Preparation of Collaborative Robot Implementation in the Czech Republic

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Abstract

The paper is concentrated on the topic of collaborative robots, especially the preparation of their implementation in the Czech Republic. The conditions in the Czech Republic are relevant in the part of the paper concentrating on the analysis of the safety requirements. Firstly, the paper introduces the topic of collaborative robots. They are described and compared with traditional industrial robots. This is followed by an analysis of the safety requirements which are an important base for implementation. Not respecting the safety requirements can have significant consequences for the company. The next part of the paper is the analysis of a company for cobot implementation. There is a description of the important steps for preparation of implementation (company overview, definition of potential workplaces for cobot implementation and analysis of potential workplaces). The last step is the final preparation of cobot implementation into specific workplaces. In this step, the specific cobot and integration company is chosen, then it is determined if the workplace is suitable for automation, and finally the technical implementation solution is created, including the investment calculation.

Keywords
Collaborative Robot, Implementation, Analysis, Safety Requirements and Industrial Robot.

1. Introduction

Nowadays, one of the most frequently mentioned subjects in modern industry is Industry 4.0. It has a significant influence on industry and on robotics, which is as one part of it. The development of robotics has led to a wide range of applications from medical to military applications. One area in industry that complements traditional industrial robots is the field of collaborative robots, which this paper deals with.

The paper is concentrated on the topic of collaborative robots, especially the preparation of their implementation in the Czech Republic. The conditions in the Czech Republic are relevant in the part of the paper concentrating on the analysis of the safety requirements. These conditions are very similar to those in other EU member countries. It could inspire the other countries about what their analyses could concentrate on.

Firstly, the paper introduces the topic of collaborative robots with a comparison between collaborative robots and traditional industrial robots. It is followed by an analysis of the safety requirements that establish an important base for implementation. The next part of the paper is an analysis of a company for cobot implementation. There is a description of the important steps for preparing implementation (company overview, definition of potential workplaces for cobot implementation and analysis of potential workplaces). The last step is the final preparation of cobot implementation into specific workplaces. In this step the specific cobot and integration company is chosen, then it is determined if the workplace is suitable for automation, and finally a technical implementation solution is created, including the investment calculation.

2. Collaborative robots

A collaborative robot (‘cobot’) is an industrial robot that is designed to cooperate with human operators. It is a new trend in robotics.

Traditional industrial robots are big, heavy, strong and robust devices that work on specific tasks. Fences, sensors and signalization are set up around these robust machines for safety reasons. Industrial robots are generally designed to work for people and they perform activities in a restricted area according to relatively complex programs.

Collaborative robots are in comparison designed to work with human operators and create values together. For example, a cobot is able to pick up an object from a box, insert it into a device (a press, etc.), then remove it and put it on a pallet or hand it directly to a human operator.

The distinction between cobots and traditional industrial robots is in their collaboration with humans and their location in the workplace. A traditional robot is limited by safety cages and sensors that are often expensive and prevent easy access, but cobots are accessible for human operators (easier maintenance, lower costs for safety). Cobots are designed to work with their human colleagues and so they are equipped with features and detection sensors that allow them to recognize where the human operators are. A cobot also contains safety features and integrated sensors that stop the motion of the machine when higher resistance or external force is detected. In addition, parts of the cobot (joints, etc.) are made of safe materials to absorb energy in a collision with a person or are covered (completely, partially) by these materials. Some cobots are even programmed to shut down immediately if there is a potential danger to a nearby human operator. This eliminates the need for safety cages. Even if cobots are relatively safe, many safety-related problems can arise during the use of cobots, therefore safety requirements need to be analysed. (Waldman 2017)

Another difference is that cobots can be easily programmed. While traditional industrial robots require advanced knowledge and programming experience, cobots are able to teach themselves. To program a cobot it is enough to perform the required moves with the body of the cobot. It memorizes these movements and then performs them afterwards.

The following table 1 was created on the basis of theoretical and practical information. It shows the advantages and disadvantages of cobots over traditional industrial robots.

Table 1. Advantages and disadvantages of cobots over traditional industrial robots (Waldman 2017)

Advantages	**Disadvantages**
Easier programming	Relatively high price
Easier to control and collaborate with	To reach maximum potential utilization, it is necessary to purchase relatively expensive components and accessories
Easier maintenance and repair	Lower toughness of the device
Higher sensitivity in contact with humans	The robot stops in the middle of operation due to human contact
There is no need to use protective cages or covers	Not very precise and clear legislation for this type of robot
Includes cameras and sensors for detecting objects and people	Industrial application is only 10% compared to traditional industrial robots
Relatively small dimensions (Easier to manipulate with)	
Greater potential in current industry	
No robot overload (resistance, pressure, current sensors)	
Real-time algorithms for settling no-collision paths	
Possibility to purchase additional accessories	

Cobots are used in the following applications (Waldman 2017):

- Packing
- Palletizing
- Machine operations
- Laboratory analysis
- Screwing
- Welding
- Polishing
- Assembly of components
- Product quality control
- Machining
- Pick and Place
- Transfer between workplaces
- Sorting (packaging etc.)
- Circuit board testing

3. Analysis of safety requirements

The first important stage related to preparation of cobot implementation is to ensure that all safety requirements are met. This is done by analysing and implementing all relevant regulations. The regulations mentioned in the article are concentrated on the relevant legislation in the Czech Republic.

There are three important parts of the safety requirements that will be briefly described. The parts are (Waldman 2017):

- Technical standards related to machines
- Legislative machinery regulations
- Technical standards related to industrial robots and cobots.

3.1 Technical standards related to machines

A technical standard is a specification of the requirements related to a product, process or service to be suitable for their purpose under specific conditions. The standard sets out basic requirements for quality, safety, compatibility, interchangeability, health and environmental protection. It is a document based on the agreement of all stakeholders related to the solution. This is different from legislative regulations that may arise without the agreement of all sides concerned.

Technical standards can be generally divided into Czech technical standards and European (or international) standards. Original Czech technical standards can be created only in sections that are not covered by European or international standards.

3.2 Legislative machinery regulations

Legislative machinery regulations relevant to manufacturers that are using cobots are mentioned in this part of the article. The legislative regulations important for the manufacturer are (Waldman 2017):

- Directive 2006/42 / EC of the European Parliament - 17 May 2006 related to machinery and about the change of Directive 95/16 / EC (revised).
- Regulation No. 176/2008 Coll. on technical requirements for machinery.
- Act No. 22/1997 Coll. on technical requirements of products and about the change of supplements to certain laws.
- Government Order No. 117/2016 Coll. on the conformity assessment of products in terms of electromagnetic compatibility when the products are placed on the market.

- Government Order No. 118/2016 Coll. on the conformity assessment of electrical equipment to be used within certain limits of supply voltages.

Manufacturers using machinery devices also have to apply the following regulation:

- Government Regulation No. 378/2001 Coll. on detailing requirements for safe operation and use of machinery, equipment and tools.

3.3 Technical standards related to industrial robots and cobots

The target was to find the legislative information that would define a cobot and regulate its operation. The most important robot and robotic standards are (Waldman 2017):

- CSN EN ISO 8373: Robots and Robotic Devices - Dictionary
- CSN EN ISO 10218-1: Robots and Robotic Devices – Safety Requirements of Industrial Robots - Part 1 Robots
- CSN EN ISO 10218-2: Robots and Robotic Devices - Safety Requirements of Industrial Robots -Part 2: Robot Systems and Integration
- CSN EN ISO 9946: Industrial Robots for Handling - Characteristic Properties
- CSN EN ISO 9787: Industrial Robots for Handling - Coordinate systems and motion terminology
- CSN EN ISO 14539: Industrial Robots for Handling - Handling of Objects Using Grip Modules - Glossary and Characteristics
- CSN EN ISO 9409-1: Industrial Robots for Handling - Mechanical Interfaces - Part 1: Cover Board
- CSN 9409-2: Industrial Robots for Handling - Mechanical Interfaces - Part 2: Shafts
- CSN EN ISO 12100: 2011 - Safety of Machinery - General Principles of Construction - Risk -Assessment and Risk Reduction
- CSN EN 60204-1 ed.2 + A1, Rev.1 - Safety of Machinery - Electrical Equipment of Machines - Part 1: General requirements
- CSN EN ISO 13849-1: 2016 - Safety of Machinery - Safety Parts of Control Systems - Part 1: General Principles of Construction
- CSN EN ISO 13849-2: 2013 - Safety of Machinery - Safety Parts of Control Systems - Part 2: Validation
- CSN EN 1037 + A1: 2008 - Safety of Machinery - Prevention of Unexpected Start
- CSN EN ISO 13850: 2016 - Safety of Machinery - Emergency Stop - Design Principles

The important ones are CSN EN ISO 10218-1 a CSN EN ISO 10218-2 that define the term ‘collaborative robot’. Collaborative robots are part of the general group of industrial robots in these standards. These standards do not specify forces or pressures related to safe contact with the human operator. There is also no specification how to create a workplace suitable for cooperation. This is one of the reasons that companies place cobots in cages or outside the work area of the human operator as stated by the regulations mentioned so far. On the other hand, there is currently a technical specification ISO / TS 15066: 2016 that defines how to design a common space for human operators and cobots. Technical Specification ISO / TS 15066: 2016 is in addition to the previously mentioned standards CSN EN ISO 10218-1 and CSN EN ISO 10218-2.

It is also important to mention the certificate TÜV SÜD, which means that if a cobot is implemented with this certification it is possible to use human operators and cobots together in the workplace. (Poór and Basl 2018)

4. Analysis of a company for cobot implementation

Before cobot implementation can be done, detailed analysis of the implementing company has to be performed. The important steps of the analysis are:

- Company overview
- Definition of potential workplaces for cobot implementation, analysis of potential workplaces

4.1 Company overview

This part of the analysis concentrates firstly on general information about the company and its products. Related to the company, it is important to describe the specific plant for potential implementation. The overview of the plant layout, its components (production/assembly line, etc.) and other relevant parameters (specific conditions, etc.) are described here. The last important part of the company overview is a general description of the products.

4.2 Definition of potential workplaces for cobot implementation, analysis of potential workplaces

Based on production observations, video footage analyses and data sets from the company, it is possible to describe all the activities performed in production. The workplaces with the most potential are defined based on knowledge of the potential cobot activities with respect to company targets.

Firstly, the processes at the workplaces have to be described. This is related to workplace layout and process description (inputs, outputs, activities performed….).

Then a table is created of all the activities performed at each selected workplace, including the time duration. The duration of the individual activities in the tables is obtained from the arithmetic average of several measurements of the activity (values can be obtained by video analysis, etc.).

Important parameters that generally need to be identified (Waldman 2017):

- Number of human operators related to the workplace
- Product description
- Manipulation unit (Packaging…) type
- Total time
- Tact time
- Cycle time

5. Final preparation of cobot implementation to specific workplaces

On the basis of the preceding analysis, the final preparation of cobot implementation process can start. The ideal target situation is that a cobot would completely replace a human operator at the workplace. However, it is likely that complete replacement is not always possible, so a human operator has to continue to perform some of the activities. In this situation, it is important whether or not other human operators in contact with the workplace are fully utilized, so they can support the activities of the first operator. This can lead to a situation where one operator can be replaced by a cobot. So it is not important for a cobot to work faster than an operator, but to replace him. The replacement has to be evaluated by the return on investment calculations.

Final preparation of the cobot implementation process can be divided into the following steps (Waldman 2017):

- Selection of the most suitable cobot and the integration company (the company that implements the cobot) – related to the previously selected workplaces
- Determination if the workplace is suitable for automation
- Creation of technical implementation solution, including the investment calculation, (in cooperation with the integration company)

5.1 Selection of the most suitable cobot and the integration company

The selection of the most suitable cobot is based on the definition of its criteria. The definition has to be done in cooperation with the integration company. An example of the criteria can be (Waldman 2017):

- Local distributor (integration company) – this supports the effective implementation (integration) of the cobot, its service, training of employees in local language, to have all the documentation and software in the local language, etc.
- Parameters of the cobot – to avoid some of the parameters being inappropriate for the selected workplaces.
- Purchase price - the basic price of the cobot without the tools. It depends on the supplier, distribution area, quantity discount, etc. It is also important to note that some suppliers include the basic software, software updates, etc. in the basic price. It is important to note that the full price will be higher because of tools, additional equipment, etc.

The comparison of cobots itself can be done in the table, using a suitable method (scoring method, etc.).

The output of this step is the selection of the cobot and the integration company.

5.2 Determining if workplace is suitable for automation

The analysis of the selected workplace together with the consultations with the integration company leads to determining if the workplace is suitable for automation. Every activity performed at each of the selected workplaces needs to be analysed – to obtain information about whether the cobot can perform the activity instead of a human operator. It can be reported in a table with a list of activities that shows the original and the proposed situation. The original situation means that all activities at the workplace are performed by a human operator. In the proposed situation some activities are performed by a cobot while others are still performed by a human operator (the integration company can help significantly with the identification of activities). It is important to note that some activities will very probably be different from the original situation, as the workplace would need to be equipped with additional features (conveyor, empty box trays, etc.). (Srajer et al. 2011) The Theory of Technical Systems view of the workplace as a product can be used to analyse the workplace. (Broum and Kleinová 2018)

Some activities at the workplace that may be problematic for a cobot, and may make workplace automation impossible. So the technical issues related to implementation have to be examined and reported for each workplace.

It also has to be evaluated whether a cobot will use only one tool or more tools (with consideration of the time required for changing tools, this could be significant). Simulation methods can be used for the evaluation. (Raska and Ulrych 2016)

The evaluation of each workplace regarding automation has to be done at the end of this step. It has to be determined at each workplace whether automation will lead to expected human workforce reduction and if there are not significant technical problems. Usually the condition that has to be met for cobot implementation is that one human operator position is reduced by one cobot.

5.3 Creation of technical implementation solution, including the investment calculation

The basis for this is information from selected workplaces where cobots will be implemented. The list of activities at selected workplaces that will be performed by a cobot and a human operator is provided by the previous step. This information helps with the investment decision in tools and other equipment.

There is a final decision about the cobot tools and additional equipment that have to be purchased. Also, the final conditions for the implementation have to be set (a new conveyor that can be reached by the cobot, etc.). The proposed layout of the workplace is then created with the cobot in its final position and any necessary safety equipment has to be integrated. (Šimon and Broum 2018)

To calculate the return on investment, all relevant costs have to be calculated. Other expected costs can be obtained from the experience of the integration company. These include for example: maintenance costs, etc. (Poór et al. 2016), (Poór et al. 2014)

A costs summarization of all the items on the list regarding cobot implementation has to be made. So the total costs that are incurred have to be compared to expected savings, and the return on investment has to be calculated. (Kurkin et al. 2011) The company management has to make the final decision based on the obtained information.

After this step, the cobot is ready for implementation according to the technical implementation solution.

6. Conclusion

The paper concentrates on the topic of collaborative robots, and especially the preparation of their implementation in the Czech Republic. The paper can be taken as recommended instructions or inspiration for future collaborative robot projects or similar projects related to implementing new technology into production. It shows the importance of the analysis of the safety requirements which establish an important basis for their implementation. Not respecting the safety requirements can have significant consequences for the company. The other parts of paper also describe important topics for the preparation of implementation, namely, analysis of a company for cobot implementation and final preparation of cobot implementation for specific workplaces. Following these steps can significantly improve the success of implementing collaborative robots.

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