human experiences and cobot support of production operations by workplace [3]. Autonomous systems have the potential save the important past process experiences, next to use these for process learning and virtual reality setting [4]. The process of workplace learning will go in new age, where the human and cobot have the same responsibilities as the pillars of stabile production process [5]. The human vulnerability can be measured through the feeling of safety by workplace and by future expectations. Main goal there is the replacement of routine human tasks through cobots and intelligent machines [6]. In recent years, we concern out attention in this area on the ethical production systems, while the production process is not only a technical matter, but collaborative human-cobot system [7]. Under systems components we manage in our digitized time the unique properties and abilities added to human and cobot, these are responsible for decision making in real time and by defined workplace [8].

Basic definition of ethics is in production process primarily oriented on the habit, which integrates the philosophy of wisdom and satisfaction with realized job output. Transformation this definition on the stabile digitized process conditions means to reflect the following parameters of human-cobot workplace:

- workplace layout—core content of value added by workplace
- production job description—knowledge of task realized by jobs
- human-cobot production operation standard—job self-realization by flexible defined production standard
- workplace productivity—"human-cobot KPI's" competency and responsibility

An analysis of the stabile digitized workplace lead our attention on the managers, legitimate activities and technical qualification of human and cobots [9, 10]. We can call it as "biodesign" [11], this refers to new way of living organism as essential component of stabile digitized production technology. Now the motivation and improvement efforts is given by behaviour (human, cobot, information) and recognition programs are the completely impersonal processes [12].

3. Data analysis of integrated "human-cobot" workplace

Production system oriented on the implementation on Industry 4.0 concept must fulfill following parameters:

- Information background—integrated information systems should create virtual reality managed by digital technologies in real time and place
- Communication platform—machines, technologies, processes, information and material flows should connect effective virtual information world with real technological world

- Operational management—optimal performance of production system in according to the problem solving and decision making with right integration of human
- Production management—integrated value chain oriented on the standardized decision making and autonomous operability of production components
- Data security of integrated systems
- A high degree of reliability and stability of realized production processes without integration barriers
- Production systems IT maintenance
- In according to the proposal of process stabilization model we identify following testing hypothesis:

3.1 Industry 4.0 concept bring the expected cumulative benefits from digitization in the form of lower costs and increased revenues

Our survey was realized in 120 industrial companies in Czech and Slovak Republic (40% automotive, 30% mechanical, 20% external supply for automotive, 10% other industry) (**Figure 1**).

Results verified mentioned hypothesis and showed, that positive cost regulation and revenues management lies in in optimal combination of advanced connectivity (14%), better "internet of things" services (26%), computer integrated processes (35%), cloud computing and advanced automation (15%) and user-friendly process standardization (15%). Right combination of all mentioned parameters secures and bring the potential of lower cost and increased revenues.

3.2 Industrial company has identified the core processes for implementation of Industry 4.0 concept

Verification of given hypothesis has brought a clear signal to the issue of identification of key business processes. The hypothesis was not confirmed, because all companies have identified key processes mostly in relation to the production process (horizontal core processes), but not in according to the implementation of Industry 4.0 concept as supporting managerial company process (vertical processes). In according to the identification of core processes we mentioned by our survey the fact, that a lot of people in industrial companies have a problem with right understanding of the "process" definition. Traditional we are oriented on the production processes, supporting processes or we distinguish between managerial or operational processes. In the environment of Industry 4.0 concept we should make radical change in our thinking, because we are speaking about digital company—digital culture—digital processes. According to this fact we speak about new type of "process content" according to the digital enterprise environment. From our survey, we achieved secondary the following knowledge: most industrial companies have respect before traditional enterprise culture, standards infrastructure, intellectual property protection by workplace, personnel leadership and coaching. This is in direct correlation with traditional model of personnel security or personnel integrated management and decision making processes. By mentioned processes was the responsibility and delegated competencies by human, now in the Industry 4.0 concept there is necessary to transfer all important operational business

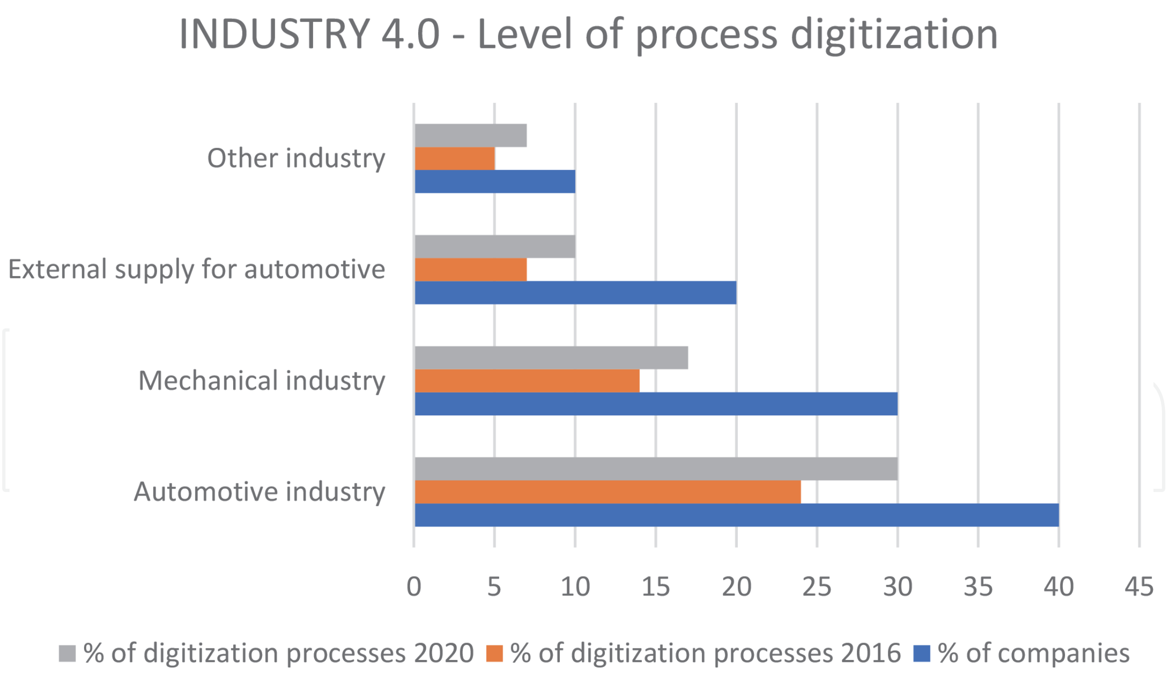

Figure 1.
Industry 4.0: level of process digitization—comparison 2016 and 2020 (source: author).

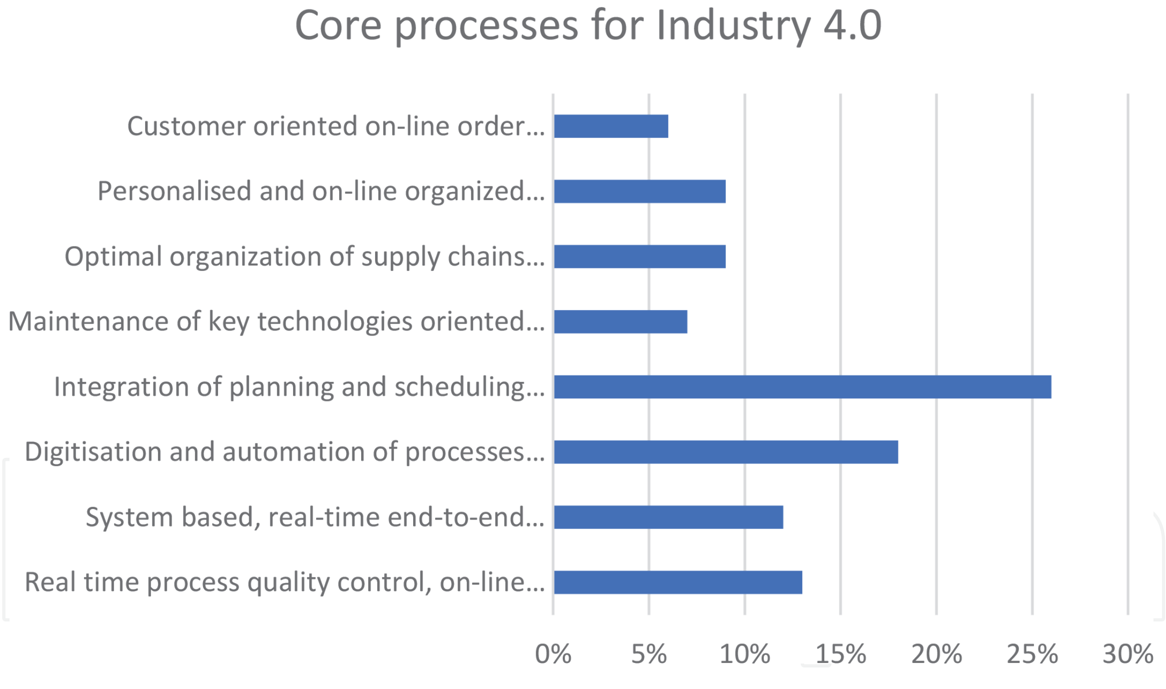

Figure 2.
Identification of core processes for Industry 4.0 implementation—process standardization and stabilization (source: author).

competencies, responsibilities connected with production processes planning, scheduling and organization to the computer technologies and digital processes (**Figure 2**).

3.3 Industrial company has a clear vision about process steps and core process stabilization pillars before the implementation of Industry 4.0 concept

A lot of companies have clear vision about content of Industry 4.0 concept, they are waiting on positive experiences from other companies, that absolved first stages of implementation process. The realized questionnaire showed the accuracy of given hypothesis with an important signal to give to the companies more knowledge and skills from successful industrial companies having experiences with first implementation steps.

Where is in enterprise competent to identify the vision and define process steps of Industry 4.0 by concept implementation? This was our principally question during realization of our research in industrial enterprises. Basic impulse for this question was the fact, that we know responsible person as a director in each enterprise for the production department (evtl. production process), but we do not know the director for implementation of supporting business processes—for example—for implementation of new IT projects. In more companies, we found during our survey product responsible person for implementation of IT project (78%), in better case for implementation of Industry 4.0 concept (14%). From point of process stabilization this is a crucial moment, because nobody from product managers cannot be responsible in industrial enterprises for combination of horizontal and vertical integrated processes. Firstly, as we can see, we should identify right person, which will be responsible complexly for the process of Industry 4.0 concept preparation and implementation (**Figure 3**).

Standardization of workplace according to the job layout, combined as "human-cobot," evokes optimal time management (possibility to cancel job when it comes to overloading or defect). It reflects the combination of integrity, security, safety, accountability, equitability and altruism components. The single most important factor in job performance and advancement is emotional intelligence [13]. Goleman mentioned in accordance to the ability to learn on the job the following parameters:

- listening and oral communication
- adaptability and creative responses to setbacks and obstacles
- personal management, confidence, motivation to work toward goals, a sense of wanting to develop one's career and take pride in accomplishments

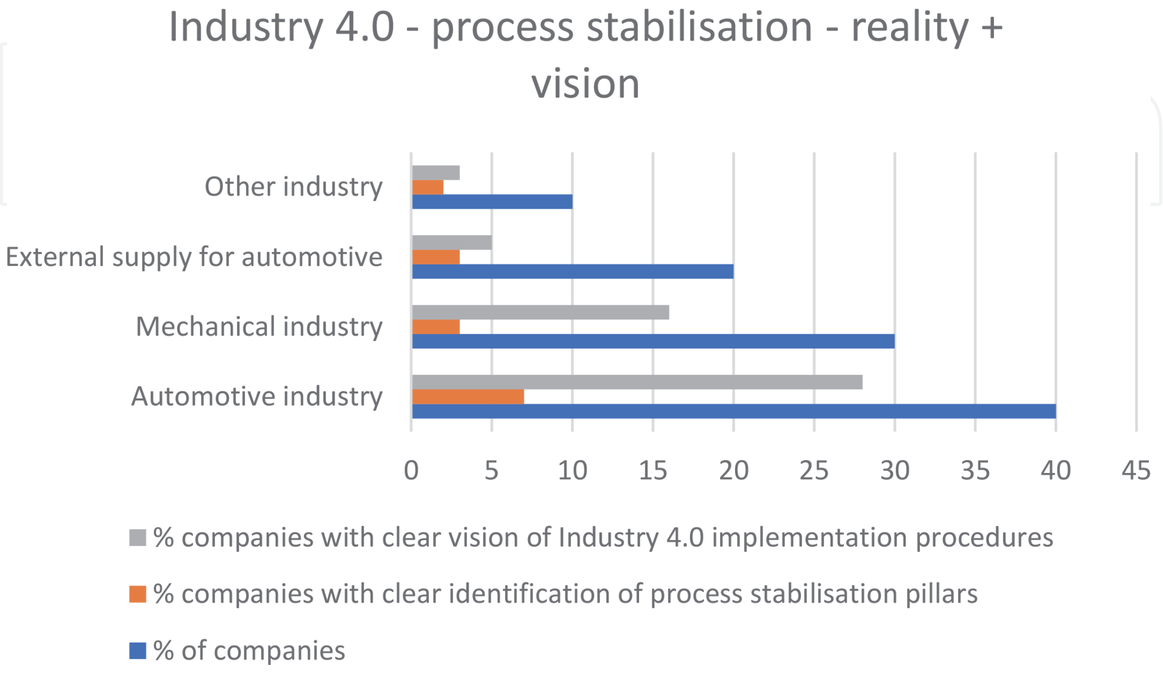

Figure 3.
Industry 4.0: reality + vision—comparison between number of industrial companies (source: author).

- group and interpersonal effectiveness, cooperativeness and teamwork, skills at negotiating disagreements
- effectiveness in the organization, wanting to make a contribution, leadership potential

Tested hypothesis:

1. **Workplace layout:** Precise job standardization and standardized layout is the most important assumption for ethical and effective "human-cobot" workplace layout (**Figure 4**)
2. **Production job description:** Knowledge of tasks realized by jobs has an impact on operative ethics and productive soft and hard cooperation between human and cobot by workplace (SMEs total number 250)
    - adequate personification of tasks realized by job and on-line organized communication and management of production processes—247 companies
    - digitization and automation of manufacturing processes—137 companies
    - flexible real-time production management by workplace—198 companies
    - on-line reception and production organization based on customer order specification—211 companies
    - continuously production flow without human obstacles or cobot conflicts by workplace—167 companies
3. **Human-cobot production operations:** People engagement into the digital organized production workplace or standardized layout design has an impact on operative ethics and collaboration with technologies (**Figure 5**)

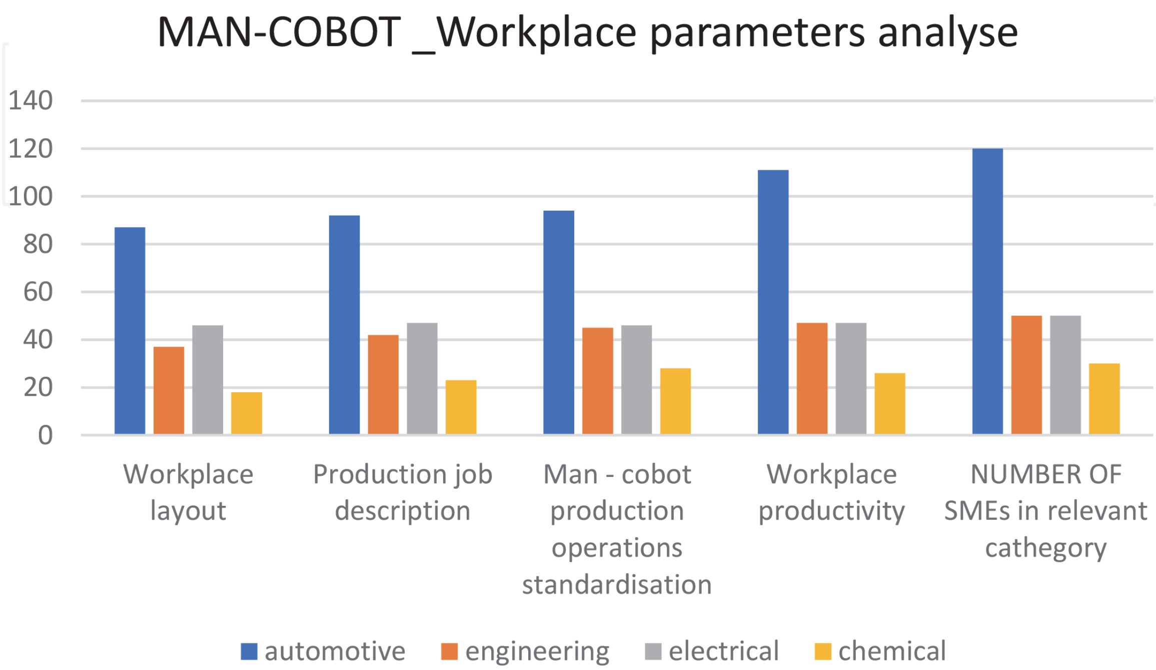

Figure 4.
Analysis of workplace layout (source: author).

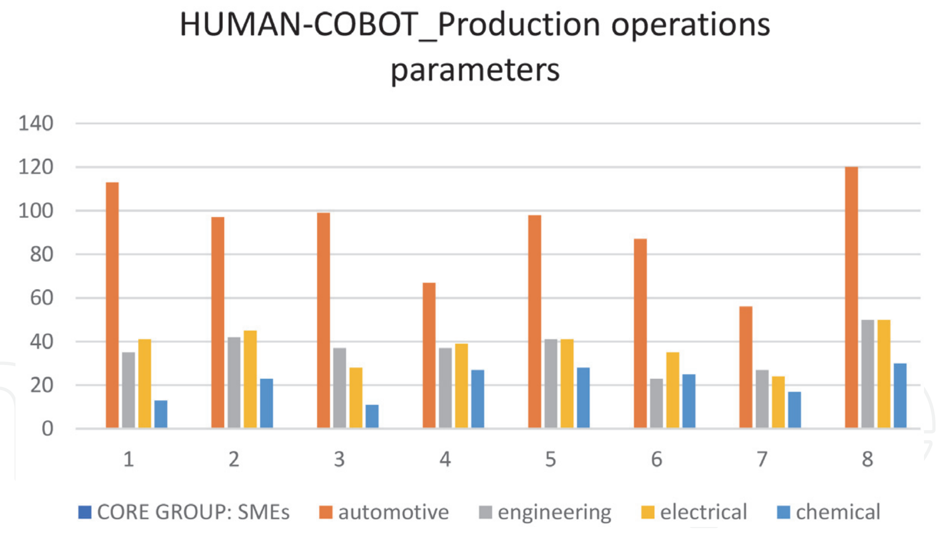

Figure 5.
Analysis of human-cobot operations (source: author): 1—comprehensive digital process map and digitized management; 2—optimal functional coordination of tasks realized by workplace; 3—defined on-line prioritization of operations and tasks; 4—flexible cooperative scheduling in real time; 7—clear standardization of ID production tasks codes; and 8—on-line digitized feedback "workplace-customer-supplier."

4. **Workplace productivity:** Virtualized knowledge and skills strong connected with the required level of mechatronics digital literacy have relevant influence on the performance KPI's connected with ethical standardized workplace "human-cobot"

Used KPI's by selected SMEs (250 companies):

- Availability of continuously production flow by "human-cobot" workplace:

$$\text{ACPF} = \text{PD–ST} - \text{PSM} \quad [\text{minute}]$$

(PD—planned time of availability, ST—service time, PSM—preventive service maintenance)

- Throughput time of e-process operation

$$\text{TePO} = \text{IITS} + \text{DeOP} + \text{WTSR} + \text{IINO} \quad [\text{minute}]$$

(IIS—instruction input time in the system, DeOP—duration of e-operation, WTSR—waiting time on system reaction, IINO—instruction input time for next e-process operation)

- Average reaction time of the system incident

$$\text{ARTSI} = \text{TSU–ID–IE} \quad [\text{minute}]$$

(TUS—time of system unavailability, ID—incident diagnosis, IE—incident elimination)

- Index of data completeness availability for process realization in Industry 4.0 system

$$\text{DCA} = \text{SRDO}/\text{RDI}$$

(SRDO—number of successful realized digitized operations given into systems as requirements, RDI—returned no realized digitized operations)

- Motivation factor for standardized "human-cobot" standardized ethical workplace:

$$MCSF = Xm_{proc} + Xm_{prod} + Xm_{pers}\ (MCSF = 1,0)$$

(Xm_{proc}—process motivation level, Xm_{prod}—product motivation level, Xm_{pers}—personality motivation level)

0,5 level of X:
full completion of tasks integrated in human-cobot system, null level of changes or mutual personal/system conflicts (100% satisfaction).

0,4 level of X:
completion of tasks in limit given by time, amount of transactions given to the e-process or system (80% satisfaction, 20% of small disruptions or conflicts, may be waiting on the system answer or delivery of right information from other worker integrated in "human-cobot" system).

0,3 level of X:
average completion of tasks by given production plan (50% satisfaction, 50% registration of process conflicts—bad order specification, late order entry, prioritization of order in 1 hour, conflicts by persons or system settings).

0,2 level of X:
small level of mutual information exchange between staff integrated in "human-cobot" system (20% jobs realized by plan, 80% of conflicts or absenteeism of right setting of e-connections in information systems and communication channels by machines.

4. Model—stabilization of digitized processes

Flexible ethical and standardized production workplace is determined by functional "code of ethics." In many companies, we have led a highly productive discussion on the issue of the equality of working standards for workers and robots. As a result of the whole series of discussions, the standard structure of working standards for both categories should be maintained. The outcomes of these discussions were a catalog of prerequisites for the creation of an ethical standard of workplace (**Table 1**):

Next, we were identified the crucial pillars of ethical production workplace standard:

- knowledge of stabile daily structure of production program and available production technologies (elimination of daily changes in production program and higher flexibility during weekly structuring of production program)

- certainties that the stocks intended for the production process are actually available (material, staff, information, standards, layout, material flow, etc.)

- setting of clear productions and supporting processes for selected e-technology with regard to the allocation of responsibilities of specific staff (alternative for each shift individual responsible person with clear own e-code in information system)

Identification of all core process components integrated in Industry 4.0 concept
Availability of all required functionalities of computerized and digitized technologies
Number of available services integrated in digitized data and cloud system
Number of intelligent drive units integrated in the Industry 4.0 concept
Defined technical functionality, virtual functionality, communication capability and model process structure
Communication ability verification by each Industry 4.0 system component
Standardization of e-connections, standardization of input and output process parameters
Number of objects managed through digitized technology in one e-chain (ID-chain) and by one ID-administrator
Number of process conflicts in pre-implementation stage of Industry 4.0 concept (technical conflicts, technological conflicts, interface conflicts, data cybersecurity)
Number of total digitized processes in production
Number total digitized machines integrated in Industry 4.0 chain
Defined human responsibility for each process component integrated in the Industry 4.0 chain
Throughput time of production process before Industry 4.0 implementation
Throughput time of production process during Industry 4.0 implementation
Real time of system communication by realization of production process through Industry 4.0 system
React time on delivery of system components availability for realization of production process after input of customer order into system (specification and commitment of customer order)
Operative cost for order processing in digitized environment
Testing and validation of digitized processes in according to the flexible planning and organization of production process
Ability to re-plan the production process virtually by given instructions through ID competencies for flexible production organization
Availability of all relevant data and on-line data corrections availability in integrated process components
React time on process defect in system between process component owner (ID) and digitized workplace in production (identified by ID)
Grade of standardization of interfaces and abilities of units for and digitized regulation of flexible production system
Number of domain borders integrated in digitized environment for production system
Stability and security of defined standards, technological and technical rules, mutual process e-communication and e-management
Number of digital certificates for authentication of realized operations
Number of identities with login data for maintenance and management of operational Industry 4.0 system
Definition of system responsibilities for human—guaranty of system timeliness and usability
Number of virtual instances for recovery functions and security incidents elimination in Industry 4.0 system

Table 1.
Catalog of prerequisites integrated into ethical workplace standard (source: Author).

- readiness of actual dates on daily basis for production planning in information system (motivated man has all necessary information available in right structured information system, he does not need manually or with big time wastes looking for all necessary dates)

- adequate working conditions by workplace for seamless realization of production planning and control (availability of databases, knowledge of performance and technological parameters by e-machines, standards for e-oriented production planning and control, software enabled flexible production planning and control in real time, feedback from unavailable machine capacity in information system just in time)

- proper allocation of competencies and responsibilities by staff linked in a process planning and control network

- possibility (competency) to influence selected parameters of e-technologies by customer requirements in real working day (in cooperation with IT-engineer)

- real feedback from workplaces about realized production losses in information system (realized production amount, re-work pieces, re-typing times, cycle times, maintenance times, etc.)

- competency to stop the production process by the system failure and active corrections in process management system as a preventive action

- possibility of self-realization by planning—realization—control of production system in according to balancing the performance management system and innovations given for higher profitability of this performance management system (**Figure 6**)

As core processes were identified following:

- Integration of planning and scheduling processes

- Digitized automation of processes

- Real time process quality control, on-line monitoring of production and manufacturing dates

- System based, real-time and end-to-end structured processes and activities

- Personalized and on-line organized processes

- Customer oriented on-line order system

- Maintenance of key technologies oriented on on-line principles

- Personalized and on-line organized production planning, control and improvement (**Table 2**)

Emotionally feeling of actual reality by workplace may be connected with overworking, or managing our emotions. Emphatically human by workplace owns the ability to detect what his colleague is feeling. Important question: is this formula valid by robot too? We do not have the same filters that other people do to block our stimulation. As a consequence, we absorb into our own bodies both the positive and stressful energies around us. We are so sensitive that it is like holding something in a hand that has 50 fingers instead of five. What is the difference between having empathy and being an empath? Having empathy means our heart goes out to

Specification of production order	Setting up and digitizing of identification codes for product parts and relevant types of production operations Creating digital bindings of the "product—manufacturing process" Providing comprehensive digital inputs and outputs
Production portfolio management by production cell	Identification, setting up and standardization of the collaborative platform for the digitally controlled manufacturing process Flexible simulation of the production process Database of availability and performance parameters of production technologies
Production planning and scheduling	Setting up and standardizing the platform and procedures for digital decision making Personalization / Setting up the e-carrier of digital links Install and manage cloud storage of production data
Flexible job organization	Multi-level, digitally-organized production scheduling in real time Organization and administration of data analytics in real time Creating online error identification and fault elimination
Production process realization	Online Workplace Performance Monitoring Scheme Optimizing material and information flows Digital management of production processes
Customer satisfaction	Setting up a digital protocol for testing the quality of the manufactured product, the production process being carried out Creation of digitally controlled process improvement systems

Table 2.
Production standard core content (source: Author).

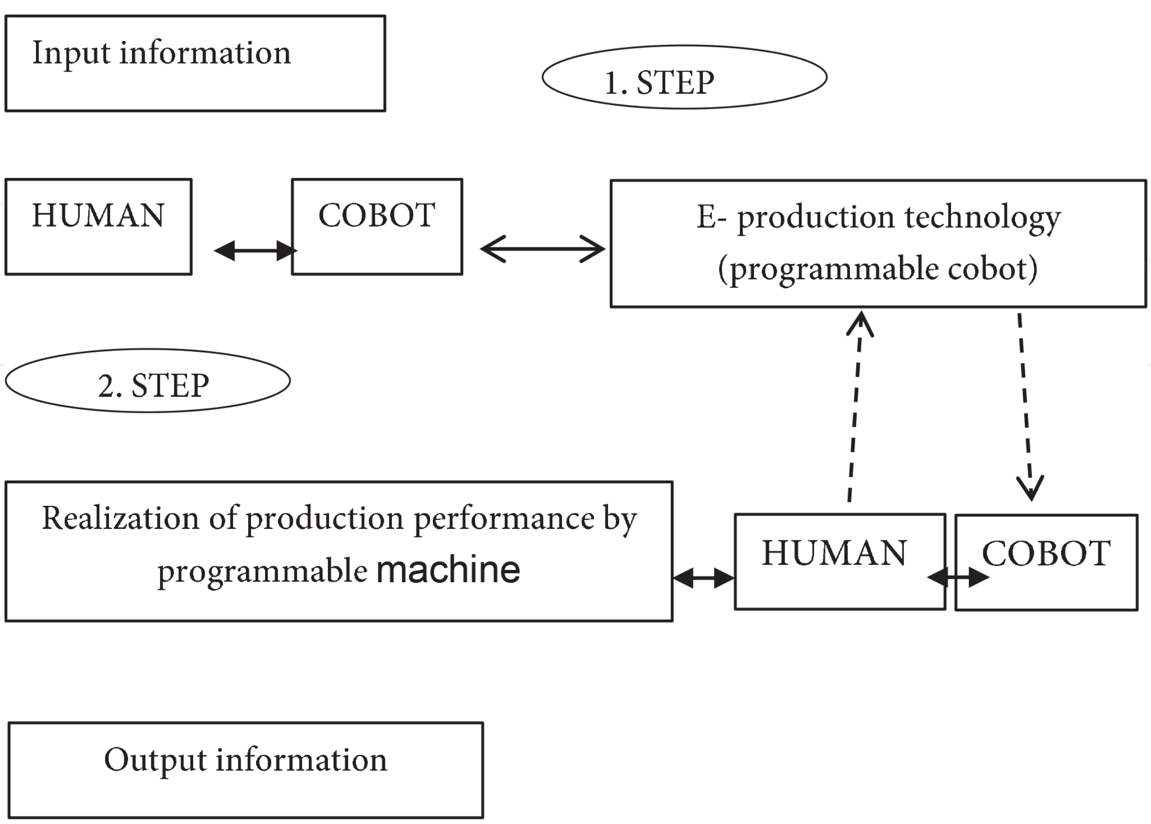

Figure 6.
Schema of mutual cooperation "human-cobot" (source: author).

another person in joy or pain. But, for empaths, it goes much farther. We actually feel others' emotions, energy, and physical symptoms in our own bodies, without the usual defenses that most people have [14].

We are supersensitive to their tone of voice and body movements. We can hear what they do not say in words but communicate nonverbally and through silence. My partner robot should understand the social situations by workplace and bring the energy to understanding of human sensitivities. Empaths are usually more successful in jobs that allow them to work in calm, well-maintained environments within a small team. Empathy goes hand in hand with emotionally intelligence. It is a complex set of skills that, when combined together, set the man up for correct relationships with other and together with yourself. And this is the first step to the self-improvement and self-motivation.

General types of empaths:

- physical empaths—human can identify physical symptoms of other people and tends to absorb them into own body
- emotional empaths—human pick up other people's emotions and can become a sponge for their feelings
- intuitive empaths—human experiences extraordinary perceptions (telepathy, intuition)

Standardly we can speak about normal empath's abilities, when the processes flow is realized continuously, without obstacles or job conflicts. If the people have not an idea, how they can collaborate or communicate in real time with cobots, they become psychologically unstable. Here it is necessary to give attention to the human sensitivity feeling moment—we should learn, how to manage standardly the human empathy, which is responsible for actual performance by workplace. In production standard is than important, to obtain real feedback to the actual experiences from loaded workflow. Man has the possibility to solve production performance defects in real time, he has also an empath to cope with the "just in moment" situation by workplace. Radically so grows his ability to react adequate according to the performance value and quality. Human is by workplace able to understand what the robot are going through in most production situations. Human empathy depends on the fact, if the automatized robot's workflow has the required working sequence as planned:

- parameters of standard construction: mind (mental state) and body (physical state)
- we distinguish next between high sensitive (high emphatic ability) and no sensitive people (low empathic ability)
- important parameter is the "depth of processing ability," which initializes by human the creative potential or ability to think in more dimensions about problem solution, high sensitive people have so good influence on the improvement processes
- big pressure on the performance or higher production value can leads to the overstimulation, which is in strong conflict with high sensitive human by workplace, is not productive and with strong influence on the surroundings (**Table 3**)

SMEs expectations—ethical aspects regarding human-cobot interaction (Analysis of 120 automotive companies CZ)					
Ethical concern	Ethical aspects	USER / OPERATOR ethical standards	MAINTAINER ethical standards	ethical behaviour of the robot itself	human behaviour (SME have ethical standards)
1st level (technical	Integrity	85—full 12—particular 23—next year	98—full 22—particular	76 SMEs accept full	46 SMEs
	Safety	113—full 7—particular	95—full 25—particular	64 SMEs accept full	92 SMEs
	Security	87—full 33—particular	89—full 12—particular 19—future	112 SMEs accept full	75 SMEs
2st level	Altruism	23—full 4—particular 93—next year	56—full 36—particular 84—future	118 SMEs accept full	24 SMEs
	Accountability	85—full 12—particular 23—next year	98—full 22—particular	76 SMEs accept full	46 SMEs
	Equitability	23—full 4—particular 93—next year	56—full 36—particular 84—future	118 SMEs accept full	24 SMEs
	TOTAL ETHICAL OPINION	78 SMEs prefer organized ethical behaviour	112 SMEs will have ethical cooperation of maintainer with cobot and operator		
Preferred attributes for "code of ethics by "human-cobot workplace"		117 SMEs—knowledge and skills of human workplace 95 SMEs—competence and prestige of human by workplace (equal opportunity for human and cobot) 99 SMEs—preparedness to realize performance 120 SMEs—association with competent persons in company (responsible for ethical workplace organization and user-friendly standardization)			

Table 3.
Analysis of SMEs expectations—ethical aspects regarding human-cobot interaction (source: author).

5. Conclusion

We collected qualitative data through semi-structured interviews with decision makers (production manager, CEOs) that are responsible are the acquisition and implementation of the cobots, workers that work side-by-side with the cobots, and through observations and demonstrations of the work system. Key requirements to the ethical standardization of "human-cobot" workplace was identified. Further research will be oriented on the next selected parameters of ethical standardized "human-cobot" workplace as automation, digitization, efficiency, intelligence with core attention given to the boundaries of digitized workplace, information by workplace, human ethical isolation (speaking with cobots), autonomy of workplace and type of knowledge used by human.

Work ethic is correlated with the intensity of firms' incentives. In societies with the wide dissemination of work ethics, firms will want effort to be complementary (as in modern production process), while the opposite is true when the dissemination of work ethic is narrow [15]. In connection to the results, presented in this paper we achieved interesting new knowledge in the area of human-cobot channels communication, identification of self-optimizing potentials by human, motion planning and job coordination as by safety, maintenance and ethical workplace standard diagnose [16–25].

Author details

Felicita Chromjakova
Department of Industrial Engineering and Information Systems, Faculty of Management and Economics, Tomas Bata University in Zlin, Czech Republic

*Address all correspondence to: chromjakova@utb.cz

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