



SMART ORIENTED WORKPLACES IN TOOL PRODUCTION

M. Milfelner¹, M. Schafler², M. Spitzer² and M. Wifling²

¹ EMO – Orodjarna d.o.o. Bežigrajska c. 10, 3000 Celje, Slovenia

² Kompetenzzentrum - Das Virtuelle Fahrzeug, Forschungsgesellschaft mbH, Inffeldgasse 21 A, 8010 Graz, Austria

Keywords: Assembly, Smart Workplace, Information Technology

Abstract.

This paper presents results of a current EU project, which deals with the development of information and communication technologies for production workers of the future. On the basis of different case studies selected from the project context the paper will illustrate the technologies that can be used by industrial companies to put blue-collar workers at the center of tomorrow's factory. In EMO – Orodjarna we are confronted with the individual production of die tools. The production process is very complicated to gather all the necessary production data in the assembly line in the right moment. To support and increase worker productivity this data needs to be transformed into meaningful information and it has to be provided in an appropriate way. We try to support workers with digital tools to access and process information with user-centric interfaces that will enable them to find and use the necessary information in the assembly line. This approach will increase job satisfaction and motivation of the workers, and have positive effects on collaboration with co-workers, solving problems and generating new ideas.

Introduction

This paper presents results from the on-going EU project FACTS4WORKERS (F4W), which develops worker-centered smart factory solutions in order to support the increase of knowledge work on the shop floor in the automotive industry. The main objectives of the project focus on measurable indicators that are: 1) increasing problem-solving and innovation skills of workers, 2) increasing cognitive job satisfaction and also improving their working conditions in terms of safety, work organization and well-being, 3) increasing average worker productivity and 4) achieving technology readiness level (TRL) 5-7. Therefore, software pilots, serving individual contexts-of-use, were developed and evaluated by the workers. This work brings the smart factory solution for a specific use case defined for EMO - Orodjarna into focus, in order to show how we approach the Industrial Challenge concerning knowledge sharing / management in this context. To measure the fulfilling of the objectives, an evaluation framework was first conceptualized [1] and introduced for the first proof of use of the software prototype in June 2017.

Since novel digital technologies steadily enter large automotive companies during the fourth industrial revolution, small and medium-sized enterprises (SMEs) in this industry will be well advised to go along with this movement. SMEs are quite close to the beginning of the digital journey [2].

The following section represents the context-of-use at EMO – Orodjarna which is a tool maker and produces tools for metal stamping (progressive and transfer tools). The company's main customers are the automotive and aviation industries and their suppliers to which EMO delivers tools for large presses. Most of the tools' components are manufactured in-house. These components are later assembled into the final product (progressive and transfer tools) that is delivered to the customer.

The assembly procedure represents the core activities of mounting the transfer, progressive, and individual tools for medium and large part production that uses aluminum alloys and other high-strength materials. The tools produced are unique, as they are individually aligned to the precise customer requirements. Hence, even if the structure and the modules of tools are similar, each tool is usually built only once. This requires a high degree of worker agility. Several tools are built in parallel and the components are manufactured just-in-time or in parallel to allow a high degree of resource utilization. On the one hand, this implies that the employees need to continuously adapt their working procedures to the current situation in the shop (i.e. the worker needs to regularly consult the mechanical drawings and assembly part lists to coordinate the assembly process). On the other hand, the decentralized self-organization within this production environment does not notice this agility. Processes are only roughly presented to the individual group leaders, but need to be dynamically negotiated between the workers for the fine planning. The detailed assembly process depends on the individual tool workers who utilize their experience to infer the procedures from the mechanical drawings, and negotiate the delivery or manufacturing of components with the machine operators [3].

With this example the industrial challenges in this industry can be described very well. These challenges were gathered by the industry partners of the EU project. They were generalized into four different sections. In this paper we emphasize the challenge of worker-centric rich-media knowledge sharing/management, which shows an implementation of a developed smart factory solution in order to meet the needs of blue-collar workers on the shop floor.

Context-of-use in the assembly line

The requirements for developing a smart factory software solution derive from predefined problem and activity scenarios. The first context-of-use responds to supporting the workers in their daily tasks on the shop floor. During the shift several issues regarding information needs occur pretty often. Missing awareness can cause investing more time and effort in gathering required information about positions and responsibilities and in specific situations it can also lead to stressed and unhappy emotions of the employees. As an example we describe a problem scenario of the persona Ivan, which is a motivated tool maker but who is sometimes frustrated when lots of things

remain unchanged. Because of that he has low motivation to share ideas for improvements. But he likes the dynamic nature of the job and all the challenges that can come up during the assembly process. In such situations most of his time is spent on searching for missing parts or correcting faulty parts which requires a lot of time. Therefore current and needed information is partly available in the company's ERP system or known by co-workers or managers. The worker has no fast access to the system nor can't get in contact with the right responsible person. Ivan can even be prevented from working on his assigned tools and has to move to another tool in the assembly line. Without the help of other co-workers, he is not able to obtain an overview of the current status of the tool and its related positions which have to be assembled. If there are quality issues with the parts during the process, it is difficult to identify the person, who has developed or assembled the parts previously.

With these problem scenarios in mind there has been developed a tailored software prototype which was evaluated for the first time by the workers itself in order ensure if we met their requirements.

Prototype description

The smart factory solution consists of several software building blocks that cope with and also serve specific tasks an assembly worker has to deal with. The tasks were documented in a process description which helps us to define the needed functionalities. As it is mentioned above, the assembly workers consult information from different sources. For accessing information out of the ERP System, a data connector was developed (see Fig. 1). The data connector provides access to Largo which holds data concerning work orders, packages and parts. The prototype demonstrates the needed information by the frontend technologies HTML5 and Angular2 via tablets and touch screen monitor and connects the data with a REST API.

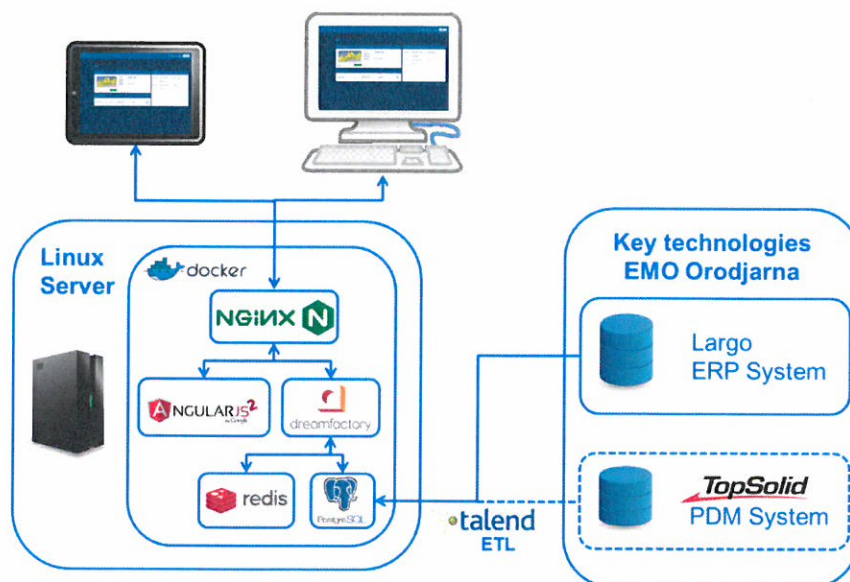


Fig. 1 Software architecture of EMO – Orodjarna prototype

TopSolid, as an external service, is implemented in order to consult CAD files for viewing. With this solution it is now possible to track every step of the part in order to document the history. Therefore it should be possible to look for previous responsibilities who worked on the part. In the first prototype the CADs are transferred as files via the File API but later on the CADs will be transferred via an ETL process.

Integration in real production environment

To support the workers during the daily work procedures the smart solution (prototype) for the workers were developed. The prototype was applied a real production environment to test the road capability. The workers in the daily process deal with various challenges. The prototype helps the assembly workers with the quick solutions in the situations on which they spend a lot of unnecessary time like on searching for missing parts or correcting faulty parts which requires a lot of time. Some solutions are described below.

Missing awareness during the assembly process

When Ivan wants to start the assembly, he first checks that all the parts he needs to complete the task are available. Some (but not all) parts are stacked next to the machined cast iron frame, waiting to be assembled. He walks around the shop to find the rest of the parts he needs, but some of them cannot be found. Where are they? Who knows something about them? On his way across the shop floor, Ivan collects the relevant information from various sources and talks to his colleagues who are busy assembling other tools and to the machinists that machine the parts. One of the parts he needs seems to be lost. No one knows anything about it, and he has to bring in others, including Andrej, the project manager, if necessary. Ivan is now prevented from working on his tools and moves on to another tool in production. With the new tool, this information gathering task starts all over again! With the help of other co-workers, he has to quickly obtain an overview of the current status of the tool and its related parts that have to be assembled. Everyone involved has a bad feeling about the situation, and Ivan inevitably takes over responsibility for other employees' work. If mistakes are made during the assembly process, it is difficult to identify whose fault it was afterwards, as the information about who has assembled which parts is only in the assembly workers' heads.

With the integrated Facts4Workers solution Ivan has his personal touch screen monitor. When he arrives at the working place, everything looks the same as before: The tools and parts are waiting to be assembled, and some of the parts are already stacked beside the machined cast iron frame. Ivan turns on his touch screen monitor and logs in. The first thing he does is to check the status of the build process, especially which parts are still waiting to be assembled. He uses the tool to find the parts grouped into logical compartments according to the sequence in which they can be assembled. At a glance, Ivan sees the packages that are ready to be assembled and those

that are still waiting for parts (Fig. 2, left). Now Ivan can start to assemble the listed parts, look about the information of the parts and the 3D models of the parts (Fig. 2, right). When Ivan has finished, he documents his progress in the system. He cannot work on the tool any longer, as the next important part is still in production. The system tells him who is working on the part and when to expect the completion of the machining processes. As it takes too long to wait for the arrival of the parts, Ivan decides to switch to another tool. Arriving at the other tool, Ivan uses his tablet again and retrieves information on the other project. He uses the same functionality to find out the current status of assembly, the parts he could work on and who worked on the tool before, if he notices any problems. [4]

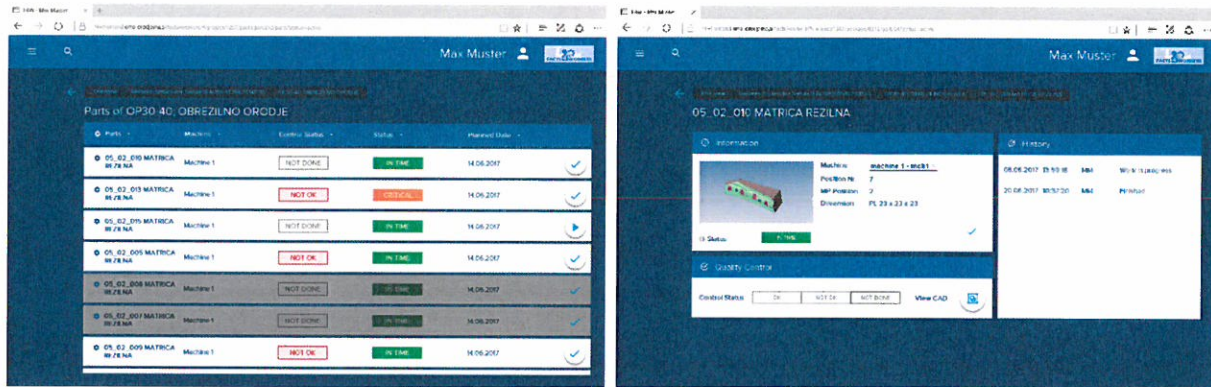


Fig. 2 Prototype for the assembly part preview

Quality control responsibilities

Ivan is in the middle of a crucial assembly step as he realizes that the part he wants to assemble does not have the correct geometry. Only through experience he was able to notice the mistake that would have created greater damage if the tool had been tested for the first time. Using his caliper, he proves a deviation from the part's drawing that he cannot fix by himself. Whenever this happens, he wonders why there is no strict quality control process in place. By chance, Ivan knows that Anton has produced this part; otherwise, he would have needed to identify the person who could help him with that. He takes the faulty part to Anton. In a face-to-face conversation, he explains the problem to Anton and asks him whether he could rework the part immediately. Luckily Anton has a bit of time in his otherwise tight schedule and places the part right into the three-axis CNC milling machine. After the part's surface has reached its final dimension, Ivan takes the part back to his tool and assembles it.

Ivan is in the middle of a crucial assembly step and is preparing to mount the next part. As this part's dimensional properties are critical to the machine operation, Ivan uses his touch screen monitor to check whether a full quality check has been performed. On the part's details view, he can clearly see that no quality check has been performed on that part. Hence, using his caliper to get a rough indication of whether the part is in good condition, Ivan performs the check by himself. As it turns out, the part's geometry is not correct, but Ivan cannot rework the part by himself. He looks up the responsible person on his touch screen monitor. This is an easy task, as the machine operators working on that part are listed on the part's details screen. Ivan sees that he has to speak to Anton. Instead of walking across the entire shop floor, Ivan uses the "report failure" (Fig. 3) and chat function to document the error and to get in contact with Anton. Anton says it is no problem to rework the part within the next hour. When the part returns from Anton, Ivan quickly assembles it. Now it fits perfectly, and thus Ivan ticks off the "quality controlled" flag as well as the assembled flag in the software. [4]

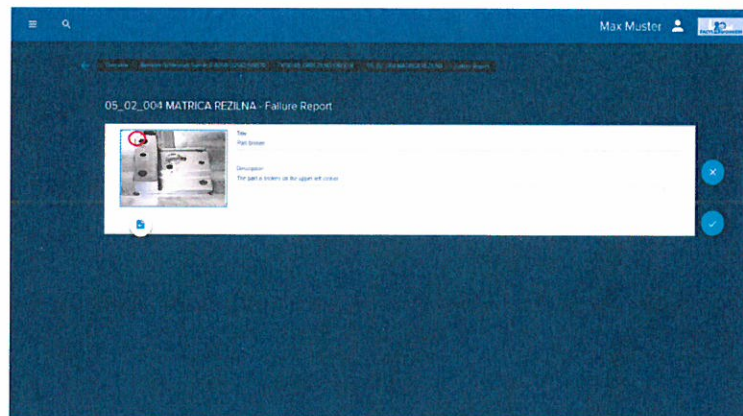


Fig. 3 Failure report

Conclusion

In the paper a smart tool solution is introduced to support the worker during his/her daily life. An assembly process is described in detail at the industry partner EMO. The smart mobile ICT solutions potentially strengthen the workers' networking and interconnection capabilities, thus providing them with more transparency and awareness. The workers' perceived frustration is currently primarily caused by lacking or insufficient information about other workers' current work status, and about the parts they produce. Here, a smart solution could offer simple means of communicating the current work status to other workers, for example, regarding what an employee is currently working on, or what he is waiting for that prevents him from continuing. Such a system would fully retain the self-organizing character of the



shop floor, but would simultaneously reduce the communication effort drastically. In addition, such a solution would help assembly workers to improve their satisfaction in the working place and to increase the productivity.

Acknowledgment

This study has received funding from FACTS4WORKERS – Worker-centric Workplaces for Smart Factories - the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 636778.

References

- [1] P. Mörtl, M. Schafler, F. J. Lacueva-Pérez: Worker Characteristics moderate the Impact of Socio-technical Workplace Interventions on Job Satisfaction: Mensch und Computer 2016 – Workshopband (Weyers, B. & Dittmar, A. (Hrsg.)), Aachen: Gesellschaft für Informatik e.V., 2016).
- [2] A. Chavez: Introducing SMEs to "Industrie 4.0". Online: <https://www.siemens.com/customer-magazine/en/home/industry/one-step-closer-to-industrie-4-0/introducing-smes-to-industrie-4-0.html> (07.07.2017).
- [3] Denner et al. (2015): "Captured and structured practices of workers and contexts of organisations". Project Report - FACTS4WORKERS: Worker-Centric Workplaces in Smart Factories.
- [4] Denner et al. (2015): "Requirements of workers and organisations". Project Report - FACTS4WORKERS: Worker-Centric Workplaces in Smart Factories.