INDUSTRY 4.0 LABORATORY

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Abstract: *Technological developments are fast and at industry level we have fourth industrial revolution going on. More and more new technologies are being applied to production to make it more efficient and more competitive. In order for new technologies to be better implemented and for the end user to be able to apply them to their industry, it is necessary for educational institutions to accompany the rapid development of technology and apply these new technologies in curricula.*

Keywords: ROBOTS, COOPERATION ROBOTS, MOBILE ROBOTS, 3D PRINTING, RFID, MES, ERP.

1. Introduction

As the deployment of robots is a reality today and at an increasing pace, there is a growing need for people who can handle robots and other new technologies. The use of robots in industry is largely influenced by the lack of qualified labor. There is a need for people who can install, set up, maintain, program robots, set up data networks and more. At the same time, business leaders must educate themselves about robots so they can better understand how robots affect the "big picture" of production [2,3].

Buying a robot is not a way to go with fashion. When buying a robot, the whole chain where the robot is installed must be analyzed. Robot's work and behavior differs from how human is working and therefore cannot be equated with a person in terms of workplace. Often a robot is viewed as a human substitute in the workplace where there is no person to take. When installing a robot, its inputs, outputs and operating environment must be reviewed and how they affect previous and subsequent processes [1,4].

In order for robots to be better implemented, people need to be educated and there is a big part to do for the education system. Robotics includes knowledge in a wide variety of fields - physics, electricity, automation, mechanics, IT. You also need to know the specifics of the robot's field of application. All this has to be taught in a standard volume curriculum [2].

The goal is to create a learning lab where you can demonstrate a comprehensive automated process from order in the ERP system to the completion and storage of the final product. The purpose of building a system is to deploy as much as possible the topics discussed in the Industry 4.0 concept, such as robots, 3D printing, Radio frequency identification (RFID), Enterprise resource planning (ERP), Manufacturing execution systems (MES) etc.

2. Solution of the examined problem

When creating the concept, the author put himself in the position of the entrepreneur where he have to chose the equipment from the market that is compatible and capable to communicate with existing devices at shop floor. When building the system, the equipment was chosen from among the most used in the industry and among those that are able to communicate with third-party software solutions.

The design of the system's logic was based on the fact that the failure of one device or the occurrence of an error would not affect the operation of other devices, as long as other devices have tasks to do. The factory works 24/7 and is 100% automated, but that does not mean that a person is excluded from the system. In this solution, a person can perform many of the same tasks that robots do. Starting and completing a task must be confirmed on the MES-related user interface.

The system is divided into five major modules:

- Production;
- Assembly:
- Storage;
- Release of the goods;
- Internal logistics.

Each module contains one or more devices. Top of the modules is MES (Manufacturing execution systems), which coordinates the work of all modules and their communication. Each module is a stand-alone unit that works independently of other modules. The connection between the modules is only through the movement of the produced product it self.

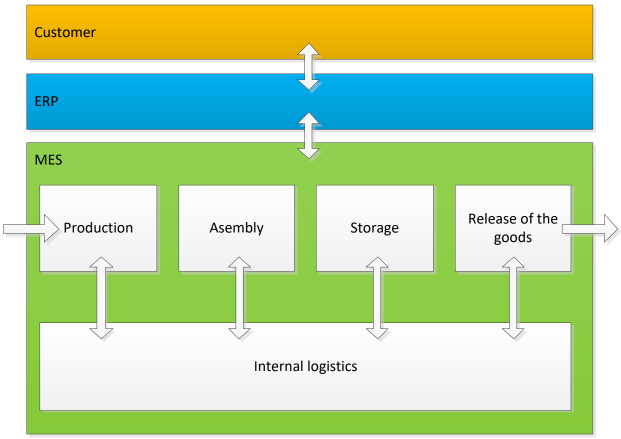

Fig. 1 *System schematic diagram*

When one module has completed its task, for example the 3D printer has finished printing, the signal is given to the MES system which analyzes the road map of the product and gives a start command to the next module that takes over the finished product from the 3D printer and performs internal operations of the module according to the product road map.

Resource management is done by ERP. Its function is to make production plane based on customer orders and consequently the need for materials and supplies. Production is not directly controlled by the ERP system, due to the fact that it is not possible to precisely define all the processes in time. System management remains at the level of the MES program, from which the start and end times of certain processes are given as feedback to ERP system. ERP will use this information for product cost calculation. Each time the information about time is different, therefore the average time of all times is calculated. For example a mobile robot moves along a freely chosen trajectory that takes a different time each time.

One of the important modules of the system is a Internal logistics where are used devices like mobile robot and robot hand. Robot arm is installed top of mobile robot. The purpose of this module is to serve all other modules by providing the necessary components and transporting the finished product between different modules. The mobile robot is freely orientated in the room based on a previously scanned map. The robot can stay in the room with the person, because the robot uses Lidars to avoid collision with obstacles. When the mobile robot moves, the robot arm is in driving position. It works only if mobile robot have stop.

Fig. 2 *mobile robot with robot arm*

The design of the MES system was based on the need for the system to be modified later and for the system to be able to add new modules and devices such as a quality control module or CNC bench to the production module.

3. Results

The study lab was prepared at TTK University of Applied Sciences. With the completed laboratory, the university can demonstrate to students and use the full functionality and essential parts of a 100% automated production system. Students will get hands-on experience and are more aware of the possibilities of implementation new technologies and interconnecting them. Students will have much better practical knowledge's when entering the labor market. Industry 4.0 study labs get knowledge about robots, mobile robots, 3D printers, RFID technology, MES and ERP programs, and their collaboration with each other.

The learning laboratory can also be used successfully to conduct in-service training. Individual topics can be taught separately, such as robot programming or explaining the functioning of the whole system. It is also possible to play through different scenarios that a customer may have in their production process.

Fig. 3 *Industry 4.0 laboratory at TTK University of Applied Sciences (Tallinn)*

4. Conclusion

The completed system works and has been implemented in the study. The construction of the laboratory was funded by the Archimedes Foundation from program ASTRA. The system left a number of options for further development, which will be done in the future. The system should be equipped with machine visioning to improve the robot arm capturing an objects, as well as AR (Augmented reality) technology to visualize factory planning and picking the goods from storage processes.

In author further research, the analyzes of possibilities of implementing a mobile robot and robot arm tandem in industry will be carried out.

5. Reference

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