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AUTOMATED AND ROBOTIZED WORKPLACES BASED ON INDUSTRY 4.0 WITH FOCUS TO SAFETY ISSUES

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Abstract: *Until now, advances in sensory interaction between people, information, and automation have led us to a technically advanced reality, also called industry 4.0, at all levels of industry. From that point of view and with regards to the personal protection, we consider also all integrated sensor systems to be one of sources for people better working conditions at any level of the automated and robotized workplace.*

Keywords: Robot, workplace, automation, safety, sensor

1 INTRODUCTION

Persons or software tools can access to the process sensors or information about its participating at security features at automated and robotized workplaces from any part of it, depending on configuration, setup, and authorization. In addition to many other safety features, sensor systems generally allow performance optimization through providing of cloud services, whether for maintenance, upgrade, or security repairing from almost all remote location [1].

One part of concept 4.0 focus on communication between intelligent automated and robotized workplaces in order to optimize their own performance based on information about its ambient conditions, e.g. material flow, number of components produced, their quality, specific measured values with data from different types of sensors.

2 METHOD FOR INDUSTRY 4.0 IMPLEMENTATION

A suitable method is control of integrated sensors directly inside the robotic collaborative arms, which automatically stop any movement immediately when external forces are sensed, and when limit values are recorded. Usually, passive methods of sensory protection are solved by external mechanical components integrated into the drive structures of robotic arms, which, by virtue of the acting force; respectively collisions generate movement in the opposite direction to prevent injury. Typical issues that solve safety at automated and robotized workplaces can be seen at Fig. 1. The modern means of ensuring favourable safety indicators in enterprises is a thorough automation of the various types of process. This is most often realized by industrial robots in cooperation with other auxiliary devices [2]. On successful safety design, testing and deployment of these types of automated workplaces into practice is an essential computer support for individual technologies and structures in production and non-production activities.

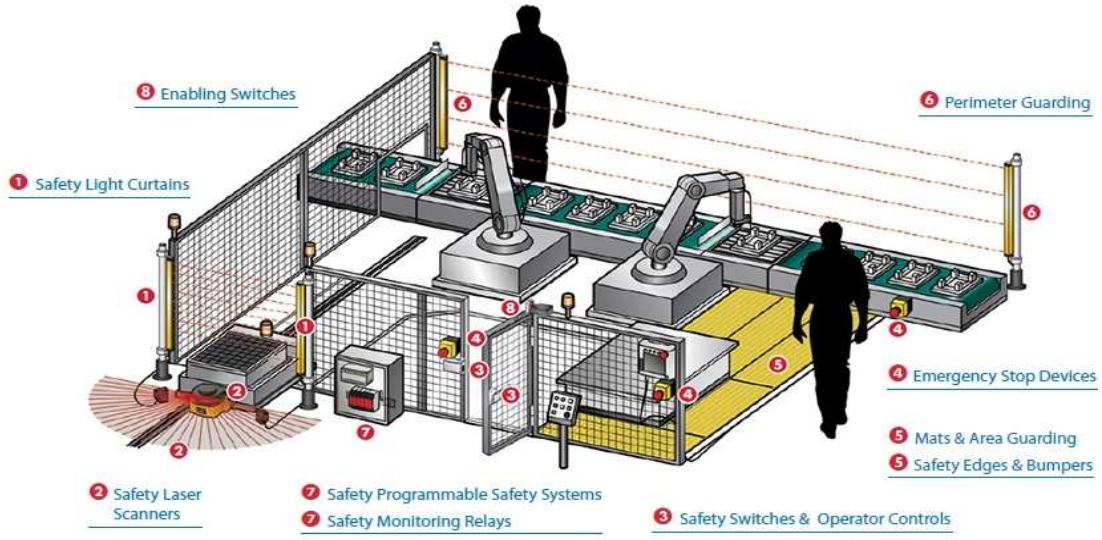

Figure 1 Safety operation at automated and robotized workplace

Safe automation of these processes is based on robotic application with industrial robots that are equipped by 3D camera system and suitable kinematic structures. Safety principles for classic industrial solutions are defined by a safe workspace, with a sufficient distance around the industrial robot, and robot must not be able to reach the operator with his working arm. To ensure 100% safely workplace, it is not enough to determine only working space in immediate close of robot. The operator must be located in such space that robot cannot attach that workspace during program operation or it's incorrectly use.

3 CHALLENGES AT INDUSTRY 4.0 IMPLEMENTATION

Industry 4.0 change the way for cooperation between automated workplaces, so new challenges are emerging that we are already facing into the following:

- *Cyber security*

The underlying principle is that all systems, including automated workplaces utilizing Internet-protocol addresses, are connected to the globally accessible Internet infrastructure. It is frightening to imagine what could happen if a cybercriminal broke into a workplace environment to access and control each and every process associated with workplace local area network.

- *Wireless communication*

Concept industry 4.0 promotes safety wireless communication layer. By its very nature, wireless communication is open to outside influences such as lightning, adverse weather, solar magnetic storms and solar plasma ejection.
Buildings and other workplaces also can pose obstacles; mobile equipment, new construction, vehicles or temporary screens used for maintenance or repair work can interfere with a signal path. Increased wireless infrastructure also raises the risk of intrusion by hackers and terrorists.

- *Real-time constrains*

Industrial automated workplaces require safety real-time reaction, making changes to that workplace is very difficult. Safely downloading the necessary data for workplace operation from cloud requires the workplace's system to access "big data" in cyberspace in real time.
Loading available software patches onto the system's malware scanners and antivirus programs could influence the stability of the process. Any real-time communication must be fast enough to facilitate process automation requirements.

- *Shorter automated workplace lifetimes*

Some safety devices on the market absent with fast enough response to workplace process conditions or sufficient memory capacity in a short time, they will need replacing. Industry 4.0 may actually lessen automated workplace serviceable lifetime that is directly impacting on capital deployed and increasing to operating expenditure.

- *Systematic failure*

Automated workplaces will boast their increased software complexity, due to large measure via powerful new software tools. This means most expected workplace failures will reside in the software lifecycle. In present, we are already depended heavily on software; our dependency will become much greater.
Unfortunately, the reliability of current information technology software is far from perfect. Ultimately, human factors may be the weakest point of Industry 4.0 for safety related automated workplaces.

- *Operation and maintenance*

At present, traditional safety sensors or final elements allow easy diagnosis and timely repair because real-time on-line support from vendors isn't necessary and the operators know how to run their automated workplaces with system data presented in graphics and alarms.

Future will require much more in-depth support by vendors and third parties as the automation complexity increases the need for expert-level diagnostics. Operators won't be able to carry out all tasks and supporting maintenance activities by themselves.

4 INCREASING OF INDUSTRY 4.0 IMPLEMENTATION BASED ON USING SAFETY EQUIPMENT

Way for increasing of a concept 4.0 consists from prediction that the basis of each automated workplace is an industrial robot. Their level of safety is determined not only by their attachment to external safety devices, which are mostly controlled by robot control system, respectively by external PLCs, but also its own safety equipment [5]. These include mainly that, which allows a limitation of workspace area where can be robot operated safely. These devices have the character of a mechanical solution and are located directly on the robot.

4.1 Mechanical end stops

Depending on the robot variant, axis ranges of main and wrist axes of industrial robot are partially limited by mechanical end stops. The axis ranges of main axes A1 to A3 and wrist axis A5 of robot are limited by means of mechanical limit stops with a buffer. Additional mechanical limit stops can be installed on the external axes, Fig. 2.

Figure 2 Mechanical end stops at industrial robot

- If the robot or an external axis hits an obstruction or a buffer on the mechanical end stop or axis range limitation, this can result in material damage to the robot system. Robot must be consulted before the robot system is put back into operation. The affected buffer must immediately be replaced with a new one.

- If the robot or an external axis hits an obstruction or a mechanical end stop or axis range limitation, this can result in material damage to the industrial robot. The manipulator must be taken out of operation and robot must be consulted before it is put back into operation.

4.2 Software limit switches

The axis ranges of all robot and positioner axes are limited by means of adjustable software limit switches. These software limit switches only serve as machine protection and must be adjusted in such a way that the robot/positioner cannot hit the mechanical limit stops [6]. The software limit switches are set during commissioning of a robot system. Example of software limit switches at each axis can be seen at Table 1 and Fig. 3.

It allows the development of dynamic analysis. It allows integrating in the project evaluation the value of the flexibility. It allows the definition of optimal decision taken structures in innovation projects. It allows simulating and incorporating, evaluation management decisions, to the project. It allows the simulation of the decision process along the life of the project.

	Axis 1	**Axis 2**	**Axis 3**	**Axis 4**	**Axis 5**	**Axis 6**
Max. value	74.9	23.8	22.6	43.7	77.3	44.4
Min. value	-174	-43	-28	-31	34	-65

Table 1 Example of software axis limitation at industrial robot

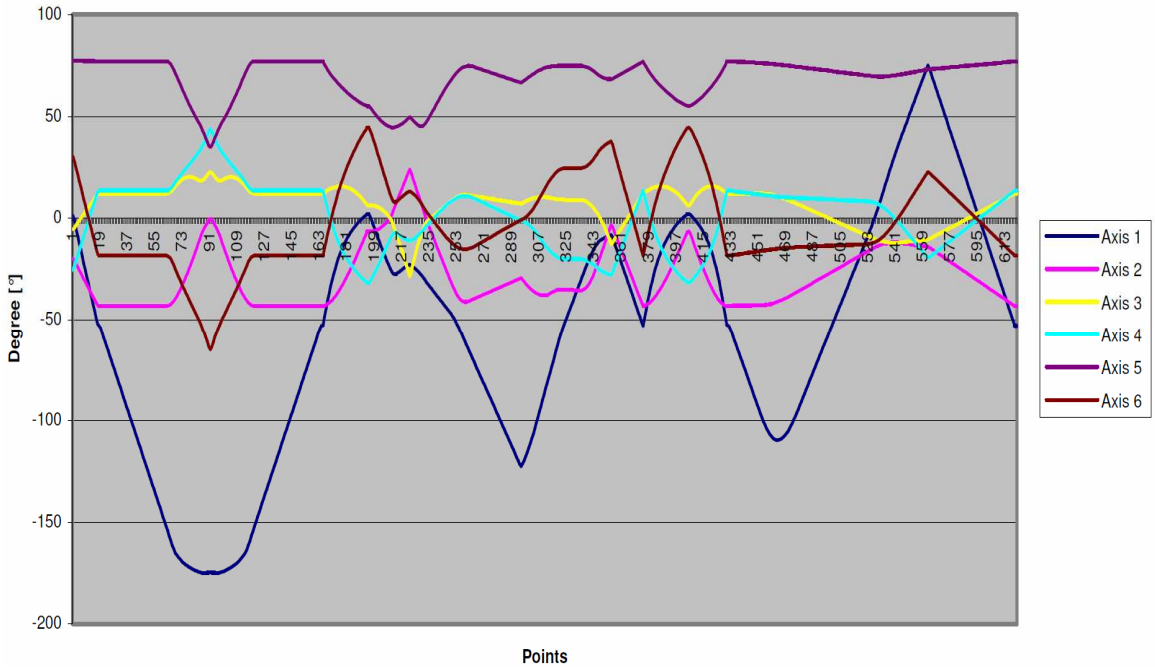

Figure 3 Software limitations of individual working axis at industrial robot

4.3 MECHANICAL AXIS RANGE LIMITATION (OPTIONAL)

Most robots can be fitted with mechanical axis range limitation in main axes A1 to A3. Additional working range limitation can be installed on the positioner axes, fig. 5. The adjustable axis range limitation systems restrict the working range to the required minimum [7]. This increases personal safety and protection of the system. Some robots can be fitted with mechanical axis range limitation in axes A1 to A3.

The adjustable axis range limitation systems restrict the working range to the required minimum. This increases personal safety and protection of the system. In case of robots that are not designed to be fitted with mechanical axis range limitation, the workspace must be laid out in such a way that there is no danger to persons or material property, even in the absence of mechanical axis range limitation.

If this is not possible, the workspace must be limited by means of photoelectric barriers, photoelectric curtains or obstacles on the system side [8]. There must be no shearing or crushing hazards at the loading and transfer areas.

Figure 4 Mechanical axis range limitation

4.4 Axis range monitoring (Optional)

Most robots can be fitted with dual-channel axis range monitoring systems in main axes A1 to A3, fig. 5. The positioner axes may be fitted with additional axis range monitoring systems. The safety zone for an axis can be adjusted and monitored using an axis range monitoring system. This increases personal safety and protection of the system.

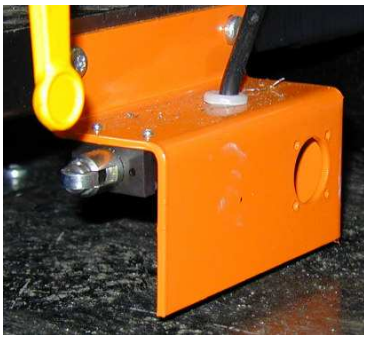

Figure 5 Axis range monitoring

5 CONCLUSION

The automotive industry continues to be a major factor in automation sector in these years and beyond, even after crisis. Key challenges for the successful implementation of Industry 4.0 are the use of new materials, process automation, and especially the demand for "green automation". Above all, it is about promoting resource-efficient technologies. Utilizing the additional functions and capabilities of robotic arms contributes to this innovative direction of automation. The main motivation should be the company's effort not to live at the expense of future generations and to meaningfully reduce consumption over the long term, without seeking a compromise in quality of life.

In a traditional production environment, with lines or cells are frequently geared to manufacture of a single product, the safety of those working in facility is generally straightforward to monitor. A risk assessment of all aspects of the operation – from individual components through to operator 'touch points' with equipment – will create a guide which in theory should remain valid until the use of that line changes or alterations are made to the equipment within it. Immediate hazards can be minimised and risks to operator safety averted, as long as correct procedures are followed.

The automotive industry continues to be the main driving force in the automation sector for the coming years after overcoming the crisis. Key challenges for a successful implementation of industry 4.0 lays in using of new materials, process automation and, in particular, demand for "green automation". This is primarily about promoting of resource-friendly technologies. It is about an innovative solution for automation.

Main motivation for "green automation" is company's effort not to live at expense of future generations, and to reduce consumption in a meaningful and long-term manner without need to seek and compromise on the quality of life.

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