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Visual Performance Management as a Cascade-participatory Information Exchange System, In-depth Manufacturing Study

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Abstract
This study is aimed at investigating the functionality of Visual Performance Management (VPM), along with determining the necessary features such a method should demonstrate to be an effective and meaningful tool for the development of Lean Management in an organisation. Based on the analysis of a case study in a large manufacturing organisation, a crosscutting assessment of such a system was made, a literature review proves the lack of such a comprehensive study. Six critical features of VPM were identified, they are very practical and giving many interesting insights into studied Lean method. The view emerged from empirical investigated shows VPM as of the wider functionality then only visual information exchange methodology. The VPM serves as cascade information exchange system and has substantial potential to support employee's participation. The study learns much from strengths of studied system alike its dysfunctionalities.

Keywords
Visual Performance Management, Lean Manufacturing, Organizational communication, Employee participation.

Introduction

Today's manufacturing companies operate in an extremely changing business environment. Dynamic changes are caused by strong competition, the changeability of customers' expectations and preferences and by the continuous development of the mass media and information technologies. This results in the demand that enterprises constantly improve, and the possibilities for development of facilities depend solely on the concepts of methods a facility is able to implement in order to improve its processes (Puchała, 2008).

New opportunities are being sought, as are as methods of nonstereotyped thinking, development of teamwork, improvement of management methods or using knowledge for the improved operation of facilities. Pioneers in this area include learning organisations which are oriented at adapting to changing conditions in an enterprise's environment (Kruczek & Żebrucki, 2013). One of the many challenges enterprises face, which requires continuous improvement, is ineffective flow of information between employees and their superiors (Tezel et al., 2016). In order to meet this challenge, an enterprise should be regarded as a "living organism" functioning in line with internal, often unstructured and informal principles. To achieve the intended response to the rate of changes in the environment, the facility should be subject to constant observation and managed appropriately. "The best method to maintain preparedness is to use visual management to that end" (Knop, 2016).

The study is focused on one of Lean techniques, the visual management of performance in manufacturing system, Visual Performance Management (VPM). The research purpose of this study is an across-the-board investigation of VPM functionalities, along with discovering critical conditions/features the VPM must demonstrate to support Lean objectives in an organisation. These will be achieved through a cross-sectional study of literature and employing a case study method for empirical investigation. The empirical part of the study is aiming at examining in detail how the system of VPM is organized, what information it contains, what visualisation techniques are implemented, how participants take their action on different organizational levels. All the advantages and disadvantages, strengths and weaknesses will be inexorably followed. All of that allow better understand-

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ing studied management tool, draw several conclusions and addressing to supposedly typical problems in many large industrial organizations. The study brings refreshed, practical insights into VPM method in a manufacturing environment.

Visual management in reference to performance

Lean Production, often interchangeably referred to as Lean Manufacturing or Lean Enterprise, is a management concept which facilitates the development of a manufacturing facility toward becoming a lean enterprise. The Lean Production concept, inspired by Toyota's manufacturing system, is based on the execution of primary goals which include high productivity, high product quality, efficient organisation, an efficient management system and satisfactory work performance. These goals are oriented at the primary task, which is meeting customer expectations (Puchała, 2008). To execute the specific assumptions correctly, an appropriate enterprise management system should be employed.

Among the many management systems deployed in enterprises, the very important visual management system may be singled out. Visual management is a broad term with many meanings, which may be used interchangeably with such notions as visual control, management by visibility, management by sight, visual workplace, visual factory, visual tools, visual communication. The visual management system aims at controlling the operations of an enterprise through combining systems, tools and methods in place in a facility by means of stimuli directly influencing human senses (Knop, 2016). It is a vital element of the Lean Management concept, on which the observation of processes in an enterprise and related communication are based (Kurdve et al., 2019).

Visual management may work as independent from other systems or directly interrelated and merged with other technology intensive operation systems in the organization. With reference to organizational reporting, there are many IT tools/systems supporting managers. Thanks to visual management, it is possible for IT systems to present work results in real-time (number of pieces produced, working time, downtime, machine failures, the need to repair a machine, control of material inventory). The Fourth Industrial Revolution can support and improve the visual management used by scompanies' information systems which can be combined with IT systems through vertical and horizontal software integration. Augmented Reality can present visual management results directly in areas of work while, the Internet of Things can connect machines with IT systems and Big Data process large data sets to support decision making. Since the level of an enterprise's development may be an obstacle in the integration of visual management with new Industry 4.0 technologies most companies use visual management in their workspaces by relying solely on the concept of Lean Management (Santos et al., 2021; Schumacher & Sihn, 2020; Kumar et al., 2020; Sanghavi et al., 2019).

Visual management is also referred to as management by sight (Mielczarek & Knop, 2016) and is not related solely to communication. It is a process of constant information analysis, problem identification, data picking to make the actions of individual teams lead to achieving the goals of an enterprise (Aguinis, 2013). Achieving goals helps boost the efficiency of an organisation and can be obtained using visual media. The triggered stimuli immediately transmit important information between people responsible for collecting information thanks to which the organisational process is made transparent (Steenkamp et al., 2017). To a large extent, visual stimuli transmit information regarding quality (of products, processes, operator work level etc.), which are necessary for operators to understand the expectations the facility has of them (Tezel et al., 2009a).

Over the last three decades, the trend in what is emphasised in the area of organisational efficiency has changed. Currently, performance measurement is less important (i.e. what and how to measure, and how to report the measurement) than performance management (i.e. benefits from means of enterprise performance management) (Bititci et al., 2016). Put briefly, visual management should allow the visual assessment of processes executed in an enterprise, and should facilitate information flow and communication between individual units of the facility.

It is applicable to variety processes in different organizational functions, like sales, production planning, supply, production, logistics, marketing, HR, company development processes and many others. Visual management has the ability to communicate these processes through the use of modern technologies illustrating effects obtained during processes flow. However, visual management is able to support and communicate within processes only to some extent, at the same time it may also cause variety of problems during its usage. That is why, to a large extent, production plants employ visual management techniques mostly in their production processes and for projects implementation. This allows for the visualization of all kinds of information coming from the area, which help to communicate with other elements of the system in order to efficiently manage and achieve appropriate results (Sztorc & Savenkovs, 2020; Goncalves et al., 2019).

For visual management to be effective in the area of work, there must be a visualisation allowing the creation of a "standard" work environment. The techniques of visual management which create this visualisation of the work environment include pictures, prints, diagrams, kan-ban boards, colour visualisation, and labelling methods (Steenkamp et al., 2017; Bititci et al., 2016), Andon light boards or towers, notice boards, training and skill boards, floor markings, visual documentation etc. Visualisation will not, however, operate standalone, without the participation of employees. The most important element of visual management is proper preparation of the content of boards and information to be presented/measured (Kruczek & Żebrucki, 2013). The visual standards developed should not result in misinterpretation which in turn could lead to drawing incorrect conclusions and making wrong decisions (Bititci et al., 2016).

Visual management in a manufacturing facility aimed at achievement of specific goals of company policy, may be applied in many ways. In management, visualisation may have an informative function (informing employees of the effects achieved), a signalling function (indicating the occurrence of irregularities or the need to respond to a specific situation), a control function or reducing the occurrence of errors (Poka–Yoke) and a communicative function (to ensure the efficient and undisrupted flow of information between operators and management) (Eriksson & Fundin, 2018; Jaca et al., 2014; Murata & Katayama, 2016). Owing to visual management of a work station, operations on it become more comprehensible, simpler in their functioning, and able to respond autonomously to deviations from the norm. This is possible thanks to the elements of a method which are responsible for the collection of necessary data from the work station and supporting operators in performing operations (Tezel et al., 2009b).

Depending on the need for improving the work station, visual management tools (presents in Figure 1) may take various forms. Andon is a Japanese word meaning a "signalling device" It is designed to halt production if a problem occurs and to communicate, using a visual or sound alert, that an irregularity has occurred. As merely one of many basic tools of visual management, Andon is not a tool conveying just one type of information. Entire networks of meanings may be assigned to visual and sound alerts, which may inform employees of problems through light signals, text, graphical signs or prerecorded statements. Therefore, Andon is a universal tool which may be adopted in many situations that require the application of visual management (Westin & Ragnmark, 2015).

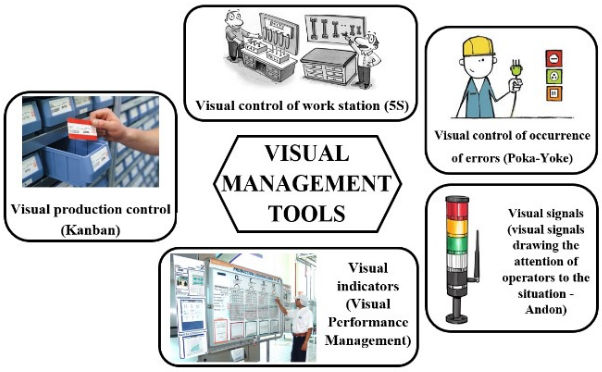

Fig. 1. Visual management tools used in a manufacturing enterprise

The purpose of the 5S method is to improve the organisation of a work station by boosting efficiency as well as productivity through organisation and systemisation of the environment (Veres et al., 2018). In line with the 5S procedure, after being organised, the work station should be put in order, i.e. visualised. The purpose of putting things in order is to arrange the work station so that every element has its own place and is clearly visualised and labelled. This may be achieved using horizontal markings, specialised racks and containers, labels, descriptions, visual standards posters etc. It allows new operators to adapt easily and thus achieve higher productivity (Ciobanu, 2014; Cichocka, 2018).

Kanban stems from two Japanese words: kan – visible and ban – sheet of paper, which may be loosely translated as a "visible list" (Smalley, 2004). The method is one of the basic systems of production in Toyota plants, which employs the principle of pull production (Yan, 1995). The primary purpose of the method is to increase the capacity for continuous supply of materials. Taking the above into consideration, Kanban stresses two main aspects, i.e. visualisation of workflow in line with specific principles and reduction of production volume to a specific limit. Thanks to the application of these two aspects, the Kanban method uses the concept of visual management and monitors the execution of production schedule and current status of product implementation in a simple manner (Frein et al., 1995).

VPM is a system which combines the measurement of performance with visualisation tools in order to create a universal tool used in production management. The VPM approach supports building and improvement of an organisation's objectives. Thanks to that, a relationship is forged between projects improving processes and the economic objectives of an enterprise, which are represented visually (Pitkänen, 2018). VPM establishes a modern approach to processes, systems and structures that constitute organisations and uses graphical visualisation techniques to boost competi-tive advantage (Bititci et al., 2016). The concept of VPM also actively uses other methods and concepts of management, e.g. management by walking around or continuous process improvement (Kaizen, Gemba Kaizen, Lean Manufacturing, Lean Management) (Knop, 2016).

The effect of active employment of VPM in production is accurate measurement of performance, graphic visualisation of the collected results, improvement of communication between various units and the level of management in the enterprise and better cooperation between departments (Pitkänen, 2018). This facilitates the implementation of measures for improvement and more rapid identification of problems, which leads to reduction of costs and easier removal of the consequences of errors (Jaca et al., 2014).

The literature studies have indicated that there is a noticeable lack of rigorous and exhaustive study of VPM method in terms of its existence in a real manufacturing facility. Studies which would investigate its existence in the manufacturing value stream, its key future, and also weaknesses, if exist. The literature abounds in guidance for managers how to introduce Lean tools, VPM included, however, it must be clearly emphasized, that they will be never the same what an in-depth critical exploration of a living manufacturing example. The knowledge deficit pertains primarily to practical solutions particular to the operation of the system, for instance visualisation techniques, methods of engaging employees, etc.

Research method

Case study methodology is employed to this study, observations and analysis were made and conclusions drawn regarding the studied facility and its situation. The case study analysis is an explorative research method which uses numerous tools, quantitative and qualitative, allowing an in-depth diagnosis of the studied object (Baxter & Jack, 2008; Tellis, 1997). To collect data, tools such as interviews, observation of the operation of the facility, and waste analysis were employed.

In practice, the case study analysis consisted in an in-depth observation of system operation, passive participation in meetings that are parts of the system, studies of documents and reports followed by assessment of the identified content and organisational artefacts by referring them to the principles of Lean Manufacturing and basic management rules. During the exploration in the facility several questions have been asked frequently by the researcher:

1. How the system of VPM is organised in the facility?
2. What visual artefacts are exploited by the system?
3. What are the roles and obligations of each of actors (working positions) within studied organization?
4. What kind of actions are taken on each organizational actor?
5. What are the attitudes and opinions of operators and other system actors, as much as these can be observed and interviewed?
6. What kind of data are processed and presented within the system?
7. How the information is circulating within investigated system?

All the data were gathered by authors, so called soft issues, like people attitudes were determined by direct observation and every day working facts reported by interviewed managers. The comprehensive understanding of investigated VPM system is possible when it is considered along with Lean Manufacturing idea and principles. There is no doubt that VPM has to support the organizational efforts towards Lean. So that, the critical features of the studied system are identified based on the three features of system which are fundamental for Lean Manufacturing approach, they are as follow:

1. Employee participation and commitment.
2. Support for process improvement.
3. Intelligibility of the system itself.

Widely proven principles of Lean Manufacturing, including criteria mentioned above, are at the same the basis for searching for directions for improving investigated VPM system.

Studied production facility

In order to comprehensive investigation of VPM method in a manufacturing enterprise, first the facility under analysis must be characterised. The investigation was carried out in a facility manufacturing large mechanical devices. The approximate manufacturing plan covers the production of over 18,000 machines a year. The product range comprises as many as 350 variants of machines in nine main product families. The manufacturing process covers main departments such as blanking and forming, machining, welding, surface cleaning, corrosion protection and automated powder coating, and assembly. Depending on their capacity and labour consumption, individual production departments work in two or three shift systems.

The main manufacturing process is supported by a number of support departments such as the warehouse/logistics department, technology department, quality control department, maintenance department, production preparation department, production planning department, purchasing department, and the construction department, which are responsible for the efficient flow of parts and subcomponents across the entire manufacturing process. The enterprise employs 800 employees. Approximately 150 people are office employees, there are 50 warehouse/logistics workers, 50 employees are engaged in the preparation processes, 500 people are line workers, 45 foremen work in individual production departments and six managers supervise production.

In-depth analysis of VPM in studied object

The structure of the VPM system in the investigated facility comprises five levels: VPM 0, VPM 1, VPM 2, VPM 3, VPM 4, the task of which is to collect information, analyse data and report to superiors. The report presents the current situation at the work station and initiates corrective measures to solve identified problems. If any management level is not able to implement improvement measures on its own, the problem is directed to a higher VPM level, where the supervisor helps in solving the problem. The hierarchy structure of VPM is presented in Figure 2.

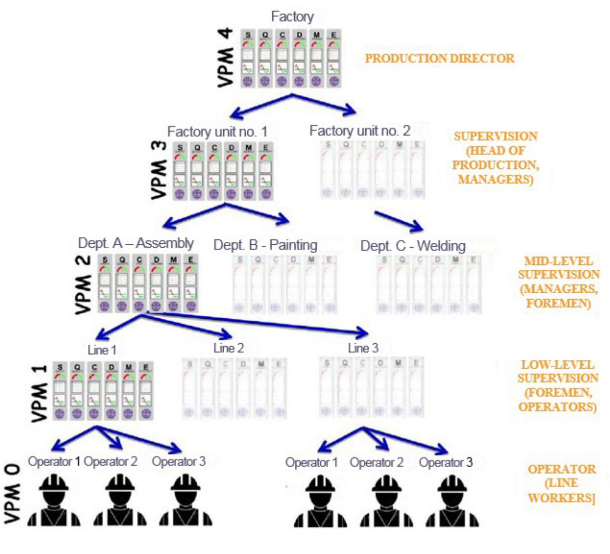

Fig. 2. VPM structure in studied enterprise

Data collected from individual work stations pertain to problems (dedicated area) belonging to one of the six main categories: Safety, Quality, Cost, Delivery, Morale, Environment.

The measures described above form a set of performance indicators in individual areas. They are determined by production leaders on the basis of the analysis of data coming from the area and selecting the main deficiencies that disturb the achievement of the assumed results. The indicators described are the same at all the levels of investigated VPM, the only difference is that the indicator used at the lower management level is more precise for solving problems at the workplace, while the indicator used at the higher management level analyses a wider spectrum of a appearing troubles that may affect the whole production system.

The functioning of the entire VPM method as well as the information flow and data analysis are not connected with the company's IT systems. This is due to the need to involve each employee in the information analysis system and to take action on the basis of information that he writes on the board. Thanks to this, the operators have a real perception of responsibility for the effects of their work. IT systems support the VPM method only when extracting more complicated data sets necessary to analyse some specific issues. All the data existing in studied VPM system is stored in an Excel file for archiving purposes, one can easily analyse the performance from a longer period of time.

The entire VPM system is based on the high commitment and independence of the operators. Based on the data coming from the area, employees independently select indicators to be measured and collect information on their own and save it on VPM tables. Together with their superiors, they make appropriate decisions to improve the production process and transfer information up the management structure. The structure and functioning of the VPM at all management levels are the same.

Level 0 of the VPM system

VPM 0 pertains to a line worker (operator, welder, painter, assembly worker, logistician etc.) who is responsible for collecting source data from their own work station. The task of the worker is to measure performance on an ongoing basis (measure: Delivery), downtimes at work station (measure: Cost) and quality of work performed (measure: Quality). Measurements are taken on an ongoing basis or at least once an hour (depending on the work station), operators record individual measurements on a form and make comments if the intended effect is not achieved.

The measurement is documented using paper work station downtime forms and on whiteboard sheets with hourly production time charts, on which operators mark the relevant level green (if the objective is met) or red (if the objective is not met). In addition, various and dedicated checklists are used. At the end of the production shift, each operator must sum up the measurements to draw up a reliable report for their immediate superior. Data collected from all work stations in a specific production area are submitted during the meeting of all operators with a foreman (VPM 1) which will be held at the end of each work shift. An example of hourly production sheet, level 0, is shown in Figure 3.

Temat: Godzinowy wykres produkcji	Sporządził: / Sprawdził: / Zatwierdził:

	Godzina	Zrobione / Cel	Suma łączna / Cel	Uwagi
Zmiana 1	6:00 – 7:00	13	13	
	7:00 – 8:00	13	26	
	8:00 – 9:00	13	39	
	9:00 – 10:00	13	52	
	10:00 – 11:00	8	60	
	11:00 – 12:00	13	73	
	12:00 – 13:00	13	86	
	13:00 – 14:00	13	99	
	Operator:		Data:	
Zmiana 2	14:00 – 15:00	13	13	
	15:00 – 16:00	13	26	
	16:00 – 17:00	13	39	
	17:00 – 18:00	13	52	
	18:00 – 19:00	8	60	
	19:00 – 20:00	13	73	
	20:00 – 21:00	13	86	
	21:00 – 22:00	13	99	
	Operator:		Data:	

Fig. 3. Hourly production sheet

Transmission between VPM level 0 and 1

The exchange between level 0 and 1 of VPM system occurs during regular meetings of operators with the foreman. The meeting of levels VPM 0 and VPM 1 is held at the end of the work shift, usually at 13:45 (various work stations meet at various times between 13:30 and 13:45). The meeting pertains to all line workers in a given team and their immediate superior, i.e. foreman (each team of workers holds a separate VPM 1 meeting). The meeting is held at the team's board (in production area) which shows VPM measurement sheets, the meeting agenda and necessary standards. Some teams use metal boards, other use whiteboards (which results from a change of VPM board standard during method implementation).

VPM team boards (example in Figure 4) are uniform and consist of a magnetic whiteboard VPM measurement sheets in A4 size. The measurement sheet consists of three parts: measurement indicator presenting the definition of the measurement, the target to be achieved and colour marks of meeting the target (green – target exceeded, red – target not met). The table under the measurement indicator presents the accumulated score for a specific measurement provided by all operators. The table is used for recording score for each work shift separately, which allows ongoing observation and response to emerging problems. A score equal to or above the target is marked in green, a score below target is recorded in red.

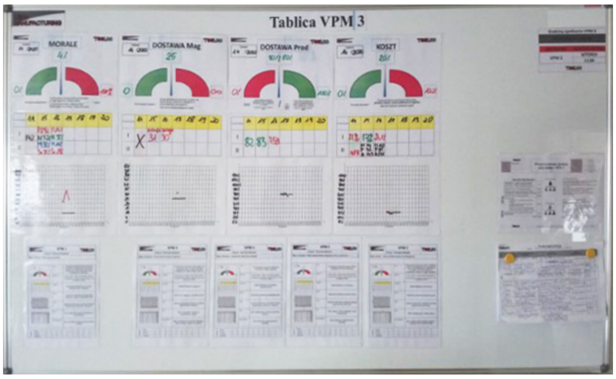

Fig. 4. VPM board used for meetings and development of improvement activities

The key element of VPM 0 and VPM 1 transfer is holding the meeting in line with the agenda (presented on the measurement board). During the meeting, the social and work safety issues of the entire team are discussed first. Then the measurements taken in the production area are discussed. Operators present the score from their work stations, which is then summed up and rec-orded on the measurements board (in the score table, under the relevant day of the week, in the cell corresponding to the shift), using the colour standard (green, red). The next step during the meeting is the report of operators regarding the recorded score, discussion of problems occurring at work and planning actions to solve the problem.

VPM level 1

VPM 1 pertains mainly to the foreman who is responsible for overseeing and assigning work among the operators/workers. The foreman's main task in fulfilling their VPM 1 responsibilities is to conduct three rounds walking around the area over the entire working shift. The rounds follow a developed pattern taking into consideration key process elements which require control. While making rounds, the foreman pays attention to how each operator completes their tasks. The foreman supervises the level at which 5S standards are maintained and inspect the VPM 0 sheets (hourly production charts, work station downtime sheets and product quality forms). If a problem arises during area inspection, the foreman must interview the operator to identify the reasons for the problem and then they should direct the operator to a solution to the problem.

Transmission to VPM level 2

The transfer between levels VPM 1 and VPM 2 is made immediately after the meeting of the foreman with line workers (VPM 0 and VPM 1 transfer). The meeting should be attended by all foremen in the given production area and the manager of the area. The meeting takes place at the VPM 2 board of the given area (in the production area), usually it lasts ten minutes. The VPM 2 board for the production area has the same whiteboard and magnetic forms as the VPM 1 boards. The forms on the board are A3 in size.

Measurements presented on the VPM 2 board are identical to the measurements recorded at work stations. Data collected on VPM 2 boards are more general than information on VPM 1 teams, as information from many teams are cumulated on the VPM 2 board of a specific area. Thanks to that, the production manager has a full view of production and problems occurring across the entire area under their management (e.g. the entire production hall). The meeting agenda and stages are also identical to those during the VPM 0 – VPM 1 transfer. At the end of the meeting, the steps taken todate to improve operations in areas should be reviewed and foremen should be account for the results achieved. The production manager takes on the role of meeting supervisor, the foremen should account for the results achieved and directing employees to appropriate solutions for improvement.

VPM level 2

The second level of VPM pertains to people who manage entire production areas (production managers). In the investigated facility six main production areas are distinguished, they are managed by six production managers who are responsible for production execution, adherence to work safety regulations, solving problems and implementing improvements in the production areas they oversee. The VPM 2 related tasks of the above management staff focus on making regular rounds in their areas (two rounds a shift), observation of the scores recorded on forms and on VPM boards, analysis of the current condition of work stations and production, drawing attention to maintaining the standards of Lean Manufacturing as well as coaching foremen regarding problems identified and offering improvements.

At the end of the shift, the production manager must hold a VPM 2 meeting with the foremen working in a given production area, and then subordinate employees account for their results. The meeting ends with allocation of further production tasks, improvement actions and employee training.

Transmission to VPM 3

The transmission of performance measures to the upper management level is performed during meeting of area managers and Head of Production. The meeting occurs not in the production area but in a conference room in the office. The meeting is not held regularly, which is a reported by some of the respondents in company as a problem, as the flow of information is irregular. The duration of the meeting also varies, as it depends on the issues discussed.

The topics and transfer of information is assumed as the same as in the case of transmission between VPM 1 and VPM 2, while maintaining a standardised course of the meeting (in line with the agenda), the meeting does not follow a predetermined form, however. The topics discussed at the meeting most often pertain to problems and delays against production schedule and not to issues related to the functioning of areas or problem solving and area improvement. Information and data collected from lower parts of the value stream are not analysed regularly. The meeting is conducted by the Head of Production who expects a full report from area managers and persons responsible for the efficient operation of support units.

VPM – levels 3 and 4

Levels 3 and 4 of the VPM system according to the assumption should be executed systematically once per shift in the case of VPM 3 and once a week for VPM 4. The Head of Production is responsible for level 3 of the method and he should make one round of all production areas per shift. On this round, the information presented on VPM boards is analysed and area managers possibly can be trained and coached.

The Production Director is responsible for level 4 of the VPM system and he is responsible, once a week, make a round as described in step VPM 3 and train the Head of Production. As it was observed that actions related to VPM 3 and VPM 4 are not performed by those responsible. There is no analysis of data or coaching of subordinates. The flow of information is lost, and it is triggered only in the event of perceptible issues related to the implementation of the production schedule.

Transmission from level 3 to level 4

According to the initial assumptions reported to the researcher the information transfer should occur regularly, once a week, during meeting of Head of Production with Production Director. The meeting should be attended by the Production Director (who conducts the meeting), the Head of Production, the managers and directors of other production departments and support units. The meeting lasts one hour and main topics related to the collected and analysed data from the lower value stream should be discussed. However, it is observed the lack of regular meetings of the VPM 3 – VPM 4 transfer. The transfer is carried out informally, during meetings in the pro-duction area, if production-related problems are encountered. Clearly limited meetings are associated with shortcomings in between levels, upper management expect formal reports in extreme situations (e.g. failures or delays in production schedule).

Discussion

In studied case VPM covers all levels of the management structure of a manufacturing company. The method comprises five levels, wherein the main actions performed at each level include data collection and analysis, reporting the current work station situation to the superior, and taking corrective measures to solve occurring problems based on current data. Table 1 below presents the observed key features of the studied VPM system, structured into three fundamental areas in which the visual management system should be functional and add value. All observed during the investigations features, positive and negative ones, are summarised taking into consideration their connection to (1) employees participation and involvement which make a fundament of Lean approach, (2) improvement of processes in value stream of studied manufacturing system and (3) intelligibility, which manifests the approachability and general efficiency of studied VPM system.

The VPM method is one of the difficult and complex tools that comprise the Lean Management concept. As presented in the case analysis the data collected and processed in the system refer not only to productivity measures (Delivery) but also to employee's attitudes (Morale) and production waste management (Environment). The set of observed VPM features (presented in Table 1 above) contains explicit advantages which undoubtedly contribute to Lean growth in the studied manufacturing system. Among them there are issues which can be recognised as particularly valuable and having special significance for Lean development. They are presented below:

Table 1
Identified features of studied VPM system

System sphere	Observed features and artefacts
Participation/ involvement	– multi-level system structure covering the entire facility – regular meeting including all employees – irregularity or lack of meetings at top levels (3 and 4) – rounds in Gemba in lower and middle levels – poor involvement of the higher level in the lower one – insufficient assistance and training at work stations – marginalised aspect of people motivation (employee assessment, material motivation and so on) – insufficient support and leadership from top levels (3 and 4)
Impact on improvement	– meetings concluded by assignment of tasks – regularity which strengthens routine – presence of action plan sheets – measures agreeability – covers detailed issues regarding work at stations – exhausts key areas, six areas – long response time of the management
Intelligibility	– aggregability of scores allows better understanding the role/contribution of each level – clarity of visual presentation, using colour symbols – location in Gemba, at work stations – using simple tables and forms – defined time standards for meetings – standard meeting agenda – data overload and time-taking data collection – ambiguity of some indicators – manual approach, IT systems are almost not exploited

1. Clearness of visual presentation on the production side which contains standard forms and colours identification.
2. The VPM system bases on the direct meeting between its actors which are held (in its major part) where real manufacturing processes are performed, in Gemba.
3. Comprehensivity of the variables important for the value stream along with the agreeability of collected indicators.

However, equally important are identified troubles and dysfunctionalities of studied VPM, their in-depth analysis might affect also with crucial VPM features. Investigated case allowed to recognize many difficulties in the proper functioning and correct implementation of the method in the facility. The first of observed issues is the variety of data which should be collected and analysed, as well as the multilevel structure of the system which measures the entire facility. The variety of analysed information results in the creation of many diverse forms of data collection. If no standardisation is in place in the process of composing analytical sheets, the situation may occur wherein the operator will be confused and unable to collect information correctly. This leads to erroneous verification of data and making decisions based on false information. The consequences may be excessive and/or groundless resulting from inadequate improvements. Therefore, it is so important to assure the functionality of action plan sheets, their clarity for employees (using simple tables and comprehensible forms) and their location directly in Gemba. This will help to easily accumulate real data directly from work stations. As it is stated above VPM is characterised by comprehensivity, at the same time, unfortunately, it could not avoid the difficulties in collecting data. It was probable due to from a very wide range of variables included by the system.

Another issue affecting the VPM system is the time-consuming execution of the method. Ongoing data measurement and analysis is a considerable benefit for the enterprise, however proper data processing needs, in studied case, high expenditure of time and work. Analysis, drawing conclusions and transfers between system levels take a lot of time. As observed many managers from studied company are not always favourably inclined towards such actions and, in many cases, deviates from such practices, focusing only of collection of data, without further analysis and without horizontal information flow. This results in pointlessly encumbering operators with the obligation to collect data without support from above in problem solving. This frustrates and discourages the bottom level operators and, in many cases, leads to abandonment of data measurement and analysis.

There are a few more issues which are noticeably significant and influential when referring to investigated VPM system dysfunctionalities. As presented above, in the section on case description, the upper level of management (on VPM level 3 and 4) participates not regularly in performance meetings, they devote very limited attention to the analysis of information from production areas. At the same time, there is observed a top-down imposed plan of improvement actions which pose significant problems on the production line. The lack of commitment from executive staff in holding meetings at top levels, declining to make rounds and hold meetings, the lack of employee training and guiding, insufficient support and leadership from top executive staff are suggested by interviewed people. Limited engagement of top management into VPM system could be perceived as the most important and main reason of vast part dysfunctionalities of the system as presented above. Lean literature states the Lean Philosophy and/or Lean Culture as inherent part of this management concept (Miller et al., 2014; Bhamu & Sangwan, 2014; Urban, 2015).

Studied system is designed as composed of the five levels, this fact is important from at least two reasons. First of all, the structure of VPM reflects the organizational structure existing in studied company, which has extensive hierarchical levels. Furthermore, it implies the circulation of performance information from the production line to the top and back to the line as some imposed improvement commands. Observed organizational structure seems to be rather similar to so called traditional management systems where the information and decisions are going down – top – and down, through many levels. There is an impression that Lean approach implemented to studied production system has been pressed into the traditional industrial organizational structure, existing before and new in the research object. On the top of VPM system (no matter how high is this level) an aggregated information on performance is absolutely necessary. However Lean approach suggest to present it to all of operators. Why not the top management would go where the machines stand and see aggregated data on the manufacturing system performance, it would be consistent with the Lean approach (Bhasin & Burcher, 2006; Papadopoulou & Ozbayrak, 2005; Hino, 2006). The observation indicates how important is not only appropriate VPM system design, but also adaptation of the entire organization structure and management philosophy to Lean requirements. Emiliani and Emiliani (Emiliani & Emiliani, 2013) state the mistaken Lean concept caused by misunderstanding of Lean principles by senior managers.

Observed VPM system should also be confronted with the Value Stream concept (Rother & Shook, 1999; Womack & Jones, 1996) which is in a central point of Lean approach. From the study emerges the view of the system looking like a pyramid, where the performance indicators are aggregated and reported from one to another upper level. The improvement initiatives are to the far extent imposed from above. There is no sign that improvement initiatives, as well as the entire manufacturing system, are commanded by the value stream and by the stream recipients. It is clearly seen that the value stream does not work according to the pull rule as indicated by Lean literature (Womack & Jones, 1996; Liker, 2004). What might be suggested from this observation is the necessity to turn the VPM system as being forced (working according to) not exactly by supervisory levels but value stream and customer requirements. In-depth analysis of VPM system dysfunctionalities allow to recognize another key highly desirable features of such system, they are as follow:

1. VPM system needs to be simple and at the same exhaustive, all the information and indicators should bring value to someone, what means be used by others, collecting necessary data needs to be not demanding and unambiguous.
2. Real engagement of the highest management level is absolutely indispensable when dealing with VPM method.
3. VPM system design needs to be as much as it possible compatible with Lean principles, flat and being forced by value stream requirements, which need fundamental coherence of the entire organizational structure and management philosophy to Lean approach.

Beside crucial amendments and potential improvements drawn from Lean principles and its fundamentals, another issue of the discussion of investigated VPM system is nowadays changes in industries referred to Industry 4.0. As stated in the case description above the system is designed as manual one, this means all the measures are presented on paper sheets, real whiteboards are exploited, the data are written by operators, etc. At the same time Industry 4.0 technologies could enable new highly probable more effective and efficient functioning in its many spheres. Among variety of so called Industry 4.0 tools (Asdecker & Felch, 2018; Salkin et al., 2018) some have a particular potential to interfere dramatically studied system. Virtual Reality/Augmented Reality along with Internet of Things solutions may change the way how performance data is gathered along the production stations and lines, and how it is visualised for the purpose of joint analysis and drawing conclusions. It looks that mention technologies may need to redesign cross-sectionally how investigated VPM system is operating now. However, abovementioned guidelines referred to Lean approach seem to be all the time valid.

Conclusions

Both sides of studied case, noticeable strengthens as well as dysfunctionalities, allowed to make valuable considerations referred to VPM method implementation and existence in the organization. From the study emerges a view of VPM method as a cascade information exchange system, it gathers structured and unified performance data and aggregates it on its higher levels. The set of measured variables is the same at all levels as well as in different processes existing in the value stream of investigated manufacturing system. This cascade approach allows to see the production system from different management perspectives and having the comparable overview. It can act as a management cockpit for all the managerial level, however as it was observed it does not fully yet, as revealed by carried out observations. Studied VPM system undoubtedly still can be evolved towards such formula, especially when gradually being supported by Industry 4.0 technologies.

Another important conclusion is that VPM would serve as strongly supporting employees engagement and their participation in the production value stream. Which are the basis of Lean approach and a fundament of Lean Culture in organization. In investigated VPM system, on the lower management levels, meetings around visual spots seem to be practiced very carefully, along with data analysis and conclusions referred to possible improvements. Notwithstanding, the longer observations and in-depth interviews with workers discovered still a limited engagement of operators from manufacturing lines. This goes along with noticeable shortcomings of engagement into VPM system by upper management level, which surely, to a large extent, determines the engagement of the rest of employees. Studied company could evolutionary better this state by following thoroughly Lean philosophy and by building Lean Culture. Thanks to this the VPM method in the observed in the study overall framework might strongly support em-ployees participation in value stream management. The system built in studied company covers all facilities and units in value stream, undoubtedly it can support effectively Lean principles strengthening.

Additionally, observed VPM fundamental dysfunctionalities have their causes in the company's organizational system design. The system apparently is composed of too many hierarchical levels, which was determined by the organizational structure at the time this method was implemented. Moreover, the performance system is forced primarily by the upper management level, but not by the value stream requirements along with stream recipients. These two fundamental faults are, similarly as stated above, their roots in limited implementation of Lean principles within studied manufacturing system. The research presented in this study shows how much the Lean tools, as VPM, are interrelated with existing organizational structure in the organization and real management philosophy considered by its managers. The research also proves that this is highly difficult to introduced properly Lean tools when general Lean principles are not fulfilled yet.

The empirical study allowed to formulate six critical features of VPM in the company, three of them are drowned from the strengths of investigated VPM and another three from dysfunctionalities. They refer to the presentation of data, measured indicators, participants engagement as well as the system design. All of them are practical and possibly can be applicable in many companies which are still in the initial phase on the Lean road. These six features can bring a value for any kind of organizations for diagnosis of their VPM method implementation and for its improvement. The study is particularly important for those who intend to introduce or improve this method.

The literature output is abounded in methodological and guidelines studies aiming at teaching managers how to implement variety of issues referred to visual management, however, as has been shown in the literature section, there is very little empirical indepth studies on how this method is functioning in a company. This is study tries to address this scarcity. The study shows clearly that manufacturing reality differs very much from what is presented by Lean gurus in management manuals, VPM reflects how the company is organised and many its dysfunctionalities have their reflections in VPM, as proved in the analysed case. VPM is not just a simple management technique, especially in a huge manufacturing system, this a method having potentially strong impact on many spheres of manufacturing system, work coordination, employee's attitudes and line productivity included. Its design eventually needs to reflect the principles and "spirit" of Lean Management, indeed.

Definitely, the study has several limitations. The main of them is due to the fact that the study bases on the investigation of one manufacturing system, what on the other hand, allowed indepth and comprehensive diagnosis of investigated system. Consequently, there is no empirical sureness how many of Lean companies affect similar troubles. Therefore, the study has primarily distinctive significance, which is also desirable by the science, alike practitioners. Indepth study of Lean tools and principles seems still to be very desirable.

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