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ScienceDirect

Procedia Computer Science 253 (2025) 403–414

Procedia Computer Science

www.elsevier.com/locate/procedia

6th International Conference on Industry 4.0 and Smart Manufacturing

The Need for Smart Shop Floor Management in the Automotive Industry: Potentials, Challenges and Requirements

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Abstract

Industry 4.0 and the accompanying digital transformation of the modern-day factory have led to various advances in manufacturing. Shop floor management (SFM) – a core instrument of production management – has to align with these digital advances as well. However, due to SFM's strong human-centric roots and manufacturers predominantly conducting SFM through analog means, it raises the question of what sort of digital support should be used for SFM and what specifications should be included in digital SFM systems. This study, consisting of a case study comprising semi-structured interviews and on-site inspections at a large original equipment manufacturer (OEM), provides concrete requirements for digitally-supported SFM derived from practice. We investigated which elements from analog SFM should be retained and where possible improvements through digital support exist. Moreover, we identified definitive improvement potentials such as the aggregation of data sources, as well as the preparation, performance, and documentation of shop floor meetings without disruptions in information flows. We conclude that digital transformation in the SFM context neither implies the mere introduction of software to solve specific problems, nor the full automation of SFM processes through digital solutions (what we call "digital" SFM). Rather, we highlight the importance of "smart SFM": the adoption of sociotechnical systems in which SFM's traditional social characteristics are maintained but are simultaneously sensibly augmented with digital solutions to improve SFM processes.

Peer-review under responsibility of the scientific committee of the 6th International Conference on Industry 4.0 and Smart Manufacturing

Keywords: Shop Floor Management; Digital transformation; Automotive Industry; Digitalization

10.1016/j.procs.2025.01.102

1. Introduction

The production environment has changed radically due to technological developments. Accordingly, there is also a need for fundamental adjustments in production routines and organizational structures to use and implement these new technologies economically [1]. One such domain in the production environment where widespread technological changes are expected, is shop floor management (SFM) [2]. SFM is a method widely used in manufacturing companies for production control and improvement and is especially prevalent in the automotive industry. SFM primarily entails the recognition of deviations and problems in the production environment and systematically addressing such challenges.

Moreover, with the advent of Industry 4.0, the production environment is shifting to a strong data-driven environment [3]. The ubiquitous availability of (near) real-time and enhanced-quality production data – enabled by the continuous integration of sensors and other intelligent objects – shows the potential to significantly affect production processes such as SFM [4, 5]. For example, automatic data generation can save significant time as shop floor (SF) employees spend 57% of their time collecting and processing data for SF rounds [6, 7].

However, despite these possible benefits, the adoption of digital SFM solutions is progressing slowly: only 17.5% of surveyed companies have introduced digital SFM solutions [8], and only 5% state the availability of fully automated processing of machine data [9]. To investigate this slow adoption of digital solutions, one must look to the history of SFM: an established, decades-old method strongly rooted in human-centric/people-orientated Japanese manufacturing principles, strongly influenced by methods and tools from lean production and quality management [4]. While previous studies have investigated the challenges of implementing digital solutions in SFM [10], we still see a lack in the multi-layered understanding of why digital solutions are not adopted in SFM. For one, we see a need to investigate existing *barriers* to digital transformation, which prevent manufacturers from attaining such improvement potentials. Moreover, we see a lacking understanding of *what* can and should be digitally transformed in SFM (i.e., specific requirements and improvement potentials in SFM).

The purpose of the paper is thus to address the abovementioned concerns by tackling the following research goals (*RG*): assessing SFM's current state and challenges by conducting a qualitative case study at an automotive original equipment manufacturer (OEM) (*RG1*) and investigating potentials and requirements of digitalization in the field of SFM (*RG2*).

2. Related work

2.1 SFM Definition and Characteristics

While the term SFM is used frequently in literature and practice [5], a unique definition is yet to be established [10]. SFM has been described as the process of "identify(ing) deviations via key performance indicators, analyzing such deviations in SF meetings, and initiating problem-solving processes and following those up" [7]. SFM has also been described as a central concept of the lean management philosophy that aims to encourage workers' self-management on the operational level, i.e., the SF [8]. SFM is thus considered a holistic management approach consisting of different elements, with a fundamental focus on the employees [5]. To further detail this focus on employees, we look to Hertle et al.'s [6] SFM classification that characterizes SFM, as it provides a thorough overview of SFM employee-centric elements. We summarize this classification below in Table 1.

Table 1. Synthesis of SFM Classification by Hertle et al. [5]

SFM Element	Characteristics
1) Mini factories	Presence on the SF; coaching; Hancho (team leader); goal management
2) Support Systematic Problem Solving	Glasswall Management; regular discussion of problems
3) Enable continuous improvement	SF meeting; benchmarking; audit; tracking process improvement
4) Visualization at Gemba (SF)	Tools of visualization: key performance indicators (KPIs), problems, improvements
5) Facilitate competency development	Technical & methodological competencies; activity & implementation competencies; social & communicative competencies
6) Empowering employees	Performance dialogue; KPIs
7) Social interaction	SF worker; management; worker-management interaction

The first element consists of (1) "mini-factories" [11], where a functional area is deemed a "mini organization" where every worker can be viewed as "president of his or her area of responsibility" [8], thus aiming to avoid a pure execution mode and increases the intrinsic motivation of workers. (2) emphasizes the need for structured approaches to be applied regularly to problems, which should lead to (3) in terms of continuous improvements being achieved on the SF. (4) emphasizes SFM's strong focus on the use of visual tools for problem-solving (e.g., dashboards) directly on the SF (also commonly referred to as "*Gemba*"). The last three elements underline the human-centricity of SFM: (5) and (6) aim to advance employees' competencies to ultimately empower them, in line with the empowerment goals noted in (1). (7) explains the different types of social interaction between SF stakeholders: both "internally" among SF workers or management, as well as between SF workers and management.

Thus, a solid understanding of the elements and different classifications comprising *traditional SFM elements* [11–14] form the foundation for researching and expanding SFM with digital capabilities, which we elaborate upon next.

2.2 Digitalization in the field of SFM

Extant research shows that SFM, understood as a central leadership and management method for production, should be supported by digital technologies [9, 10]. There are various options for digitalizing SFM. Digital support options for SFM include, for example, automated tracking of problem-solving status and responsibilities [10], automated feedback on decisions and escalated problems [12], and AI-based recommender engines [15]. Digital tools can also support SF meetings, such as using digital SF boards [9, 10]. Visualizations can be customized to target groups, and KPIs can be prepared transparently and tailored to specific requirements [7, 10]. These options increasingly find their way into SFM processes and promise clear advantages.

Depending on the extent to which digital solutions are integrated into SFM, different maturity levels can also be distinguished: if information and KPIs are entered manually on the SF board in production, this is referred to as *analog SFM*. Due to the manual procurement, preparation and documentation of information, the preparation and follow-up of meetings are not only time-consuming, but certain information may also get lost [14]. These efforts can already be significantly reduced through further development toward *digital SFM* (dSFM). For example, through the implementation of automated reporting or digital displays, the time-consuming process of manual filling can be made obsolete [16]. As a further development stage, a holistically conceived solution with comprehensive data integration can offer further advantages. This extent of digitalization comes with customizable reports that help

employees to identify existing problems intuitively are described by Bock and Höfer as *smart SFM* [16]. If error analysis is carried out largely on the basis of algorithms with solution measures as an output that are delegated to the employees which then only have to execute them, the status of *autonomous SFM* is achieved [16].

However, despite these benefits, as mentioned, only 17.5% of surveyed companies have introduced digital SFM solutions [8]. Previous studies have shown that especially the lack of willingness to change is identified as a huge challenge for the transformation of SFM [15, 17].

3. Research methodology

To address the research goals, we chose two consecutive research steps. As a first step, we conducted a thorough systematic literature review to gain a comprehensive understanding of the field of digitalization in SFM. Based on this, we conducted a qualitative case study consisting of semi-structured interviews and on-site inspections.

3.1 Literature Review

In preparation for the case study, we systematically analyzed the existing literature related to dSFM, focusing on the potentials, challenges, and requirements of dSFM. Therefore, a title-abstract-keywords search with the search string shown in Table 2 using the SCOPUS database was conducted (date of the query: 30 September 2021). The initial search results comprised 68 publications. After initial identification, we screened the titles of all 68 resulting articles. In this review, we looked for publications that (1) focus on the application of digital technologies in the field of SFM as a unit of analysis and (2) analyze potentials and challenges of their implementation. This led to a preselection of 36 publications (Fig. 1). Based on the abstracts of the 36 articles, a further selection was made, applying the criteria (1) and (2), which resulted in a final set of 18 publications which we then reviewed in detail (see appendix A).

Table 2. Search string used for the systematic literature review

Shop floor Management	“Shopfloor management” OR “shop floor management”
AND	
Digitalization	“Information delivery” OR “data based” OR “Information provision” OR “data driven” OR “transformation” OR “digital” OR “Industrie 4.0” OR “Industry 4.0” OR “Digitisation” OR “digitalisation” OR “automated” OR “digitization” OR “virtual”

Based on the learnings of the selected papers, we conducted a qualitative case study at a European automotive OEM to assess SFM’s current state and challenges (RG1) and to investigate potentials, challenges, and requirements of digital technologies in SFM domain (RG2).

3.2 Qualitative Case Study

The application of a case study approach is expected to be appropriate to tackle the mentioned research goals, as our research is of exploratory nature [18]. We chose the sample of our case study in such a way that it could enable a comprehensive view from different disciplines, perspectives, and hierarchical levels. Our sample included group spokespeople production section managers, department managers, production managers, plant managers and representatives of indirect departments such as material management and logistics. Our sample was supplemented by a survey of employees responsible for the SF IT and data management of the IT-departments. The participants

were spread across three production plants and four different production activities: logistics, body shop, lacquering (paint shop), and assembly. We conducted a total of 23 semi-structured interviews.

We derived our questions from the findings of the literature review, specifically aimed at understanding workers' views on potential digital improvements in SFM. Participants were asked questions such as: "What does SFM mean to you?", "How relevant is the SF meeting for your daily work?", "What digital and technical tools do you use?", "Do you think that the current SFM process is efficient/optimal?" and "Do you think that digital solutions can make the shop floor management process more efficient?". We conducted the interviews either in-person or via Microsoft-Teams and their duration averaged 50 minutes per interview. In addition to the interviewer and interviewee, at least one other person attended the interview to take notes and transcribe them. To allow a reliable triangulation, the

Table 3. Interview Guidelines

Questions
What is your current job title and background?
What does a typical day/work routine look like in your job?
What does SFM mean to you?
How do you operate shop floor management?
How relevant is the SF meeting for your daily work?
Which methods (PDCA, Ishikawa) do you use in your unit/area to support the shop floor meetings?
Could you describe a typical store floor meeting?
How do you prepare the shop floor meetings?
How satisfied are you with the current way information is information (e.g., illustrations, charts, etc.)?
How do you think SFM has affected the way we work together in the plant?
How are digital solutions changing collaboration in SFM?
How do you experience leadership behavior and leadership on site within the of the SFM?
What are the KPIs that are important to you and where can they be found?
How is the relevant data for your KPIs recorded, e.g. manually, automated, etc.?
What digital tools do you use?
Do you think your current store floor management process is efficient?
Do you think that digital solutions can make the shop floor management process more efficient?

interviews were also iteratively coded by two researchers in MAXQDA.

As the use of multiple data sources increases the internal and construct validity of research [19], we complemented the primary data gathered during the interviews with data from additional sources. Therefore, we executed an additional survey addressed to the OEM's IT departments with a focus on IT-related responsibilities and pain points. Furthermore, we conducted extensive on-site inspections in various areas: logistics, lacquering (paint shop), and assembly at three production plants of the OEM. We also accompanied SF workers in SF meetings along all hierarchical levels in the SF process, which allowed us to gain first-hand insights into the SF processes. Following the observations, knowledgeable SFM stakeholders of the OEM addressed any and all of our questions. Findings from the literature review were used during the on-site inspections to prepare follow-up questions regarding aspects mentioned in the literature. To supplement the primary data obtained through the interviews and on-site inspections, we analyzed secondary data from extensive internal documentation and manuals that described SFM's internal processes and responsibilities.

4. Results

4.1 Main Learnings from Literature

The fact that digitalization is becoming increasingly essential in the SFM sector is reflected in the sharp increase in research papers relating to digital SFM since 2016, as seen in Fig. 2.

Our analysis of the selected papers shows that individual digital solutions already exist in the SFM domain. These

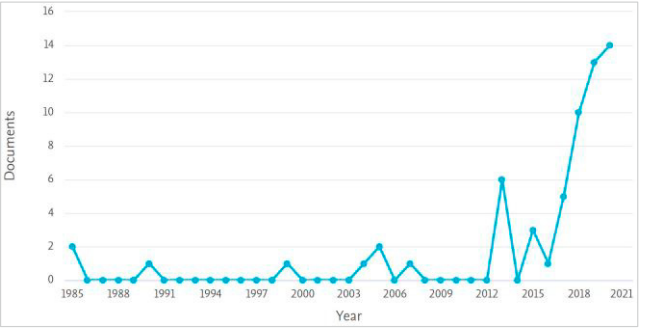

Fig. 1. Publication history per year

solutions are associated with different potentials: the “reduction of manual tasks” [7, 15, 20, 21], the possibility to use “assistance systems for better fault detection” [10, 15, 20], and the “improved possibility for visualization” [7, 12, 20] are mentioned frequently in literature. To be able to realize these potentials, however, some challenges have to be overcome. We identified two key challenges in the literature: the lack of acceptance of digital SFM solutions [7, 9, 15], and the issue of data inconsistency due to non-compatible IT architectures [10, 17, 22]. Regarding requirements, publications often deal with requirements for the qualification of production employees in generic Industry 4.0 environments [23]. Few publications specifically address the requirements for the implementation of digital SFM in the context of the Industry 4.0 strategy, and if they do, very specific solutions such as digital SF boards are examined [24–27]. Furthermore, there is little evidence in the academic literature on workers' acceptance of these technologies.

In general, literature tends to focus on individual aspects rather than considering the holistic effect of digital technologies on various aspects of SFM. However, a holistic view would be helpful in order to fully grasp the potentials of digitalization in the SFM sector.

4.2 SFM’s current state and challenges

The interviews showed that there is a broad consensus about the understanding of SFM with its general purpose and characteristics. Key characteristics of SFM mentioned by most of our interviewees were SFM as a management instrument, leading on-site, methods for problem solving, visualization of data and information, and transparent information sharing. Therefore, the characteristics mentioned showing an overlap with the most of the SFM elements identified before (see Table 1). Interviewees described cascaded information transfer, data visualization, and problem-solving time on the SF as highly relevant. The problem-solving time describes a predefined time window that is available daily to discuss problems and changes that occur at the SF with managers and to take appropriate measures. Despite the largely identical understanding of SFM, a large variance between the production sites and production areas in the realization of SFM was found. The content discussed during SF meetings differs, as does the way in which measures are carried out. There are also differences in the data sources, the type of data preparation and visualization, and the tools used to conduct these activities. Most of the analyzed areas still use analog SFM. They are using analog SF boards, have daily face-to-face meetings, and mostly have no opportunities to digitize the content discussed. We also identified teams that are using hybrid formats to conduct daily SF

meetings, and selected departments are using digital solutions for the visualization of KPIs. Overall, SFM is perceived as an advantageous and value-adding instrument by the interviewees.

Nevertheless, participants addressed several challenges derived from their experiences with SFM in its present form. Table 4 lists the challenges identified and specifies whether a challenge was identified through the interviews (I), the survey (S) and/or the on-site inspection (OS). Most challenges identified pertain to data and KPI preparation and visualization (1). Moreover, we identified challenges concerning SF meetings (2), exchange of knowledge and information (3), and cause-effect-analysis, problem-solving, and measure tracking (4). Across all the challenges, it became clear that time requirements or a lack of time are major challenges for employees. The effort required to collect and update the KPIs is described as high, and at the same time, it is mentioned that there is often not enough time to prepare the SF meetings. The historically grown landscape of legacy systems can be identified as another difficulty, which in turn results in several other issues. For example, a non-transparent, insufficient and decentralized data storage as well as a lack of data-consistency. In addition, IT interface variety was named as a a further difficulty. The challenges related to the topic of data were particularly highlighted in the survey, as the people queried are responsible for data management for the SF in their daily work.

4.3 Smart SFM: potentials, challenges, and requirements

In addition to current challenges, we also posed forward-looking questions and asked respondents about possibilities for optimization in SFM, especially through digitalization. The mentioned optimization potentials are listed in Figure 3. The most frequently mentioned optimization opportunity relates to the tracking of improvement measures and problem solving. During the interviews, it became clear that activities in this area are often neglected: determined improvement measures, their implementation and impact are not tracked sustainably. If, for example, an assembly error is discussed in the SF meeting and a solution is reached together to avoid such a problem in the future,

Table 4. Challenges of shop floor management

Challenge	I	S	OS
(1) Data preparation and visualization			
Analogue SF-boards are perceived as outdated	x	x	x
Lack of data consistency	x	x	
Limited visualization options (e.g., only PDF and small, standardized paper formats)		x	x
Manual compilation of KPIs from various systems is time-consuming	x	x	x
Manual updating of KPIs is time-consuming	x		
Non-transparent and insufficient data storage	x	x	
(2) Shop floor meetings			
No cameras available in hybrid/digital sessions	x		x
Not enough time for preparing	x		
Participation not always possible	x		x
(3) Exchange of knowledge and information			
Different information requirements in the various production departments	x	x	x
Insufficient information exchange between working shifts	x		x
Insufficient information transfer from top to bottom	x		
No sum up at the end of a shift	x		
(4) Cause-effect-analysis, problem solving and measure tracking			
Lack of systematic cause-effect-analysis	x		x
Lack of measure tracking and follow-up of interventions	x		x
Non-sustainable documentation of problem-solving processes and outcomes	x		x
Other			
Value of SFM is difficult to quantify	x		

Notes. I = Interviews, S = Survey, OS = On-Side inspection, “x” = challenge has been identified

this is usually only recorded in handwriting. Usually there is no joint reflection on whether the solution was effective. The respondents emphasized that digital tools could support this, e.g., through a digital supported task assignment and tracking. In addition, reminders of previously defined actions could help to check their success. Respondents also frequently expressed a desire for companywide standardized SFM tools and solutions. The interviewees pointed out that there should be a consistent/central system for the company, as isolated solutions are perceived negatively. Even more favourable would be a consistent solution, but which can be adapted individually to a particular area of an organization and its units, as well as on a team or individual level. Some of the mentioned potentials for improvement were also addressed in the survey: standardized SFM tools (e.g., digital boards, software for KPI visualization) and methods within the organization, minimized media inconsistencies and interfaces between data sources, and more effectively designed processes. Digital tools that could be helpful (according to the respondents) are listed in Table 4.

Table 5. Digital support options for SFM.

Category	Support option
Compilation, presentation and preparation of KPIs	• Automated compilation of KPIs • Automated updating of KPIs • Individualized presentation of the KPIs • Use of digital boards that display KPIs automatically • Filter functions in KPI reports • Access to information via mobile devices
Problem solving and measure tracking	• Digitally supported knowledge management • Intelligent analysis of information and data • Digitally supported task assignment • Digitally supported task tracking

Furthermore, an optimized SFM should support the preparation and implementation of SF meetings and contribute to a reduction of routine tasks. Nevertheless, the respondents noted that despite advancing digitization, the employee should remain the most important core element of SFM. In this context, the interviewees also mentioned the relevance of regular and face-to-face communication, which should not be replaced by digital tools. However, some of the interviewees are in favor of hybrid SFM meetings to enable as many potential participants as possible to attend.

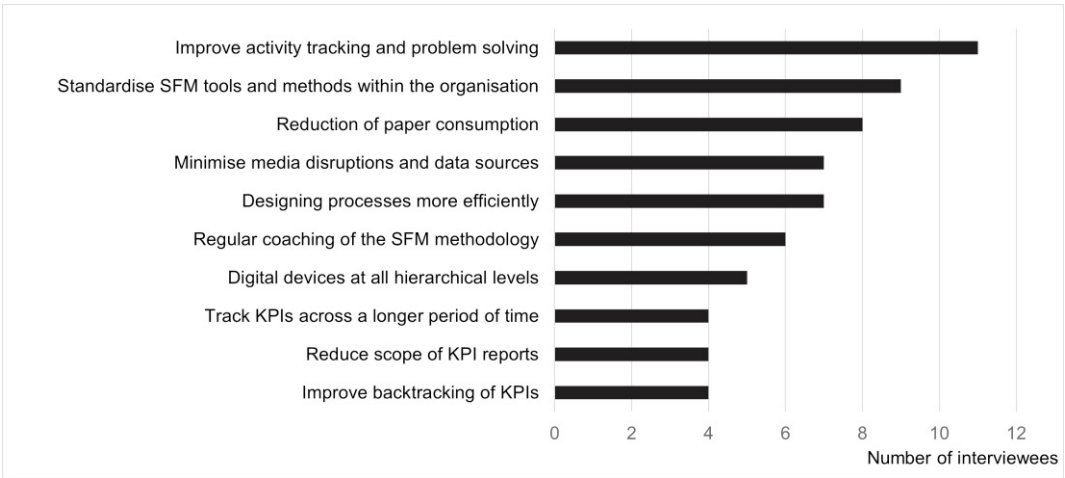

Fig. 2. Potential for optimization for SFM

5 Discussion

The digitization of SFM is becoming increasingly relevant. Previous studies illustrated that there is potential for optimization in the area of SFM [24]. In particular, the potential of digital SFM was described as high regarding e.g., the "reduction of manual task" [7, 15, 20, 21], the possibility to use "assistance systems for better fault detection" [10, 15, 20] and the "improved possibility for visualization" [7, 12, 20]. These findings are confirmed by the results of our analysis and show potential for optimization especially in the area of data preparation, data processing, as well as data visualization. Nevertheless, the philosophy of SFM should be maintained and digital solutions should contribute to strengthening the basic principles of SFM [24]. With a higher degree of digitalization, the effort of manual data analysis must be reduced at the same time. Moreover, in-line with the human-centred view of SFM, a digital solution must continue focusing on employees and contribute to their empowerment. In particular, employees should still be the focus of SFM.

5.1 Smart SFM as holistic and employee-centric solution

The current practice of SFM in many companies is faced with numerous challenges. One potential solution to overcome these challenges is through the digital transformation of SFM. However, it is crucial to ensure that employees remain at the centre of SFM for this transformation to be successful. To effectively combine human-centricity and digitalization in SFM and unlock its full potential of digital solutions, we recommend a Smart SFM approach. Smart SFM can be understood as a holistic solution with comprehensive data integration that facilitates the preparation and follow-up of SFM meetings through the fast and intuitive output of individualizable reports. The use of interactive digital boards can enable a target group-oriented visualization of the most relevant information and the immediate digital documentation of the measures decided in SF meetings. In this way, the participating employees are supported in a targeted way to quickly capture the existing problems through data-supported analyses, to recognize cause-effect relationships, and to understand which measures currently have the highest priority.

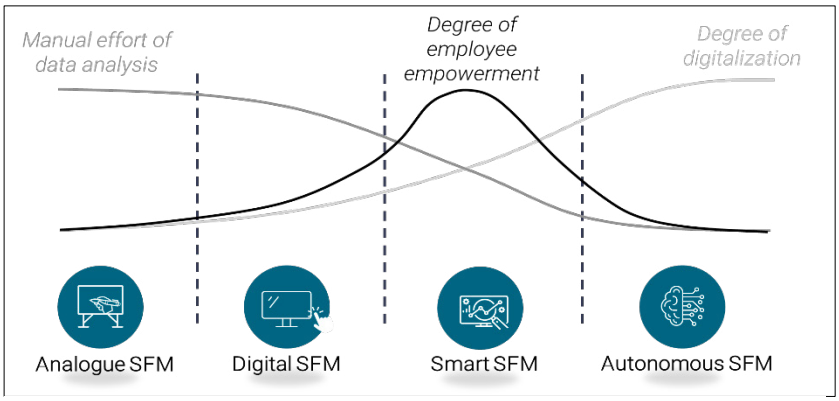

Fig. 3. SFM, digitalization and the role of employee empowerment

We propose distinguishing between "smart" and "digital" SFM, with smart SFM referring to the augmentation of existing analog SFM processes and its human actors with digital solutions, rather than pure digitalization (digital SFM). A stage that goes beyond the smart SFM is the so-called autonomous SFM, which is characterized by autonomous algorithm-controlled cause and problem analyses [16]. The focus is on monitoring and correcting manufacturing systems and processes, and the focus on the employees recedes into the background. Fig. 4 illustrates the different forms of digitalization in combination with the empowerment of employees and shows the advantages of combining targeted digital solutions with a human-centered approach The smart SFM status therefore leads to the highest level of employee empowerment and marks the optimum trade-off between the amount of manual effort and the level of digitization.

We find and argue that smart SFM necessitates a meaningful interplay of analog and digital processes and entails measures that provide employees with targeted digital support where traditionally manual strenuous efforts were required. Following the classification by Hertle et al. [3], the seven addressed principles can be strengthened through

a smart SFM approach. Systematic problem solving and continuous improvement can be enhanced by digitally supported knowledge management, intelligent analysis of information and data as well as digitally supported task assignment and task tracking. Furthermore, the principle of visualization at Gemba can be improved through the use of digital SF boards, which enables an individualized as well as automated presentation of the KPIs. Moreover, smart SFM enables an automated compilation and updating of KPIs. At the same time, digital data storage makes it possible to track KPIs over a longer period of time. This, in turn, can also have a positive effect on problem-solving processes and continuous development.

The use of smart technologies can also have an impact on skills development and employee empowerment. In the interviews, it became clear that a standard and consistent, yet adaptable, SF system is highly relevant for a smart SFM solution. The introduction of such an adaptable core system would also suit the understanding of the mini factories as noted by Hertle et al. [3]. Furthermore, social interaction should be maintained despite a high degree of digitalization. In the interviews, the desire was expressed several times that personal contact in particular must be maintained. The presence of employees from different hierarchical levels on the SF would still be necessary. According to our understanding of smart SFM, digital tools should contribute to support social interaction and not substitute it.

All in all, it is central that the philosophy of SFM is maintained and strengthened through the introduction of smart solutions. Employees are still the core of SFM and should remain as such; however, they should be supported by digital tools. None of the areas examined win our case study today achieves the maturity level of a smart SFM. The majority of the investigated areas are even mainly analog. This also corresponds to the results of former studies [8]. We also note that previous studies have focused on sub-areas of SFM and not on the digitalization of SFM as an overall concept. In our study, we have aimed to look at SFM with all its facets and can thus contribute to the digitalization of SFM as a whole.

5.2 Practical Implications

The presented findings illustrate the potentials and advantages of smart SFM for companies. The optimization potentials presented here can serve as a suggestion for companies to improve their SFM. The case study approach we opted for can also be transferred to other companies and used as a method for analyzing the current situation and development potential. To generate the most comprehensive overview possible, it is recommended to look at a broad spectrum of production areas. For example, even the departments responsible for compiling the KPIs and monitoring reports should be involved in the assessment process. It is also crucial to understand the existing data and IT systems used. Based on a comprehensive analysis of the current state, the existing optimization potentials and needs for a digital transformation can then be identified. Nevertheless, the transition from analog SFM to smart SFM is a complex task and requires profound change. This transformation poses challenges for companies, which should be addressed by a systematic digitalization strategy. Based on a detailed analysis of the current situation and requirements, a company-specific target vision for smart SFM should be developed. It should also be noted that further research is needed to measure the impact of digitalization on the principles of SFM to achieve an optimal level of digitalization.

6. Limitations and future research

Naturally, our study comes with certain limitations. Firstly, as our investigation had a strong focus on the automotive industry, the transferability of our findings to other industries should be reviewed in further studies. Although several sites and a wide variety of production areas were examined both in our interviews and during the on-site inspections, we have only considered a single company. For future research, we encourage investigating other industries to extend our findings and draw conclusions from comparing different manufacturers that vary in terms of industry, company size, and their position in the supply chain. Furthermore, the focus of our study is on the holistic capture of characteristics, opportunities, and advantages of a smart SFM. Therefore, our results do not allow any estimates on the effort that comes with a smart SFM implementation or on requirements that need to be fulfilled. Such estimates are, of course, prerequisites for an investment decision. A consideration of the costs and benefits of individual digital solutions could therefore be helpful in a further investigation. Additionally, our study

is limited to companies that already have well-established SFM practices in place. Consequently, our findings may not be transferable to other companies that want to implement a smart SFM without having previously gained experience with the analog variant. Therefore, continued observations would contribute to further clarity on the initial state of a manufacturer willing to implement digital SFM solutions.

7. Conclusion

In this study, we have aimed to investigate which digital potentials and improvements SFM shows. To do so, we conducted a case study with a large European OEM, in which we interviewed several stakeholders of the SFM system, supported by extensive observations of the production area. We have first identified challenges of SFM, specifically focusing on where current digital solutions may be subpar in the eyes of the SF stakeholders. This created the basis for potential improvements, and from our interviews and observations, we identified several concrete digitalization improvement potentials. Our results also validated two core concepts we held as fundamental during our study. Firstly, SFM is a holistic and multi-faceted production management system, and while studying individual components may have its merits, we found and maintain that any digitalization solution must be considered in an integrative manner for all elements of SFM. Secondly, we found and maintain that in line with its roots, SFM is fundamentally a human-centered system, and should remain as such. Any digitalization solution to be implemented should be done with strong consideration for existing social structures and interaction. We thus advocate strongly for the development of smart SFM solutions.

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