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Semi-automated Data Acquisition for Management of the Company in Non-automated Production System – Case Study

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Abstract: This paper presents case study of data acquisition in non-automated discrete production system. The issue of acquisition of data from the production system in order to support company management is essential for the integration of business and manufacturing areas of the company. Properly organized data acquisition system, consisting of hardware, software and organizational solutions, should provide access to real-time data on production tasks, flow of materials and work in progress, usage and effectiveness of workers and equipment, and the quality of production. Availability of data depends on type of production system, more precisely on the level of automation of technological processes. The Manufacturing Information Acquisition System (MIAS) methodology has been used in order to support design of the data acquisition system for the company producing large tanks, in which there is no automated equipment and most of production operations are realised manually. The algorithm of acquiring data from workers, organisational solutions and data processing in developed *Mistrz* IT system has been described, as well as problems with MIAS encountered during system operation in early stages of introduction.

Introduction

The issue of acquisition of data from a production system in order to support company management is essential for the integration of the business and manufacturing areas of the company. The structure of the company consists of at least three levels, having different needs in terms of the software support. According to ANSI/ISA-95 these are business planning & logistics, manufacturing operations & control, and direct control of production processes (shop floor). Integration of a typical company, realized by middleware systems (MES) is standardized. ANSI/ISA-95 focuses on cooperation between MES and ERP systems, leaving communication between the physical production process and MES systems not standardized, thus creating the need of developing the methodology supporting design of solutions allowing vertical integration of production area (shop floor) and operational levels of the company [1].

IT support needs of companies are met by software of many classes, like MRP, HRM, CRM, etc. in the business layer, often integrated into modular ERP system, providing most functions of the IT support of business planning & logistics level of the company. MES (Manufacturing Execution Systems), MOM (Manufacturing Operations Management), CAPA (Corrective Action / Preventive Action) systems, Historian industrial databases, SDMS (Scientific Data Management Systems), Workflow/BPM (Business Process Management), PDM (Product Data Management), CAQ (Computer Aided Quality), CAPP, and many others classes of IT systems are used on the manufacturing operations & control level of company [2]. CAx software used as technical production preparation support should also be mentioned [3].

HMI/SCADA (Human-Machine Interface / Supervisory Control and Data Acquisition) systems, connected to PLC or DCS devices can be used on the shop floor level of automated production systems. In these systems data (binary, digital, analogue) from sensors and devices are used directly

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in order to control automated production processes, while the SCADA application allows supervisory control. In case of non-automated production systems there is a need to develop solutions, consisting of organizational tasks and additional software/hardware, allowing acquisition of data on the state of the system [4]. In many companies there are no formalised sources of data on operation of non-automated production system [5].

It is possible to conclude that data acquisition system should ensure data feed for various IT systems, used in companies, because efficient management of the company competing on today's globalized market is only possible thanks to the wide use of IT systems supporting various areas of the company operation, like planning, accounting, relations with customers, designing of products [6], process planning [7], scheduling [8], human resources, machines and material management, and many others [9]. Properly organized data acquisition system, consisting of hardware, software and organizational solutions, should provide access to up-to-date data on flow of materials and work in progress, usage and effectiveness of workers and equipment, realisation of production tasks, and the quality of production. Data acquisition system allows continuous introduction of corrections and rapid response to emerging issues, which in turn leads to reduction of losses and increases company's competitiveness on the global market.

Data Sources in Various Types of Production Systems. Availability of the data strongly depends on type of the production system, more precisely, on the level of automation of technological processes [10]. Presence of automated equipment (PLC, HMI/SCADA, etc.) with standardized network interfaces significantly improves possibility of data acquisition, allowing fully automated data acquisition, requiring only pre-processing, basic aggregation, reduction and archiving of the data. In case of low automation level, resulting in significant number of manual operations in the production processes, it is necessary to acquire data from sources classified as non-automated. Raw data acquired manually, directly from workers in form of interview and reports, is not fully reliable, because of possibility of mistakes, delays and sometimes even data falsification. It is desirable to develop more dependable data sources allowing faster acquisition and verification. These issues have been discussed in [10].

Methodology of Design of Data Acquisition Systems

As a result of research carried out in various companies, it is possible to formulate requirements concerning data acquisition for the needs of company management support:

- Information should be collected and transmitted without delays, in soft real time if possible, without the involvement of employees, and automatically whenever possible - data acquisition should be automated itself;
- Information should be verified – especially data collected from workers, that can be mistaken, delayed or corrupted;
- Data should be reduced and pre-processed – especially data from control systems – in order to avoid data flood;
- Information should be complete, which can be a problem in non-automated production systems, without formalised data sources.

Practically, data acquisition is an interdisciplinary challenge (requiring knowledge from the field of organisation of production processes, informatics, electronics, automation, industrial technologies, etc.), but there is not enough comprehensive literature on this issue. It can be concluded that there is a need for developing the methodology of data acquisition. Expected functions of the Manufacturing Information Acquisition System (MIAS) are presented on Fig. 1.

The Manufacturing Information Acquisition System (MIAS) methodology, described in [1], was developed in order to support design of the customised data acquisition systems, providing information on the state of production system, allowing supporting of company management. The MIAS methodology supports design of data acquisition systems for different types of production systems, branches of industry, automation levels, etc. Specific MIAS developed according to the proposed methodology should cover needs for automated data acquisition, archiving and pre-processing system, able to provide real-time data for various clients (managers, ERP, MES, etc.).

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MIAS developed according to proposed methodology should be only the intelligent interface and data source for ERP/MES/other IT systems, so there is no need for advanced data processing.

An example of the MIAS methodology in the company leading automated continuous production processes has been described in [11]. This paper is focused on application of MIAS methodology in non-automated discrete production system.

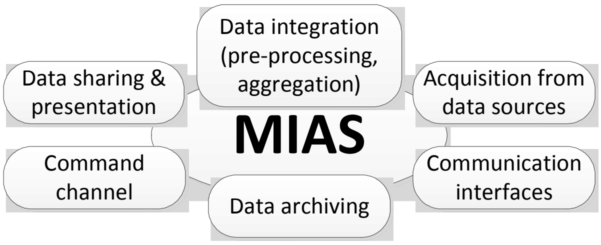

Fig. 1. Functions of the Manufacturing Information Acquisition System (MIAS)

Case Study of the Data Acquisition in Non-automated Discrete Production System

Many of the problems with the acquisition of data are related to the lack of automated machines and control systems, providing easily accessible data for both control of production processes and management of the company. Non-automated production system is naturally worse supplier of data than automated one. The company "A" located in Upper Silesia, Poland, producing mainly large objects (i.e. liquefied gas tanks ~120 m^3), in small series to the customer order, with significant share of operations performed manually, will be used as an example of a production system difficult in terms of data acquisition.

The Overview of the Exemplary Production System. Described company produces various large tanks for liquefied gases (volume up to ~120 m^3), transportable vessels for liquefied gases (volume ~1 m^3), process equipment, etc. Typical products are large (maximal length ~18 m) and heavy (14-15 tons). Company "A" in most cases do not use automated production equipment (the only exceptions are CNC lathe, CNC plasma burner, some welding machines without network interfaces). Most operations are performed manually, carried out using simple tools and machines. The main technologies used in production process are: welding, machining, cutting and shaping metal sheets. Most of components are made in the main production plant, some parts are made by subcontractors. Transport operations are not automated, performed using gantries, cranes and forklifts (for smaller components). There are large share of workstations, that do not have fixed localizations – because of size of tanks, workers move equipment and tools to the places in production hall, where assembled tank is currently placed. Most of locations are equipped with sets of rolls, allowing rotating cylindrical tanks.

Because of the size of components and nature of some technological operations (welding, tack welding, grinding) in the main production process (assembly of large LPG tank), time of typical operation is in the range from tens of minutes even to over 8 hours.

IT Systems and Former Data Acquisition System. The SAP R/3 SPRINT ERP system has been introduced in order to support company management in areas of the production planning, scheduling, resources management, accounting, sales, etc. – set of function typical for ERP systems. SAP system also generates orders of production operations, carried out in production plant.

Printout of the SAP production order can include a barcode, allowing worker or manager to confirm the operation execution. Initially, confirmation of the operation was carried out by the production plant manager, who collected data on the status of operations performed during production shift from foremen and entered it into the SAP system terminal at the end of the 1st shift. It was a typical example of the manual data acquisition, where the information appeared in the ERP system with a significant delay, frequently with errors and glitches.

Registration of production material flow is supported by the dedicated SAP module available for workers in warehouses, but only release of materials for the production from warehouse and the arrival of a finished products to the product warehouse are tracked - there is no information about the intermediate stages of the production of tanks.

In the described production plant, system allowing acquisition of information about the production tasks completion, and the flow of materials and finished products within the production hall, required significant improvement. The unsatisfactory state of data acquisition in the company

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has led to the development of the solution, that currently include tracking of production operations performed by the employees. In the later stages of development it is planned to include also materials, components and partially completed products flow management in the reporting system.

Manufacturing Information Acquisition System in Tank Assembly Plant. The main role in the production data acquisition system covers *Mistrz* IT system, designed according to the MIAS methodology. *Mistrz* is working as the interface between ERP (SAP) and production hall and plays role of two-way interface. Scheme of the *Mistrz* is presented on Fig. 2. *Mistrz* operation is based on production orders, imported from SAP. SAP generates also a barcode allowing confirmation of the operation. The data on ordered operations is copied to the separate *Mistrz* SQL database. Production operation confirmations are stored in the same database. The main source of data are portable data collectors Datalogic (Viper, Falcon, with Windows CE operating system), equipped with barcode scanner, touchscreen or keyboard, and WiFi interface. Menu-driven, intuitional and easy to use application installed on data collectors is responsible for communication with *Mistrz*, allowing easy data entry using barcode scanner and touchscreen.

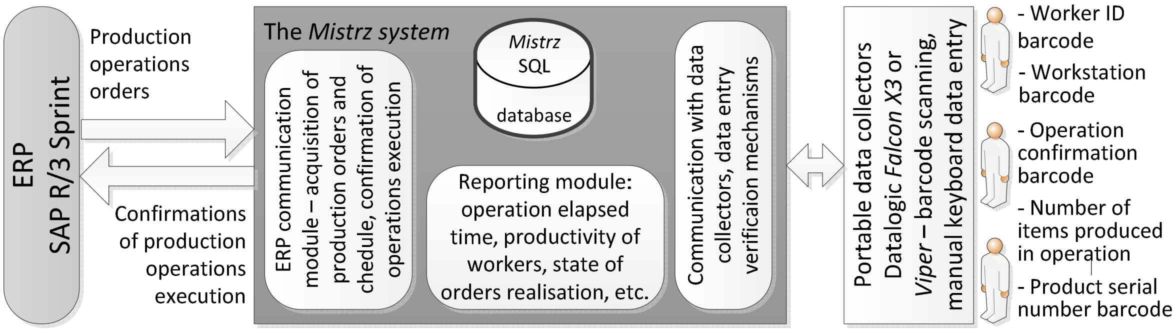

Fig. 2. Scheme of data acquisition using the *Mistrz* system

Data collectors are placed in the data acquisition cells in separate areas of the production hall, common for a few workstations. There are three types of barcode cards available in the data acquisition cells, each containing description and corresponding barcode. First type of cards contain codes of production workstations – it allows worker to specify on which workstation he was working (or will work). Second type of cards contain specification of operation and confirmation barcode, allowing worker to confirm execution (full or partial) of specific operation. The third type of cards are lists and barcodes of product serial numbers, used in case when workpiece has an assigned serial number (currently only semi-finshed tanks have serial numbers). Each worker has a badge with a personal barcode in order to identify himself at the beginning of logon process.

Operation of the Data Acquisition System. Before starting his work, worker should log-on to the workstation, scanning his personal badge barcode and code of the workstation. The worker performs operation ordered by his foreman or production manager, but there is no record on it in *Mistrz* at the beginning of operation. After completion of the operation, or at the end of the production shift, worker goes to the nearest data acquisition cell, re-scans his personal code and confirmation code of the performed operation. Then worker can also determine the degree of realization of the operation (complete execution of the production order, partial execution or the zero-execution, in case when worked performed an operation, but failed to complete a single piece due to the fact that the execution time exceeded the production shift time). If worker performed operation on a final product (with a serial number assigned), serial number should be also scanned. Employees are usually reporting production orders at the end of their shift, often entering confirmation of several different operations performed on the same workstation during the shift, causing additional lags in data acquisition.

After initial problems (large amount of mistakes because scanning wrong barcodes), the data input is validated in the real-time. The list of the verified attributes contains i.e.:

- worker personal code compliance with a list of employees present that day at work;
- correctness of confirmation code of operation order - only codes of operations that are partially completed or not entirely completed previously are allowed;

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- compliance of the number of completed items with the number specified in the order;
- correctness of a serial number.

The *Mistrz* is responsible for communication with data collectors, verification of data entry, importing of production orders from SAP, confirmation of executed orders into SAP. Important part of the *Mistrz* is reporting module, allowing generation of reports necessary for the management of the company, thus providing some MES-like functions. All required and collected data is stored in the local SQL database. *Mistrz* administrators are responsible for the formal verification of entered data, processing and exporting information to the SAP. Those administrators have also high access privileges in the SAP system, which allows correction of occurring errors. Production manager, his deputy and company management have also access to *Mistrz* system. These users can generate reports on production orders and employee productivity. Worker productivity is determined basing on the difference between the operation execution time planned in the SAP and elapsed operation time (even though in some cases time is not measured precisely).

Results and Conclusions from the Exploitation of the *Mistrz*. Although the *Mistrz* has been used for over 2 years and still under development, it is difficult to directly and clearly demonstrate the benefits of its use. Changes in work organization are difficult to measure – assessment is based mainly on subjective evaluations of enterprise management efficiency before and after the introduction of the data acquisition system. Implementation of the system brought about the necessity of a change in habits of both workers and management.

Initially, the number of errors and problems was very high, but it was significantly reduced by improving the *Mistrz* system and procedures of verification of entered data. Workers often used to forget about reporting their tasks, or entered improper data. Management of the company declares that the *Mistrz* significantly improved the flow of data in the company and enabled the optimization of production capacity utilization. Possibility of using incentive pay system based on the reported results of the performance of workers is also very important.

Currently, there are two main problems with the data acquisition system in the described company. The first one is insufficient information on the flow of materials and components. Current data acquisition system covers only raw material issuing from the materials warehouse (in the SAP system) and reception of the finished products into the finished products warehouse. Full record of the circulation of materials and semi-finished products should be achieved using a barcode labels printed on durable material or applied on the part itself (e.g. laser tagging). Durable RFID tags can also be used, but it would require purchase of new data collectors.

The second problem is the delay in entering information about the execution (complete or partial) of manufacturing operations and the lack of information which production order specific worker performs until it will be reported at the end of the shift. Sometimes workers forget to confirm the operation or enter incorrect data, despite of the data validation. Data acquisition requires attention and diligence from workers, who have been burdened with additional responsibilities. It is proposed to extend the set of data to be entered at the beginning of the shift by worker with the information about the production order and operation, assigned to a particular worker. Confirmation of orders should be made immediately after completing an operation, before taking other jobs. Described problems require modification of *Mistrz* and data collectors software.

The analysis of the *Mistrz* database from its whole lifetime showed very large discrepancy (up to several hundred percent) between the times of operation declared in the technical documentation and reported, especially in the initial period of use of the system, which in most cases resulted from forgetfulness of reporting employees or entering mismatched data.

Conclusion

Various types of automatic identification systems plays an important roles in the companies, allowing the acquisition of data that cannot be collected using existing devices of industrial automation and control systems. Automatic identification systems can be seen as a data source parallel to the control system or the primary source of data in non-automated production systems.

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On the basis of the experience with exploitation of the *Mistrz*, it can be concluded that data acquisition in non-automated production systems is much more difficult than in automated ones. In particular, it is difficult to obtain accurate data on workers activity and circulation of materials in the production system. Automatic identification systems often used as standard solution in non-automated production systems have to be supported by organisational solutions and algorithms validating entered data. All components of data acquisition system (data collectors, labels, etc.) should be also resistant to the harsh operating conditions in the production system.

In most cases, it is necessary to create a middleware between the business area and the shopfloor, responsible, among other things, for the semi-automatic data acquisition, validation of entered data and reporting. Semi-automatic data acquisition methods should be user-friendly, allowing the worker to input the required data easily and quickly. On-line validation of entered data should be carried-out, and organisational solutions forcing workers to act according to established procedures with no delays should be applied. Installation of systems identifying objects from a distance, without the need for activity from workers (e.g. long-range RFID tags) should be considered, allowing automated collection of data on specific parts of the production system operation.

References

[1] G. Ćwikła, The methodology of development of the Manufacturing Information Acquisition System (MIAS) for production management, Applied Mechanics and Materials. 474 (2014) 27-32.

[2] A. Sękala, A. Dobrzańska-Danikiewicz, Possibilities of application of agent-based systems to support functioning of e-manufacturing environment, in: Mechatronics systems and materials VI, Ed: A.V. Valiulis, Solid State Phenomena. 220/221 (2015) 781-784.

[3] A. Gwiazda, A. Sękala, Z. Monica, Integrated approach to the designing process of complex technical systems, Advanced Material Research. 1036 (2014) 1023-1027.

[4] M. Hetmańczyk, P. Michalski, The aid of a mistake proofing with the use of mechatronic systems according to the Poka-Yoke methodology, Advanced Materials Research. 837 (2014) 399-404.

[5] A. Sochacki, J. Kubiatowicz, J. Surmacz-Górska, J. Ćwikła, Plant-wide modelling and simulation using steady-state data: a case study of the Gliwice WWTP, Poland, Water Practice and Technology. 8, 1 (2013) 142-150.

[6] A. Dymarek, T. Dzitkowski, K. Herbuś, G. Kost, P. Ociepka, Geometric analysis of motions exercised by the Stewart platform, Advanced Materials Research. 837 (2014) 351-356.

[7] C. Grabowik, K. Kalinowski, W. Kempa, I. Paprocka, A survey on CAPP systems development methods, in Modern Technologies in Industrial Engineering, Advanced Materials Research. 837 (2014) 387-392.

[8] K. Kalinowski, C. Grabowik, W. Kempa, I. Paprocka, The graph representation of multivariant and complex processes for production scheduling, in: Modern Technologies in Industrial Engineering, [Eds:] C. Carausu, Advanced Materials Research. 837 (2014) 422-427.

[9] A. Sekala, W. Banaś, A. Gwiazda, Agent-based systems approach for robotic workcell integration, Advanced Materials Research. 1036 (2014) 721-725.

[10] G. Ćwikła, Methods of manufacturing data acquisition for production management – a review, Advanced Materials Research. 837 (2014) 618-623.

[11] G. Ćwikła, C. Grabowik, W. Janik, Case Study of Manufacturing Information Acquisition System (MIAS) in Automated Continuous Production System, Applied Mechanics and Materials. 657 (2014) 808-812.

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