Zarządzanie Przedsiębiorstwem. Enterprise Management
Volume 22 • Number 3 • September 2019 • pp. 19–23
DOI: 10.25961/ent.manag.22.03.03

EDUCATION IN THE CONTEXT INDUSTRY 4.0 AT THE BRANDENBURG UNIVERSITY OF TECHNOLOGY COTTBUS-SENFTENBERG

Eckbert Jankowski, Christoph André Dreßler, Duc Tran Anh

Brandenburg University of Technology Cottbus-Senftenberg, Germany

Corresponding author:
Eckbert Jankowski
Brandenburg University of Technology Cottbus-Senftenberg
Universitätsstraße 22, 03046 Cottbus, Germany
phone: +49 355 69 4810
e-mail: jankowski@b-tu.de

Abstract

The industrial development of the economy requires specialists in handling processes and digitization. This applies to both the manufacturing industry and the service sector. Human-machine communication plays a major role in this aspect. The Chair of Industrial Information Technology at the Brandenburg Technical University Cottbus-Senftenberg is an educational institution. One of the main focuses is teaching in information management and the associated communication strategy with its IT environment. The students are introduced to real processes and trained through experimental exercises by means of practical approaches in research. To this end, the IIT Chair uses current technologies that are state of the art in industry. This is illustrated in this article by the production of floor coverings.

Keywords

Industry 4.0, Big Data, RFID, Cloud Computing, education, BTU.

1. Introduction

The environment of the global industrial landscape is currently shaped by various trends, such as the Internet of Things and Services, Cloud Computing or Big Data. These trends are mainly driven by the consumer markets, whose products are characterized by increasing complexity and individualization. From the point of view of the economic efficiency of development and production processes, manufacturing companies are therefore being urged to act increasingly networked in value-added networks [1].

The Federal Republic of Germany has also recognized this need and established the term "Industry 4.0" at the Hannover Messe 2011. The objective pursued within the framework of the addressed high-tech strategy is to strengthen Germany as an industrial location in order to be prepared for the future vis-à-vis the global industrial nations. The focus here is on the holistic digitalization of industrial production and logistics processes in order to achieve a fusion of the real and virtual world. The development and implementation of modern information and communication technologies should lay the foundation for the development of intelligent, networked systems. These systems in turn form the basis for the implementation of a self-organizing production environment in which people, machines, production plants or products communicate and interact directly with each other [6]. The resulting production and logistics systems are thus enabled to control themselves decentrally as far as possible without central intervention. This is achieved with the help of so-called intelligent objects, i.e. semi-finished or finished products that can communicate and interact with their environment. For example, a semi-finished product of a production plant can communicate which operation is to be carried out on the object or trigger transport to a specific processing location within a logistics system. On the other hand, production and logistics systems can consult the intelligent objects, e.g. in order to equip themselves according to the product characteristics or to find out the current location of the object [2].

The technical basis in this context is formed by so-called cyber-physical systems. In these, software and IT components are linked with mechanical and electronic parts via a data infrastructure, e.g. the Internet. The resulting network of a multitude of embedded systems is characterized by a high degree of complexity [3].

This is exactly where the Chair of Industrial Information Technology at the Brandenburg Technical University Cottbus-Senftenberg comes in. In the future, trained specialists will be needed to design, implement, support and further develop the required systems. The necessary know-how is characterized by a strong interdisciplinary character and includes knowledge from the fields of business administration, computer science, mechanical engineering and industrial engineering [5]. It is therefore not surprising that the courses offered by the IIT chair in the context of Industry 4.0 are mostly attended by students of the above-mentioned disciplines.

This, in turn, means that the different levels of education of the students must be taken into account when designing the content of the courses. Here the chair of IIT concentrates on a practical development of the exercises as well as on the adaption of theoretical structure of the teaching. In this way, the students should be able to understand the theoretical concepts and technologies they have learned in the context of Industry 4.0 on the basis of real-life processes. As a result, the individual learning process of the students should be strengthened by the practical exercises.

The focussing design of the exercise offer is to be illustrated by means of a specific exercise. First, the case study is explained, which describes a process on which the structure of the exercise is based. Then the experimental setup is explained, which prototypically depicts various key technologies in the context of Industry 4.0 in the case study. Finally, the concrete learning contents of the exercise are listed.

2. The case study "parquet and laminate production"

The basis of the exercise is the illustration of a strongly abstracted production process for the production of parquet and laminate panels. The process is characterized by 4 steps, which the students go through at different workplaces: sawing, milling, coating, and packaging.

The source of the manufacturing process is an upstream forester's shop, which supplies the logs required for production. To simplify matters, the sawing of logs into boards is dispensed with in the exercise, so that the required boards are fed directly into the production process.

The sink of the process is a DIY store, which has given a defined production volume in order.

In the "sawing" sub-process, the board is sawn to specified panel dimensions and equipped with an RFID tag. This tag contains all data necessary for the production and enables the panel to communicate and interact with the environment.

In the "milling" sub-process, a groove and a tongue are milled in two passes on each side of the panel. By communicating between the panel and the milling machine, the machine independently determines which milling head configuration is required for the respective work step.

In the "coating" sub-process, a top layer is applied to the panel, which defines the late appearance of the floor. Here the possible automation of internal logistics processes is shown to the study participants by equipping the coating material with an RFID tag.

In the final sub-process "packaging", a predefined number of panels is commissioned and prepared for dispatch. A special advantage of the RFID technology, the so-called bulk detection, for the control of the individual panels and the determination of the number of panels per package is demonstrated.

3. The experimental setup

The model does not focus on the function of the individual machines, but rather on aspects of information acquisition and processing. A simplified machine is available for each production step, the function of which must largely be implemented by the user himself. There are neither mechanical drive means nor functioning tools for product processing. For reasons of reusability, the materials are specially prepared.

Each machine has an input and output reader for reading and writing RFID tags in order to read the information required for production control directly from the product and to execute the corresponding setup or machining processes on this basis.

The user's attention should be drawn to information processing. Each machine was equipped with a special "terminal" for this purpose. With the help of this user interface, the most important information about the configuration of the machine and the production process is to be displayed. Errors in the production process or necessary actions of the user are signaled accordingly.

A central point of the work place is the display of the memory content of the RFID tags read. It should be made clear which data are read and written in each case in order to automate the production process as comprehensively as possible and to realize an individualization of the products.

In Fig. 1, the memory content of the RFID tag is displayed at the beginning and end of processing. On the graphical user interface, the stored work plan and the status of the processing progress are to be highlighted. The documented processing progress should determine the continuation of the production process as well as the configuration of the following machines.

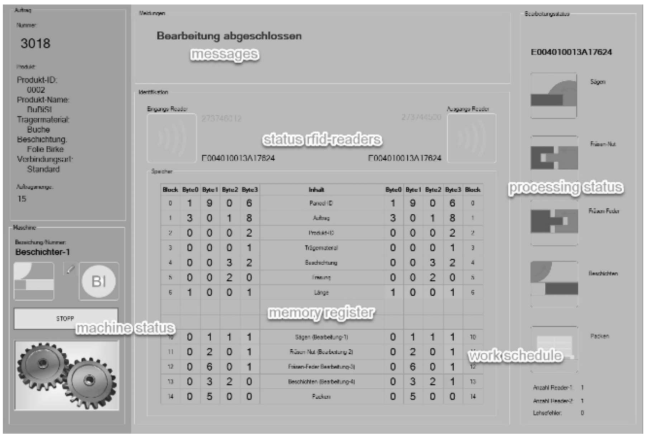

Fig. 1. Graphical user interface of a machine terminal.

This data is difficult for the machine operator to interpret and monitor. For this reason, additional data accompanying the object is read from a database in a parallel way and displayed on the terminal. The user is now able to additionally control the production process.

Step 1: Sawing – The carrier material for the panels is to be cut to a defined length from prefabricated boards of different lengths with the aid of a saw. First, when the starting material is inserted into the machine, the wood and manufacturer information of the board is read by barcode and the use of the correct starting material is checked. Once the raw material has been successfully selected, the production process is started.

After cutting, the basic panels are measured using a measuring device, sorted out if necessary and the result transferred to the database for quality assurance and monitoring material consumption.

At the same time, each panel is provided with an RFID tag. The tag is described with the help of the machine's output reader with all necessary order, product and production data and presented to the user in a tabular overview of the machine terminal.

The first work step is thus completed. On the control terminal of the machine, the progress of the work is now indicated.

Fig. 2. Work space sawing.

Fig. 3. Communication interface: sawing.

Work steps 2 and 3: Milling – After cutting the carrier material to a given size, a groove or tongue is milled on each panel in two operations, which is serve as connectors between the individual parts.

A milling machine equipped with different milling heads is used for this purpose.

After the panel has been inserted into the machine, all object-related information is read from the RFID tag on the input reader. Based on the information about the production progress, the machine is automatically configured. In the model, this is realized by electromagnetic switches that activate the corresponding milling head for the current machining operation. Once the product has been sufficiently machined, it is routed to the next workstation. Otherwise, an automatic reconfiguration and a second machine run with subsequent checking of the production progress takes place.

Within the "Milling" sub-process, it is particularly clear how the current product information controls the configuration of the machine and thus the further processing of the product.

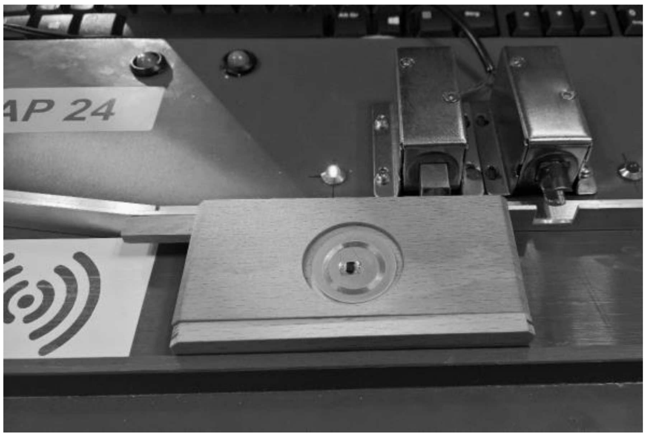

Fig. 4. Tool control with RFID sensor system.

Fig. 5. Data recording: milling.

At the end of each production step, the production progress is again documented on the RFID tag with the aid of the output reader. Product processing and the exchange of information between the machine and the product are now complete.

Step 4: Laminating – After all forming operations have been completed, a special coating machine is used to apply a veneer to the carrier material.

The information from the RFID tag of the panel is first read by the input reader, the corresponding production progress is determined and the configuration of the machine is checked on the basis of the product information. Since an additional material is added to the product in this processing step, the coating material may have to be converted according to the product data. On the basis of a processing strategy to be defined, the changeover of laminating tool can take place immediately or only from a corresponding quantity of waiting parts.

The holding device of the coating material is also equipped with an RFID reader. When the corresponding roll of coating material is inserted, the product data is read from the RFID tag on the roll and transmitted to the machine. For the operator of the machine, the product-accompanying information from the database is displayed.

If the product data at the input reader matches the configuration data of the machine, the processing process starts. In this case the coating is done manually by the operator of the machine. At the output reader, the corresponding production progress is documented in the work plan within the RFID tag on the panel and displayed on the terminal.

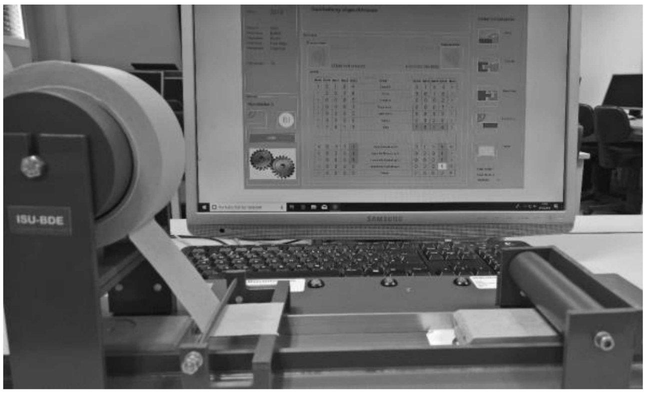

Fig. 6. Laminating process.

Step 5: Bulk reading and packaging – After completion of the production process, the finished panels are packed into packages and then provided with the necessary information about the product and the package by QR code.

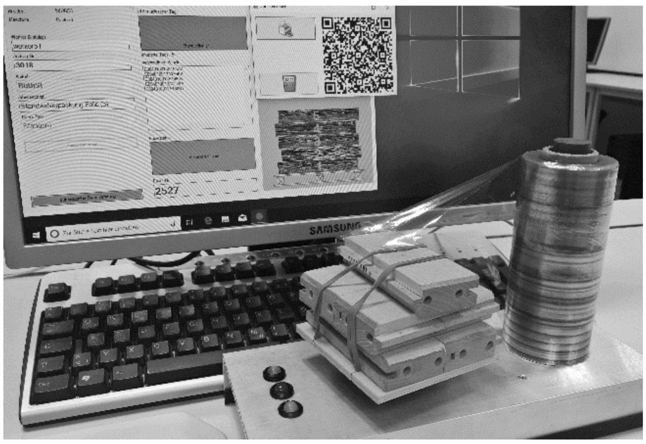

Fig. 7. Bulk scan.

A special feature here is the equipment of the workstation with a powerful RFID reader and a correspondingly large antenna. This creates a spatially large and strong electro-magnetic field in order to detect all the panels in the packing device simultaneously. This is known as bulk threading.

All panels located in the reading area of the reader are simultaneously checked to see whether they are from the same product or order and whether the quality values, for example the length of a panel, comply with the standard.

The packaging process and the creation of a parcel label in the form of a QR code sticker are only started when the correct quantity of panels is sorted and of the correct quality in the reading area.

4. Learning contents of exercise

The main focus of the exercise is on information processing and the associated information flows within the described process flows. Depending on the strategy applied, a distinction is made between object-accompanying and object-bound data flows. In the case of object-accompanying data flows, the material flow is synchronized with an additional information flow. The latter is characterized by central data storage in databases, which is accessed by an action carrier via a network at the time of need. Typically, optical tags, e.g. bar codes, are attached to the object in which an ID is stored that serves as an access key to a specific database. In addition, the ID can be differentiated here with regard to a speaking and a non-speaking key. If information can already be derived from segments of the ID without having to access a database, this is referred to as a speaking key. Otherwise it is a non-speaking key [4].

Object-bound data flows are characterized by the fact that the object-relevant data required for object processing are stored directly on the object. Electronic tags are used for this purpose, in which the data can not only be read, but also changed and supplemented. RFID technology is a typical example of that usability [7].

During the exercise, the students will first understand the optical coding methods in connection with the integration of databases. The concrete functionality of the databases themselves will be explained in a subsequent seminar.

Furthermore, the students will gain knowledge in the functionality of RFID technology. Particular importance will be attached to understanding how to read and write data to the memory of the RFID tag. The unencrypted data used here represent a possibility for storing data in the memory register of an RFID tag.

In addition to the many advantages and possibilities that RFID technology can bring to the design of Industry 4.0, technical and organizational peculiarities for the use of RFID technology will also be explained in the course of the exercise. For example, the influence of metallic bodies on the quality of the electromagnetic field and thus on the stable work of information technology.

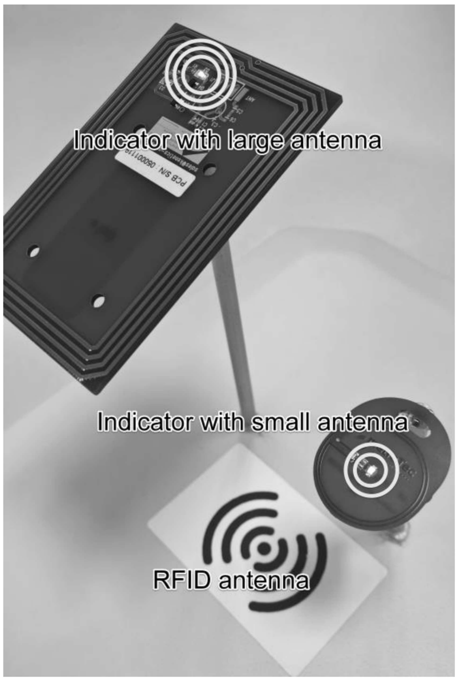

Fig. 8. RFID technology.

LED-lights are used to make the electromagnetic field "visible". Among other things, the influence of shape and size as well as the position of the antennas of the readers and transponders for the effective range of action of RFID technology is made clear. The aim is to provide students with a better understanding of how RFID technology works and to highlight the opportunities and problems associated with the use of this technology.

This case study is intended to illustrate how object-related information can be used for communication between intelligent objects and machines. The product-related information is available at all times for the production process, even without network access to a database. Product-related information in the example only serves to better understand the automation of the process and the interpretation of the memory data of the RFID tag for the machine user.

5. Conclusion

The 4th industrial revolution will significantly change the existing production and logistics processes within value creation networks. The internal processes within manufacturing companies will be increasingly decentralized in their organization and control, and the cross-company processes between the individual actors in the supply chain will increasingly be networked with each other. Especially in the case of manufacturing processes characterized by a high degree of variance, future systems will make it possible to achieve economic efficiency similar to today's series production.

These systems are characterized by a high degree of complexity both from a process and an IT point of view and require adequate specialists who are capable of designing, implementing, supporting and further developing the systems. The necessary interdisciplinary knowledge ranges from business administration and computer science to mechanical engineering and industrial engineering. In numerous courses offered by the Brandenburg Technical University Cottbus-Senftenberg, the aforementioned focal points of knowledge are specifically taken up and taught to students in a structured manner. In this context, the described exercise structure of the Chair of Industrial Information Technology is only a case study of how the teaching operation in the context of Industry 4.0 is designed for students at the university.

References

[1] Bauernhansel T., *Die Vierte Industrielle Revolution – Der Weg in ein wertschaffendes Produktionsparadigma*, [in:] Vogel-Heuser B., Bauernhansel T., Hompel M. [Hg.], Handbuch Industrie 4.0 – Allgemeine Grundlagen, 4. Aufl., Berlin, pp. 1–32, 2017.

[2] Deuse J., Weisner K., Hengstebeck A., Busch F., *Gestaltung von Produktionssystemen im Kontext von Industrie 4.0*, [in:] Botthof A., Hartmann E.-A. [Hg.]: Zukunft der Arbeit in Industrie 4.0, Berlin Heidelberg: Springer Verlag, pp. 99–110, 2015.

[3] Gillert F., Hansen W.-R., *RFID – für die Optimierung von Geschäftsprozessen*, München, Wien: Carl Hanser Verlag, 2007.

[4] Hänisch T., *Grundlagen Industrie 4.0*, [in:] Andelfinger V.P., Hänisch T. [Hg.], Industrie 4.0, Wie cyberphysische Systeme die Arbeitswelt verändern, Wiesbaden: Springer Gabler, pp. 9–32, 2017.

[5] McAfee A., Brynjolfsson E., *Big data: the management revolution*, Harvard business review, 90, 10, 60–68, 2012.

[6] Sauter T., Soucek S., Kastner W., Dietrich D., *The evolution of factory and building automation*, IEEE Ind. Electron. Mag., 5, 3, 35–48, 2011.

[7] Spekman R.E., Sweeney P.J., *RFID: from concept to implementation*, International Journal of Physical Distribution & Logistics Management, 10, 736–754, 2006, doi: 10.1108/09600030610714571.