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## SOME ASPECTS OF VISUAL MANAGEMENT SYSTEMS APPLIED IN MODERN INDUSTRIAL PLANT

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### ASPEKTY STOSOWANIA SYSTEMÓW KONTROLI WIZUALNEJ W NOWOCZESNYCH ZAKŁADACH PRZEMYSŁOWYCH

#### Abstract

The paper describes the main features of visual management systems applied to track production state inside manufacturing cells. The description is restricted to the class of the systems called electronic andon system. The way of gathering data from manufacturing cell about process performance is depicted. Integration of electronic andon with ERP systems is presented.

*Keywords: visual management, andon, shop floor control*

#### Streszczenie

W artykule opisano główne cechy systemów kontroli wizualnej stosowanych do śledzenia produkcji w gniazdach przedmiotowych. Ograniczono się do opisu klasy systemów kontroli wizualnej zwanej elektronicznym systemem andon. Zobrazowano sposoby gromadzenia danych w takich systemach. Przedstawiono sposoby integracji tych systemów z systemami zewnętrznymi na przykładzie komunikacji z ERP.

*Słowa kluczowe: kontrola wizualna, andon, system kontroli produkcji*

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## 1. Introduction

Effective functionality of an industrial enterprise requires a real effort to control production activities. Effective management of the production systems requires receiving valuable and adequate information from the area where operations are processed. It can be noticed recently that manufacturing plants need a revolution in communication between operative units within a company. Traditional methods such as e-mail, reports, telephones or computers – are not enough. These channels are overloaded, information is illegible, the working environment is becoming crowded, and operating expenses get out of control [1].

It means that information should be simple, clear and suitable for immediate interpretation in order to still improve manufacturing productivity. This information should inform, warn and motivate for every employee responsible for the production process on the shopfloor. Moreover, the information should be gathered as fast as possible to have instant performance feedback about how the system is utilized. The answer to this is the concept of visual management.

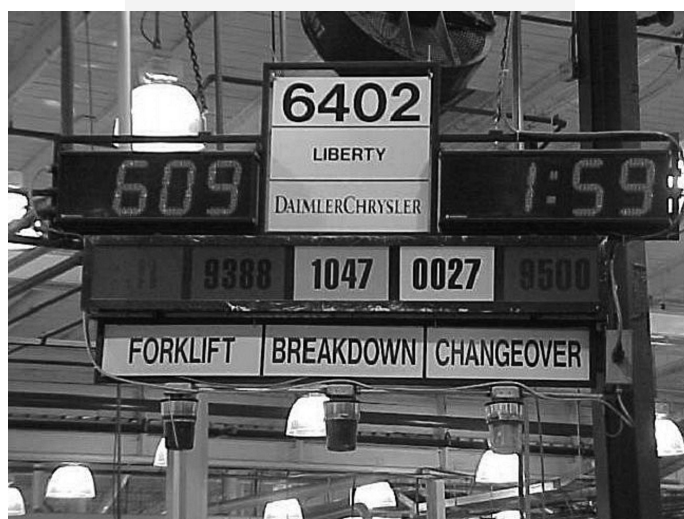
According to ref. [2], the concept of visual management was created to highlight the problems associated with the production directly to the workstation. Production problems, in particular reasons of their occurrence, result in production losses, classified into Six Big Losses [3]. It can be categorized into the availability losses, which include losses caused by unplanned downtime related to equipment failures or lack of material and losses caused by workstations stopping due to changeover of machines. The next two categories of production losses concerns the case in which workstations performance declines. These contain any reduced speed of ideal production run rate or small stops. These are extremely dangerous categories of production losses in the case of low production cycle times (approximately 10 seconds), because, from the point of view of production of individual pieces, these losses are almost “invisible”, and the accumulation of their value, e.g. per shift, may exceed losses due to machine breakdown. The latter two categories are associated with the generation of quality defects. These include loss of quality in steady-state production as well as quality losses emerging at the start of production of a new batch (for example, after the changeover, it can also be rejects during warm-up, startup or other early production state).

Decision makers of production system are required to manage in five areas known as 5M [4]. These management areas include: employees, machines, materials flow, methods or procedures, and measurements. Due to the wide range of activities of visual management, the rest of the article is limited to the analysis of visual controls considering first two areas 5M used inside production cells, namely, employees and machines. Article focuses on issues concerning the measurement of key performance indicators KPIs and their presentation in the form of messages by visual control systems. Hence the article is prepared as follows. Section 2 gives the description of widely utilized visual control systems which can be applied into manufacturing cell. Among this, the definition of andon systems as foundation of visual control systems is quoted. Section 3 describes how to gather data directly from the manufacturing cell by the use of electronic visual control systems. In Section 4 the communication between visual control system and other resources like enterprise resource planning ERP is explained. Chapter 5 provides a summary of the article.

## 2. A note on visual control systems

A visual control system is the system which gathers data from real process, transforms these data into more valuable information in the form of KPIs and displays critical information so that anyone entering a work place, even those who are unfamiliar with the details of the process, can very rapidly see what is going on, understand it and see what is under control and what isn't. Essentially, the current status of the process execution can be assessed immediately.

A visual control system derives from traditional andon system which has been exploited for many years before. Based on the foundation of , Andon refers to any visual display that shows status information on the shopfloor. Its origin is in the Japanese word for “paper lantern” using electric light board or other signal devices [5] which can be hung in the factory like depicted on Fig. 1. The first andon systems in manufacturing were simple lights that enabled operators to signal line status based on color: green for normal operation, yellow when assistance was needed and red when the line was down. Today, more sophisticated visual displays are often used for andon systems, but their purpose – efficient, real-time communication of shopfloor status – remains the same [6].



Rys. 1. Przykład systemu andon [7]

Fig. 1. An example of andon system [7]

One of the earliest descriptions of andon system can be found in the book which explains in detail Toyota Production System [3]. In that book the andon system is presented as a set of line stop boards that show the location and nature of trouble situations at a glance. It is outlined a three-color system of lights controlled by the operator, where green indicates normal operation, yellow indicates a call for an adjustment and red alerts that the line is stopped. Over time, the nature and role of andon systems has evolved. Visual cues are

sometimes reinforced with audible cues, and basic stack lights are sometimes replaced with more sophisticated message boards creating modern electronic andon systems. Nonetheless, the basic principles remain the same: firstly show line status at a glance (e.g. running, stopped, changeover or standby), secondly enable operators to call for help as needed (e.g. from maintenance or supervisors) [8].

One of the key principles underlying electronic andon systems is the possibility to control the process by giving information about KPIs. KPIs are measurements and metrics that support and facilitate achieving critical goals of the organization. KPIs are very important for understanding and improving manufacturing performance both from the lean manufacturing perspective of eliminating waste and from the corporate perspective of achieving strategic goals. As an example, one of the most valuable KPIs is OEE factor which presents every kind of production losses in the form of percentage value. It is very important factor when higher machine effectiveness is required to perform products quickly and more reliable [9]. Proper gathering data from manufacturing cells allow to calculate OEE factor in the on-line mode.

### 3. How to gather data for electronic andon system

An electronic andon system is equipped with standard I/O modules which allows to connect this system to accessories located on production asset. A production asset is the place in manufacturing system which is embraced of monitoring by andon system. It can be production line as well as manufacturing cell. It is valid that batch production should be performed inside a production asset in order to fully gain advantages of andon system. The reason is the adaptation of andon system to track production according to cycle time between two consecutive parts leaving the production asset [10].

There are two kinds of andon systems: open architecture andon system and closed architecture andon system. The first one uses external database to manage data from production asset. The second one is built as a firmware which contains database as well as management tools to make primary settings inside a box integrated with visual display. An example of closed architecture andon system is depicted on Fig. 2. The latter case is explained in more details below.

Good	17,667	Run	5:48	OEE	73%
Reject	178	Down	0:59	Avail.	81%
Rate	3,076	Setup	0:22	Perf.	91%
Cycle	1.17	Stdbby	0:50	Quality	99%

Fig. 2. An example of closed architecture andon system [8]

Rys. 2. Przykład systemu andon z architekturą zamkniętą [8]

A closed architecture andon system can be used to instantly track process in production asset by one andon unit. The installation of that system is very simple because there is no need to implement specification of production asset. Integration with production asset is

based on set a specific standard configuration in order to get data from asset in appropriate manner. All data gathered from production asset are stored in two dependent databases. The first database is connected to control module which tracks production on-line. This database stores real-time data and metrics generated by control modules in the form of registers which can be displayed on monitor. Registers store information about current production state, therefore the size of database is limited to set of parameters defined by the user.

The second database is used as a warehouse of historical data about production states as well as shifts or jobs performance. This database stores archived data in the form of production records named streams. Historical data can be exported to external information systems such as ERP system or manufacturing execution system MES.

Communication between closed architecture andon system and production asset can be devised regarding many options. Data from production asset can be gathered by traditional electrical devices such as sensors, buttons, encoders or relays. In this case, andon system is equipped with I/O module which watches on electrical signals from devices. Based on this signals, andon system reacts on production behaviour of the asset. This way of communication is presented on Fig. 3.

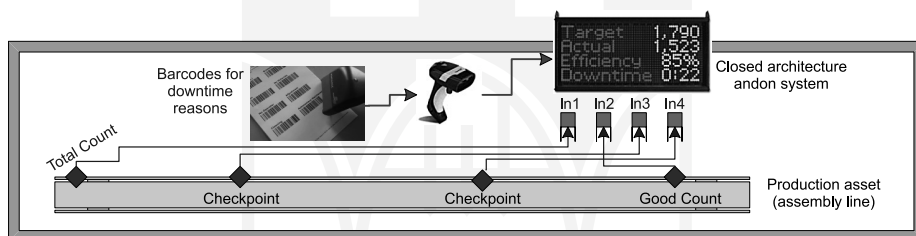


Fig. 3. An example of communication between andon system and production asset

Rys. 3. Przykład komunikacji komórki produkcyjnej z systemem andon

Other examples of communication establishments concern transferring signal by standard communication protocols. It is allowed to transfer signals by RS-232/RS-485 standard and 10/100 Ethernet standard as well. The first case is used, e.g. to set a communication serially between andon system and operator panels installed on machines. Features include installing multiple panels and addressing multiple andon units as a group, and verifying transmissions through different protocol packages. The way is to send specific frame of data between transmitter (operator panel) and receiver (andon system). The second case is used in order to establish connection between andon system and PLCs integrated with machines. That communication allows to send automatically data from PLC to andon system. Inverse direction of data transferring is not permitted because andon system cannot be the unit which controls manufacturing process. Data are transmitted with the usage of OPC standard in order to read and write registers values in the form of traditional data types.

The aforementioned description introduces the communication of andon system and other devices installed on production asset to track process performance inside this asset. Further, integration of multiple closed architecture andon systems with other systems inside manufacturing plant will be explained.

#### 4. Integration of andon systems in an industrial plant

One andon unit can be installed to track process inside individual production asset. The challenge is to integrate many andon units into one consistent system which can cooperate with other systems such as ERP or MES implemented into manufacturing plant. It is a challenge for engineers in terms of talking the same production language as well as interpreting factors and metrics generated by andon systems in the same way.

This problem generally concerns closed architecture andon systems, because data and information stored in the unit are isolated and unavailable for other systems. While communication and transferring data between andon systems carried out by the same supplier can be done, these functionality is impossible without additional system integrators.

Possessing tools for transfer data between andon systems and other applications enable managers be more flexible in terms of possibility of systems integration from different suppliers. Production data can be modified and sent to workers in order to improve process based on the clues prepared by lean managers. An example of real integration of andon systems in manufacturing corporation is showed on Fig. 4.

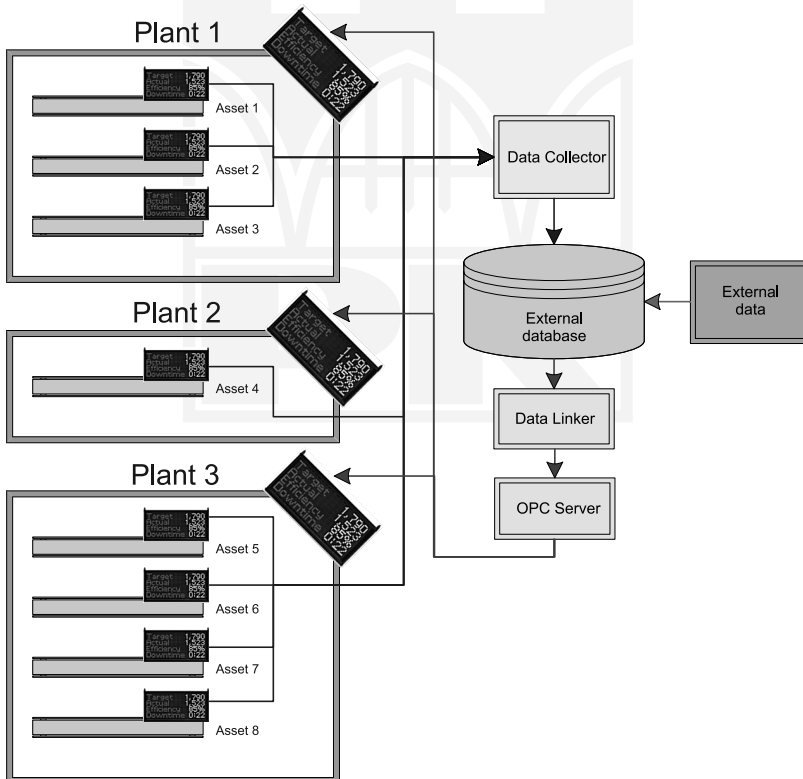


Fig. 4. An example of integration of andon systems in manufacturing corporation

Rys. 4. Przykład integracji systemów andon wewnątrz korporacji produkcyjnej

This integration includes three manufacturing plants producing ceramic products such as tiles, toilets, shower cabs, etc. Each manufacturing plant consists of several production lines. Each production line is able to fabricate selected products family, thus production lines have individual effectiveness which should be monitored. The general requirement is to control process performance and effectiveness for every shift per production line as well as aggregate separated values of process performance in order to obtain one value of performance which represents separated manufacturing plants and also whole company. By the use of additional andon systems which display aggregated factors, the company is able to instil motivation elements into workers who try to improve process to be more efficient.

## 5. Conclusions

Each production company, whether or not they practice continuous improvement, strives to achieve process flow uninterrupted. The only way to know the level of plant effectiveness is to adopt some form of visual management system called andon system. This is a term that refers to a system used to notify management, maintenance and other personnel of a process or quality issue. The green, yellow and red lights displayed by andon systems facilitate communication on the shopfloor by messaging in action. Mounted up high, these simple andon systems enable everyone to see the status of every production asset. A green light means the asset is running well, while a yellow light usually indicates the asset is running but requires attention. A red light almost always means that the process has stopped and requires immediate attention to repair a breakdown of the asset. This kind of alert is convenient and it provides a lot of other information which in detail describe production status of the asset.

The amount of increased profit a given company achieves by the use of andon system depends on the company, and its existing processes. It should be considered that the greatest productivity improvement can be gained if downtime of production assets could be reduced by as much as possible. Companies considering implementing andon systems should combine andon with others tolls for process improvement. However, just how little improvement is necessary to realize an attractive return of investment may be surprising. Further, since some solutions cost only a few thousand dollars, there is very little risk involved for what is a potentially large return.

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