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Indicating and analysis the interrelation between terms – visual: management, control, inspection and testing

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Abstract

The multitude of concepts and methods of management and control related to the word "visual" in the area of production and quality management may cause difficulties with their perception, proper understanding and use of these terms by researchers from various backgrounds (not necessarily related to production) and countries, including Poland. In particular, the noticed inaccuracies in the use of terms with the word "visual" concern such terms as visual: management, control, inspection, and testing, where, for example, in the Polish language the first three different terms in English are named with the same phrase, which sometimes causes some confusion. The aim of the article was an attempt to distinguish, sometimes "troublesome" definitions, to indicate the area of their application, to define possible relations between them, which is a peculiar novelty. The article is an analysis of the literature related to these concepts, systematizes the types of visual concepts and methods in the area of production and quality. It defines in what context the indicated terms should be used by researchers and what is the relationship between them, and under what conditions they can be used separately or jointly. The article is an attempt to indicating and analysis of the interrelation between concepts in which the word "visual" appears concerning production practice. Concepts visual: management, control, inspection, and testing, as the author proves in the article, they should be translated into English with due diligence, due to the differences between them. It has been shown that there is a strong relationship between type definition pairs as visual management & visual control and visual inspection & visual testing, where it is not a mistake to use them interchangeably, and cases, where all these concepts can intertwine, are also given.

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1. Introduction

People are beings guided largely by the sense of sight - this makes broadly understood visual communication extremely effective and efficient. When we see something, it is easier for us to understand, and a drawing is often worth more than a thousand words. With visual language, it can be spread knowledge much more effectively than with any other means of communication. Visual communication is universal and international. Visual language can convey facts and ideas more broadly and deeply than any other means of communication. Visual language brings many benefits and is generally easy to apply, hence the popularity of "visual" concepts and methods in the area of production management and concept quality.

Visuality in the workplace is often related to transparency, which poses a challenge in the application of visual concepts

and methods. People are reluctant to be transparent in the workplace, which is related to their fear of the reaction of the environment in the event of revealing the results of the operation of the "visual system", and of using this knowledge for purposes contrary to their interests. However, this defiance can be overcome, and the benefits of using visual concepts and methods often outweigh the weaknesses and problems associated with their implementation and then their application in practice. The popularity of visual solutions and all concepts in the production area with the word "visual" is related primarily to their universality, relatively low implementation and application costs, the ease and speed of transforming various types of information into knowledge, and its adaptation by all interested persons (stakeholders).

Work and its results in the area of production management can be seen with the use of many visual means. The choice of the appropriate one depends on its area of application, the distance criterion and the complexity of the information conveyed visually, but mainly on the purpose of using visual solutions. Concepts and methods in the area of production based on the word "visual", such as visual management, control, inspection, and testing, indicate the area of their application in from the very name. Visual solutions can be used in the broadly understood area of work environment management, in the area of process control, quality control, and quality testing. The article aims to define the terminological scope of all mentioned: "visual concepts" based on the analysis of English-language literature, to indicate the differences and similarities between them and the mutual relations. The result of the analyzes will be diagrams of dependencies showing the relation between the studied terms.

2. Literature review

2.1. Visual management (VM) and visual control (VC)

The term visual management (Imai, 1997; Liff and Posey, 2004; Drew et al., 2004; Denis and Shook, 2007; Liker and Hoseus, 2008) is close in meaning to the concepts of: visual workplace (Greif, 1991; Hirano, 1995; Galsworth, 1997, 2005), visual controls (VC) (Shingo, 1989; Shimbun, 1995; Liker, 2004; Mann, 2014), visual factory (Bilalis et al., 2002; Aik, 2005), shop floor management (Suzaki, 1993), visual tools (Parry and Turner, 2006) and visual communication (Mestre et al., 1999). Misuse of the terms is a common practice (Standard and Davis, 1999). Tezel et al. (2016) indicate that these terms are related but nonetheless different, so it is important to distinguish between them. They also emphasised that degrading and narrowing of VM concept to some house-keeping, production, or quality control methodologies can also be seen. VM is defined as a managerial strategy that emphasises close-range visual (sensory) communication and is realised through different visual tools, including visual controls (Tezel et al., 2016). In this contest, VM is considered as a way of making work actions visible in order to improve the flow of work (Beynon-Davies and Lederman, 2017). Rich, et al. (2006) defined VM as a solution aimed at using visual forms of information about work management in the organization, consisting of visualizing the analysed issues or the process of providing solutions to a particular problem. Huber (2006) defined VM as any kind of visual support or device that allows managing information more effectively, which eventually leads to the reduction of losses in the enterprise. The VM is defined by Liff and Posey (2004) as a management system that seeks to improve organizational performance through the connection and alignment of vision, values, goals, and organizational culture with other management systems, work processes, work environment elements, and people participating through stimuli that are directly connected to one or more of the five senses (sight, hearing, touch, smell, and taste). VM involves a set of visual devices that are intentionally designed

to enable the sharing of information between people, including messages communicated through any of the five senses (Galsworth, 1997).

VM is used to share information, work standards, build on those standards, highlight problems, stop problems occurring, and prevent problems altogether. The core objective of VM is related to increasing process transparency, reducing variability (Formoso et al., 2002), implementing continuous improvement (Bernstein, 2012; Kurpjuweit et al., 2018), and other core Lean Production principles. Besides, VM simplifies production control (Koskela, 1992) and allows faster understanding and response to problems (Bateman et al., 2017).

VM is formed by a combination of Visual Metrics and Visual Controls (VC) into easily digestible information with little to no training to understand. VM consists of fairly simple visual practices, such as boards that contain procedure information, production drawings, or performance metrics (Brandalise et al., 2018; Tezel et al., 2016), and more advanced practices requiring planning and stability within the production system (Brandalise et al., 2018; Tezel et al., 2016).

Lewinski (2018) indicated that VM should include its maximum range of the company's operation to take of all its advantage. It also emphasised that VM must incorporate the entirety of the manufacturing process to promote transparency throughout the company (Mikusz, 2014; Steenkamp et al., 2017). VM goes beyond production management in shop floors (factories), and it can be successfully adopted by commercial, educational, healthcare and governmental service, IT, and construction organisations (Tezel et al., 2016).

There are many proven benefits of implementing and using a VM (Formoso et al., 2002; Moser and Dos Santos, 2003). VM provides it easier for managers to define the priorities and optimize their working time as well as allows them to delegate tasks, but also initiates a real exchange of experiences and mobilizes the team to achieve goals and joint problem-solving (Wojakowski, 2013). The benefits of the VM include increased self-management, better team coordination, better promises or an increasing PPC, easier control for the management, and with the 5S, an improved workplace condition with decreased item transaction process times, savings in workspaces, and a better health and safety condition (Moulding, 2010; Liker, 2004). VM keeps an organisation focused on monitoring, filtering, simplifying, and effectively presenting quality information, which is necessary, relevant, correct, immediate, stimulating, and located as close to the relevant place as possible or integrated with the workplace, process, machinery, tool, inventory, etc. (Tezel et al., 2009).

VC is referred to as one of the VM tools (Lewinski, 2018). VC is perceived as the "micro" concept and VM as the "macro" concept (Richardson, 2014), where VC is in the area of VM. VC is shown as one of the five ways to create a visual workplace, in which VM is realized (Galsworth, 2005). VC relates to the Toyota Production System (lean production), where the term was used in the context of the production control efforts. VC is a fundamental element in Toyota's production system (Toyota production house), a particularly important tool in the "pillar" named Jidoka (Liker, 2004). Liker (2004) defined the VC system as communication devices that

tell people how things should be done and show the deviations at a glance, helping people see immediately how they actually perform their jobs. VC is defined as a production control tool, used to impose a limit or strong guidance on employees' actions, which is perceived as a more operational VM tool. Another definition describes VC as "any intuitively-easy-to-understand system for monitoring and controlling a process." (Systems2win). All mechanisms of VC are at the micro-level, exactly at the process level to help team members at a process level to know where they were compared to the ideal state/standard in all scenarios. The purpose of VCs is to focus on the process and make it easy to compare expected vs. actual performance (Wright, 2009). VCs are integrated into the process related elements (e.g. the process itself, equipment, and inventory, etc.) (Brady, 2018). The main purpose of VCs is to organize the working area so that people (even outsiders) can tell whether things are going well or something is amiss (Galsworth, 2005). VC gives opportunities in a matter of minutes determining the status of the operations and getting answers to a few questions: What might be abnormal? How the material is flowing? What job is currently being worked on? What job is next to be worked on? (sixleasigma.com). Other definitions emphasized that VC systems are used to limit, to track, and to regulate work processes through simple visual clues (e.g. cards, tokens, signs, signals) (Motwani, 2003; Ortiz and Park, 2011; Mann, 2014).

It is indicated that matters of where items are located, general housekeeping, and controlling the flow of production can all be covered by VC. VC makes product flow, operations standards, schedules, and problems instantly identifiable by each stakeholder. Liker (Liker, 2004) defined VC as means, devices, or mechanisms that were designed to manage or control operations (processes) so as to meet the defined purposes. According to Liker VCs (I) make the problems, abnormalities, or deviation from standards visible to everyone and thus corrective action can be taken immediately (identification); (II) display the operating or progress status in an easy to see format (informative); (III) provide instruction (instructional) and (IV) helps formulate and proliferate plans (planning). VC brings numerous benefits to the process on the shop floor including process transparency; first in first out (FIFO) of product at individual operations; transference of process ownership to the operators; transparency of bottleneck and problems arising, a mechanism on which to base process reviews, focus on continuous improvement efforts (Parry and Turner, 2006; Kurpjuweit et al., 2018). VC is key factor in production process of companies from automotive branch (Borkowski and Knop, 2013).

It was defined fundamental requirements for VC, which include six elements such as (1) compares expected vs. actual results, (2) is visual, (3) is near the place where the work is done, (4) is updated frequently, (5) has notes explaining reasons for every miss, (6) is accompanied by a Lean Management (Systems2win). A VC and VM system must be visual. It was indicated that data hidden inside a computer does not meet the above criteria until perhaps it is printed or otherwise reproduced in a way that meets the specific criteria. Systems2win gave the requirements (criteria) ex. for a visual control chart,

pointing out that it has to be any printed or hand-written chart that: (1) is used for monitoring or controlling any aspect of production, (2) is posted in plain sight very near the place where the actual work is done, (3) is frequently updated with the latest results, (4) graphically highlights problems, (5) has notes clearly articulating the reasons for 'misses' and (6) can ideally be understood at a glance by anyone passing by. All these requirements must be met to be able to name ex. Visual Management Board is a visual tool.

There are many VM and VC tools available (Abdelkhalek et al., 2019), their list is all the time open (Singh and Kumar, 2020). As previously indicated, the VC is contained within the VM. The VC tool will be also VM tools. Four types of VM tools identified by Galsworth (1997) contain: 1) visual indicators, 2) visual signals, 3) visual controls, and 4) visual guarantees. One source of classification gives the following division of VM tools, which contain also VC tools (table 1).

Table 1. Tools used in VM and VC (Ad Esse Consulting)

The workplace itself	Visual information	Visual controls
<ul style="list-style-type: none"> • Signs • Marked floor areas • Direction of process flow shown • Shadow boards to visibly store physical items if used • Identified equipment & locations – including files, processing status, etc. 	<ul style="list-style-type: none"> • Process documentation • Procedures • Skill & training boards 	<ul style="list-style-type: none"> • Visual process indicators (work in progress, productivity, output, lead time, etc.) • Maximum work-in-progress levels show to prevent over-production • Status boards • Kanban visual signals
Autonomization	Visual performance measurement	Visual safety management
<ul style="list-style-type: none"> • Machines stop automatically when a problem occurs, informing you about it. 	<ul style="list-style-type: none"> • Quality charts • Performance charts • Status of the organisation 	<ul style="list-style-type: none"> • Safety warnings • Precaution information.

Fig. 1 organizes VM tools for the purpose of establishing a visual workplace (Galsworth, 1997). VM employs one or a combination of four types of visual tools, among which is VC.

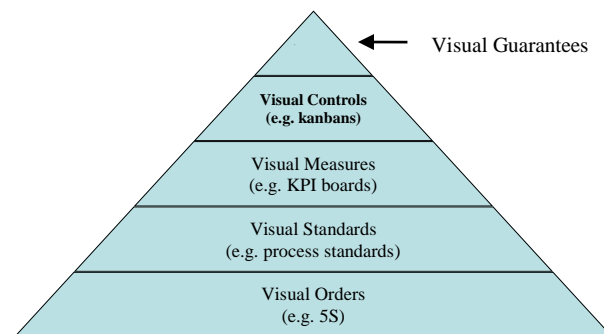


Fig. 1. Pyramid of VM tools for establishing a visual workplace

Another list of VM tools contains: standard signs with specific colours (display boards), colour coding, visual display of data in the form of graph 5S, Heijunka, Big Room, Andon,

Kanban, Poka-Yoke (Singh and Kumar, 2020). This list also includes examples of VC tools.

Examples of VC include control tables, kanban, daily production boards, signs classifying sections, coloured lines on the floor indicating how a product is to be stacked, metal clipboards, containing information that is needed at your fingertips (Mann, 2014; Knop and Mielczarek, 2016). Kinds of VC deeply rooted in the Toyota culture are visual indicators that contain graphs, charts, Andon and kanban systems, and the A-3 report standard. One of the greatest innovations of Toyota in the field of visual control is Obeya (Liker, 2004; Knop and Mielczarek, 2016). Toyota plants use in Jidoka pillar VC tools called Andon - an information board that indicates the place of the problem in the production process by means of light signals, tones, music. As mentioned before, the list of VC and VM tools is open. It is emphasized (Glasworth, 2005) that the only limitation in the practical use of VC / VM is human imagination.

VM/VC is a Lean tool (Liker, 2004; Singh and Kumar, 2020). VM and its associated VCs have long been cited as a fundamental part of the Lean production system (Tezel and Aziz, 2016). VM/VC is an element of lean and is inherent in lean implementations (Radnor, 2010; Bateman et al., 2016). VM/VC is perceived together with 5S as the heart and soul of a Lean production system. VM/VC is an essential tool in Lean linking the data and the people. VM/VC is releasing the potential of Lean and has the power to drive performance and to engage and enthuse the whole team to better results. It is perceived also as the key to sustaining improvements. In a lean strategy, the essence of VM/VC is to obtain a work environment in which nobody will have to guess anything. In this case, no one means 100% of the stakeholders (employees, leaders, managers, trade unions). Nothing is about three basic aspects: performance, processes, and leaders. With VM/VC, companies implementing Lean can achieve better agility of the organization, which is a competitive advantage (Ulewicz and Nowicka-Skowron, 2017).

Visual Control and Visual Management together are a piece of a larger pie which Richardson (2014) called "the cultural infrastructure," contributing together to job security and the long term sustainability and growth of a company. The primary goal of VM/VC is to communicate the fact that a problem has occurred to everyone. The effectiveness of VM/VC is the result of the tools used to communicate information and it is closely correlated with the time of informing about a non-standard situation (problem). The best visual communication tools are "cheap" (the cost of their implementation is low), "fast" (allow the recipient to quickly find out about a standard and non-standard situation), and "good" (achieve the intended goal for the first time, through the first "glance"). The basic principle of implementing VC / VM tools is the same as in implementing Poka-Yoke (Hinckley, 2007) and says: Don't wait for a perfect VC / VM project/tool. Do it! If your idea for VC / VM tool has more than 50% chance of success... Do it now.... improve later!

2.1. Visual inspection (VI) and visual testing (VT)

Visual inspection is a type of quality control, which consists of determining the properties of the inspection object (e.g. products, machines, devices, or their components) in the process of its manufacturing or operation with the help of "visual" methods (Kolman, 1998). It can be performed only by a human and his senses (organoleptic - visual inspection), without his participation (vision systems, machine vision) or by a "man-machine" hybrid (visual examinations with the use of visual aids, e.g. defectoscopes, microscopes, magnifiers in as part of visual tests - VT) to assess the compliance of the inspection object with the requirements. It may take the form of a numerical inspection, where the result of such inspection is a specific numerical value of the measured characteristic (ex.: measurement of components intended for subsequent welding, dimensioning of the finished joint for compliance with the technological instruction) or an alternative inspection, by comparing with the pattern and issuing a two-option assessment, e.g. "compliant product" or "non-compliant product", or multi-option (ex.: control of the compliance of the surface color with the requirements) (Knop et al., 2019; Webber and Wallace, 2007). Visual inspection is used when the measurement of object features is difficult or economically unjustified (Božek et al., 2017; Knop et al., 2019). VI is often described as a way to detect a product's functional anomalies (Baudet et al., 2012).

Organoleptic - visual inspection is an inspection in which the inspector, when determining the properties of the product, uses only the sense of sight (Kolman, 1998). It is used to define: general appearance, shape, colour, uniformity, surface defects, impurities, etc. The organoleptic visual inspection may take the form of a visual inspection to initially verify whether the part is fit for use in the further course of production, whether it should be rejected or if it can be repaired. Despite their imperfections and a high risk of non-conformities not detected or inadequate assessment by an employee performing a visual inspection, manufacturers of metal products (e.g. rolling bearings) still commonly use traditional visual quality control methods, supported only by auxiliary measurements of measuring devices. (Giesko et al., 2011a, Giesko et al., 2011b; Szklarzyk, 2014).

Visual inspection may take the form of a machine visual inspection or an automatic inspection (*vision systems, machine vision*). Various types of machine vision systems are used, allowing for single or multiple inspections to be performed simultaneously, which significantly shortens the inspection cycle. Optical inspection systems are used to detect surface incompatibilities of elements, i.e. cracks, material loss, corrosion, contamination, and shape geometry defects (Giesko et al., 2011a, Giesko et al., 2011b). The applied VI systems based on machine vision allow for the inspection of the correctness and completeness of the execution, shape and dimensions, identification of markings, determination of the location, and surface inspection of various products (Kwaśniewski, 2015).

Visual testing (VT) is also known as visual: testing examination, nondestructive inspection, or nondestructive evaluation or examination (Marshman, 2019). VT is defined as the

process of observation and measurement aimed at verifying whether a tested object meets specified requirements. VT is the oldest and most common nondestructive testing (NDT) method (Zetec). VT is a popular method of NDT because it is easy to perform, it is a low-cost method, and it requires minimal equipment (Zetec). VT involves observing a component with the naked eye - direct visual examination without aids (because there is no gap between the eye and the object), with the use of visual aids - direct visual testing, which enhances VT quality. Among the visual aids in VT are used among others: glasses, boroscopes, mirrors, magnifiers, telescopes, microscopes, fiber-optic instruments, endoscopes, or other computer equipment for remote viewing. The third type of VT is an automated visual inspection. It is remote visual testing where the nature of the image is modified: for example, the optical image is converted into an electronic image by the camera. The logic diagram used to identify the appropriate visual type test is shown in Fig. 2.

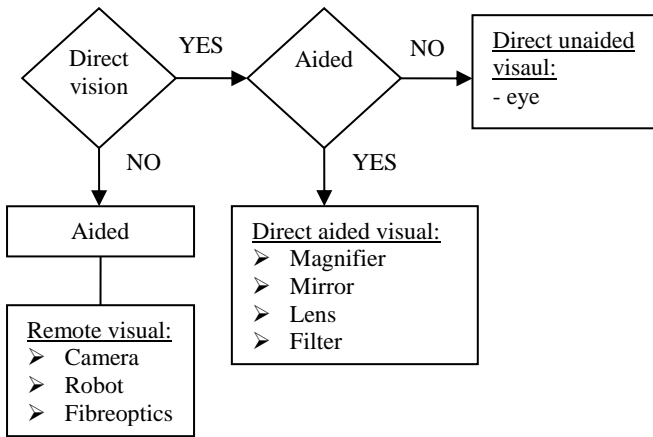


Fig. 2. Logic diagram for selecting the appropriate test in VT

In VT process can be used optical and mechanical aids (table 2).

Table 2. Example of aids used in VT

Optical Aids	Mechanical Aids
- Microscopes	- Micrometers
- Borescopes	- Calipers
- Fiberscopes	- Depth gauges
- Video Cameras	- Thread pitch gauges
	- Feeler gauges
	- Weld gauges

VT belongs to the category of surface testing. VT allows for the detection of discontinuities on the surface, such as flat or narrow fissures. The purpose of VT is to assess the surface condition (e.g. corrosion or erosive changes, cracks), control of shape deviations, joints (especially welded ones), as well as control of the object after its repair. The VT method is used in the material production process and during the facility's operation. VT plays an important role in the metal industry because of their versatility and the ability to detect a large number of non-conformities. Many defects in shape and dimensions, surface defects, also defects for inaccessible interior surfaces can be detected by VT but flaw assessment on a deeper level of

the product is impossible by VT. VT is especially used in the control of rolled and forged products, castings, and welded joints, in relation to products such as: welded metal structures, steel plates, universal plates, and hot-rolled sections, forgings. Carrying out VT in good time avoids costly repairs and problems. VT is inexpensive and requires less training than other testing methods. It is emphasized reduced effectiveness in detecting non-compliance of products by VT due to the participation of unreliable human factors (greater margin of human error), hence VT should not be used on its own as a means for a complete inspection on critical points. VT supports other NDT testing methods, such as penetration, magnetic particle, ultrasonic, and radiographic (Zetec).

In English terminology, the terms visual inspection (VI) and visual testing (VT) are often used interchangeably (Zetec; MME-group). Being in line with the European and International Standards (EN, ISO) that specify VT as a process, the term used as this type of visual test and assessment method should be VT, not VI. VT could be treated as a specialized form of visual inspection (VI) process because VT is carried out in accordance with strictly defined procedures and standards. There are many specific standards (National, European, and International Standards) that strictly define the general principles of carrying out these tests, their equipment, and the auxiliary devices used, in relation to specific production technologies (founding, welding, forging, special techniques). There are also many variations that need to be managed (Mrugalska and Ahram, 2016), caused by personal, technical, organizational, and environmental factors. They must be limited for the VT results and also VI results (Kujawińska and Vogt, 2015; Kujawińska et al., 2016) to be reliable. This is why specialized companies are responsible for conducting especially VT, because they have experts and facilities that allow the selection of appropriate measures necessary to carry out the entire process.

Both, VT and VI are often carried out by one single inspector who assesses the quality of the product by referring to either a set of standard products or to his own experience (Baudet et al., 2012).

Summarizing, the relationship between VI and VT is that each VT is VI, and not all VI is VT. The concept of VT is contained in VI.

Despite the development of measurement methods based on more and more objective measuring instruments, visual inspection is still the dominant quality control method in many companies.

3. Results and discussion

3.1. Relationship between VM and VC

The analysis of mutual relations between the concepts of VM and VC type were presented in this section.

First, the terms VM and VC were distinguished according to the area of application in the company (macro approach), as shown in Fig. 3.

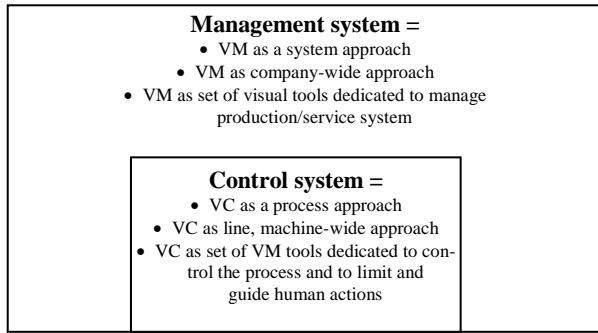


Fig. 3. Relation between VM and VC concept

VM should be treated as a company-wide "nervous system", including all departments in the enterprise. It should also be perceived as a set of "visual" tools that facilitate company management (overall), not only production management. In Lean concept most of VM application refers to production and quality management (on production hall), hence the concept is often (wrongly) narrowed down to the area of production management. VM can be used in any area of the organization's activity. VC should be understood as a tool of the VM concept dedicated to the management and control of the production (but not only) process and to limit and guide human actions. Summarizing this part - VM includes VC. VC is an integral element of the process-oriented VM, aimed at indicating its status, standards, identifying problems in its course or results, and informing stakeholders about other important aspects of the process (e.g. KPI) and all this "at a glance" (as soon as possible).

Given one of the goals of visual management, i.e. creating a clear, visual workplace that is easy to orientate by all people in the company, VC is one of the tools to achieve this goal (Fig. 4).

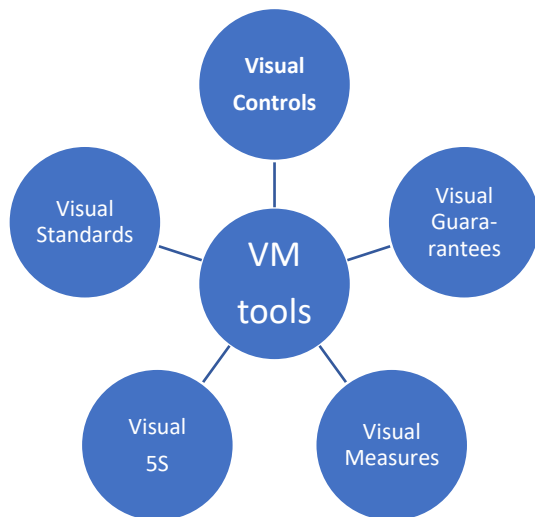


Fig. 4. VC as one of the 5 VM tools in creating visual workplace

Considering the visual management system as a set of tools, the concept of VM encompasses these tools much more than the concept of VC, as shown graphically in Fig. 5.

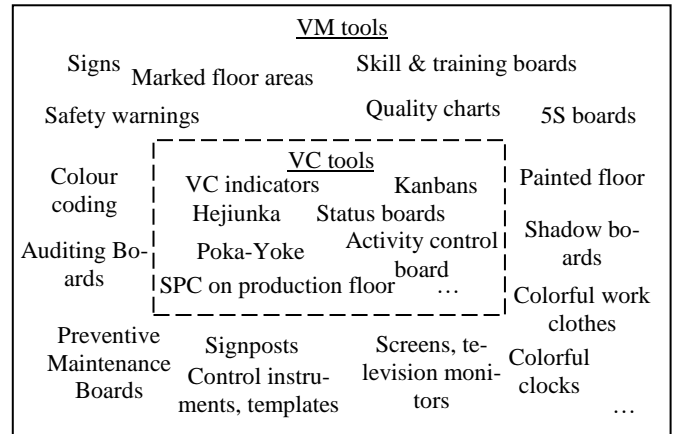


Fig. 5. Examples of VM tools and VC tools

VC tools are dedicated to the process, its management, and control, while VM tools can relate to all aspects of the company's operations (marketing, research, and development, distribution and customer service, employee recruitment). VM is a universal concept that can be implemented anywhere, for any type of human activity. The list of VM and VC tools is open (there may be an infinite number of examples), hence the indication in the form of three dots.

Summarizing this section, VM and VC tools are often used together to manage and control various aspects of the business, in particular, they are popular in manufacturing companies that use the Lean concept (Mann, 2014; Parry and Turner, 2006; Pettersen, 2009). Their goals coincide with each other, only the narrower area of influence of VC tools differs. VC tools are process-oriented and are designed to help control the process flow by making it transparent and easy to evaluate and control, and therefore to take quick remedial actions when the process flow itself or its results are abnormal.

3.2. Relationship between VI and VT

VI is a common method of quality control, data acquisition, and data analysis which includes various methods of visual evaluation (numerical evaluation) and/or assessment (alternative evaluation) with different human participation in these processes. VI processes can be divided according to various criteria. It was decided to analyze possible criteria for the division of VI methods according to 5W+2H questions (Knop and Mielczarek, 2018). The division of method VI was made on the basis of literature research (Blikle, 2018; Budet et al., 2012; Evans and Lindsay, 2011; Hamrol, 2005; Hinckley, 1997; Knop et al., 2019; Kolman, 1997; Kujawińska et al., 2018; Oakland, 2007; Starzyńska et al., 2018; Sun et al., 2018; Ulewicz, 2018; Ulewicz and Mazur, 2019; Webber and Wallace, 2007) and for the purpose of the study. The result of an analysis is shown in Fig. 6.

As shown in Figure 6, VI may occur in many different varieties depending on the adopted classification criterion. 15 such criteria have been listed. VT was indicated as the VI variant from the degree of specialization of the control process.

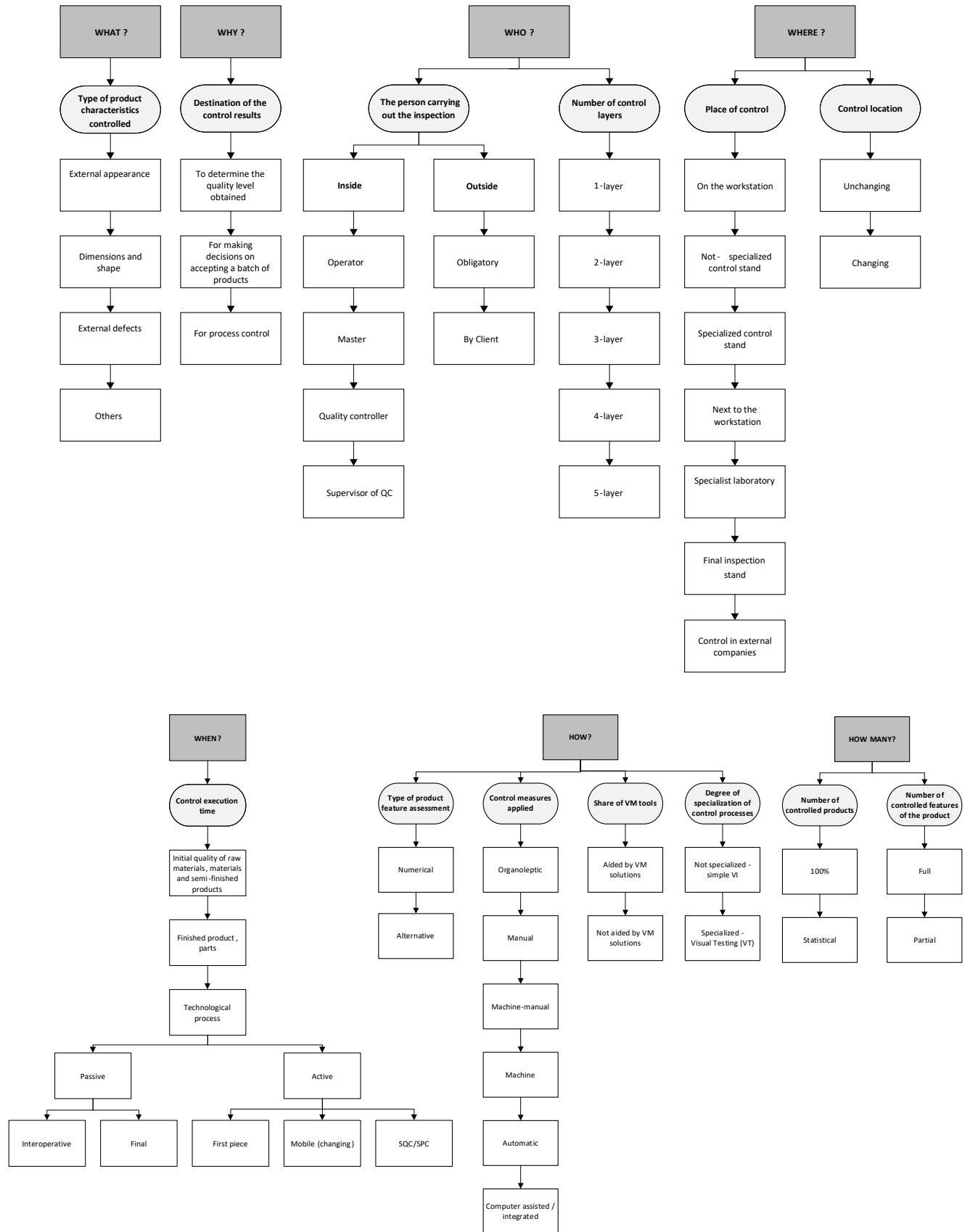


Fig. 6. Division of VI methods according to the 5W2H criteria

The personnel carrying out VT should have appropriate experience, appropriate technical knowledge and excellent regulations, standards and requirements related to the technology of manufacturing the tested elements. VT tests must be performed in appropriate conditions (ex.: lighting, proper access to the test area).

There are certain standards closely related to VT, this makes VT a specialist visual inspection. Can visual testing be called visual inspection? Of course yes. Can visual inspection be called visual inspection in all cases? No, because the term VT carries certain connotations. Therefore, these terms should be used interchangeably with great sensitivity.

3.3. Relationship between VM & VC & VI & VT

The terms VM & VC with VI & VT may be used together under certain conditions. VM & VC makes the process state visible to everyone at a glance as a result of its application. The visual aspect of VM & VC is that everyone can look at a process and tell at a glance whether it is under control or not. In this case, the visually assessed processes are VI & VT. VM & VC is implemented through the use of various types of visual "tools", where VM & VC is a set of tools, i.e. means, devices or mechanisms that are used to manage or control operations (processes) so that specific goal can be achieved. To consider VI & VT in the context of VM & VC certain VI & VT visual tools must apply. This visual tool, in turn, must meet specific VM & VC goals. One of the most important goals of VM & VC is to quickly detect process anomalies, problems in general. If, as a result of the implementation of visual solutions to the VI & VT process, problems (whether related to the execution of this process, its results, or the "inputs" to the process itself) become immediately visible for all interested persons, then it can be stated that the goal VM & VC was realized. VM & VC is to enable easy control of the basic parameters of the effectiveness and efficiency of processes. If indicators or all important parameters covering the VI & VT process are established, they should be visible to all participants of this process at a glance.

The visual workplace, as a result of implementing VM & VC to VI & VT processes, should show a tendency to self-improvement. VI & VT workstation should be self-organizing, self-explaining, self-regulating, and self-correcting - where, what is going to happen is going to happen, on time, every time - as results of visual solutions.

The relationship between the terms VM & VC and VI & VT can be determined from Fig. 7.

As can be seen, the overarching concept that can cover all departments and processes in the company is the VM concept. VC tools can be used to manage production control also to safety control or maintenance. They limit and guide human actions. For VI / VT processes, VC solutions may apply. The VI / VT processes may or may not be supported by the VC as indicated by the dashed line. Identically, the VM concept may include all departments in the company or only some or selected places or processes carried out in a given department

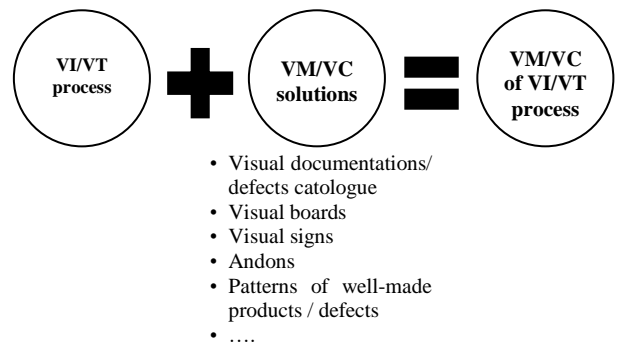


Fig. 7. VM & VC of VI & VT process

The relationship between VM & VC and VI & VT process is presented in Fig. 8.

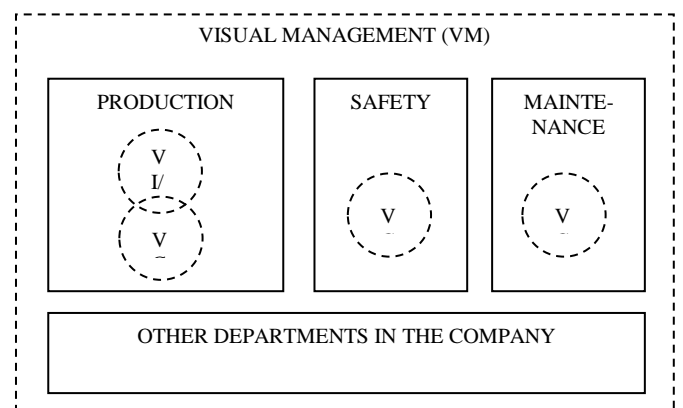


Fig. 8. The interpenetration of methods VM & VC & VI & VT

Some examples of the use of VM / VC solutions in VI / VT processes are shown below:

- visual documentation - a catalogue of defects located at the control stand,
- marked samples of well-made products placed at the control stand as a reference point in the assessment,
- optical camera connected to the Andon system, providing visual and light information about the detected defects,
- defect interactive mapping (heatmap) from 3D scanners and vision cameras presenting in real-time graphically the defects detected on the product's image and next enabling data-based decisions in a way that ensures easy access to this data by each employee,
- shadow board on the control stand indicating the right place for the control instruments used in the VI / VT process.

There can be many examples of using visual solutions in VI / VT processes. The limitation is the time, costs, and resources (people) associated with creating visual solutions and the expected benefits related to their functioning in the area of control.

In summary, the following minimal conditions must be met to combine the terms VM & VC with VI & VT:

- implementation of appropriate VM & VC tools to the areas of VI & VT process execution,
- enabling quick visualization of problems, deviations from the standards in terms of VI & VT process inputs (5M), the

course of the process or its results, and ensuring immediate reaction of people,

- making it possible to show and explain the purpose of the improvements in the VI & VT area, if such improvements have been made,
- transparency of visual solutions in the VI & VT area and easy access to them (availability) by all stakeholders,
- ease of defining the purpose of using VM & VC tools in the VI & VT system and information provided by them by each employee,
- ensuring that VM & VC is an active management and control support system (e.g. routine meetings at visual information boards, the inclusion of the VM & VC system as an element in the process of training new employees or employees changing workstation),
- the ability to emphasise tangible benefits related to the functioning of the VM & VC system in the VI & VT area by the management staff and subjective benefits by each employee.

It should be emphasised that VM / VC can improve any process, including VI / VT, by making it run more efficiently by making the steps in the process more visible. Measurable, proven benefits related to the implementation of the VM / VC system to various areas in the enterprise encourage the implementation of visual solutions for quality testing and inspection processes.

4. Summary and conclusion

The article deals with terminological issues related to the concepts and methods of management and control based on the word "visual". The analysed terms and relations between them were presented. Indicating the mutual relations between the all "visual" terms is the added value of the article. The article shows that the terms VM and VC overlap, as well as VC and VT. There is a strong relationship between them.

VM was defined as a general, universal concept that could cover the entire enterprise. On the other hand, VC as a collection of visual solutions dedicated to the management and control of the production, safety or maintenance process. Despite their frequent interchangeable use, the author orders to use these terms with appropriate care, depending on the area and purpose of use.

The same observation applies to the type VI and VT as inspection and testing methods. As shown in the literature analysis these terms can be used interchangeably, but it was emphasised specific connotations about using VT term. This VT method was defined as a specific, specialized VI method based on specific procedures and standards. As was shown, naming VT VI does not cause any confusion, while the use of the term VT instead of VI should already be dictated by certain conditions.

It has also been proven that the VM / VI concepts can overlap with the VI / VT methods. It has defined what minimum conditions must be met in order to do so. VM / VI tools can help identify problems in VI / VT processes, indicate standards and deviations from them, ensure staying in touch with reality, and indicate quality goals, the degree of their implementation, achieved results from VI / VT processes. The range

of influence of VM / VC tools in the area of VI / VT processes can be narrow or very wide, depending on the demand and awareness of the benefits of having such a system. It has been shown that companies implementing the Lean concept consider the VM / VC concept to be fundamental, necessary for implementation in the areas of production and quality, hence they are certainly more willing to implement such solutions to various processes in the company, including quality control processes. Examples of applications of VM / VC solutions in VI / VT areas were also indicated.

The aim of the article was achieved because the definition of the four studied terms with the word "visual" was systematized and the mutual relationship between them was defined.

Visual management solutions are becoming bolder and bolder in production and service companies. The proven and described benefits of having such a system by many companies mean that many managers want to have such solutions in their company. Quality control processes are one area of their application, certainly not the most popular one yet. In the era of industry 4.0, you can notice an increasing connection of visual systems with quality control and testing systems. VM / VC in a digitized form is required to be implemented in quality control processes in Industry 4.0 enterprises. Vision sensors, optical or industrial cameras connected with a lean digital board instead of a traditional lean board can display data in real-time dynamically informing about the results of the quality control process so that evolutions and alerts from the process can be taken into account instantly. Digital transformation is happening covering visual management systems and quality control processes. An interesting one for scientific purposes is to evaluate the role of visual management systems in the changing production reality, moving towards the challenges of Industry 4.0.

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指示和分析术语之间的相互关系 – 视觉：管理，控制，检查和测试

關鍵詞

视觉管理
视觉控制
视力检查
外观测试
相互关系

摘要

在生产和质量管理领域中与“视觉”一词相关的众多管理和控制的概念和方法，可能会导致来自不同背景的研究人员在理解，正确理解和使用这些术语时遇到困难（不一定与生产有关）和其他国家/地区，包括波兰。特别是，在使用“视觉”一词时发现的不正确之处尤其涉及视觉等术语：管理，控制，检查和测试，例如，在波兰语中，英语的前三个不同术语被命名为使用相同的词组，有时会引起一些混乱。本文的目的是尝试区分有时是“麻烦的”定义，以指示其应用领域，定义它们之间可能的关系，这是一个新颖的现象。本文是对与这些概念相关的文献的分析，将生产和质量领域中视觉概念和方法的类型系统化。它定义了研究人员应在何种情况下使用所示术语，以及它们之间的关系，以及在何种条件下可以分别或联合使用这些术语。本文试图说明和分析概念之间的相互关系，其中出现了与生产实践有关的“视觉”一词。视觉概念：管理，控制，检查和测试，正如作者在文章中所证明的那样，由于它们之间的差异，应将它们认真翻译为英语。研究表明，类型定义对之间有很强的关系，例如视觉管理和视觉控制以及视觉检查和视觉测试，可以互换使用它们不是错误，并且所有这些概念都可以交织在一起的情况也是如此。给定的。
