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A concept for a production flow control system toolset for discrete manufacturing of mechanical products

Abstract

Requirements for product traceability in certain industrial sectors make Production Flow Control Systems (PFC) a desirable component in the operation of production enterprises. Such a system serves as a valuable tool for companies by preventing defective products from being sent to customers, enabling the automatic blocking of defective parts once the cause of the defect is identified. This article discusses a proposed PFC system toolset that meets fundamental industrial requirements in the field of discrete manufacturing of mechanical products. The system integrates key elements such as rework, disassembly, single non-controlled stations, as well as various essential and optional software applications and modules.

1. INTRODUCTION

Demands for product traceability in certain industrial sectors, such as food (Zheng et al., 2020; Conti, 2022; Xiao, 2021; Agnusdei et al., 2022), pharmaceuticals (Leal et al., 2021; Kumar, 2024; Sarkar, 2022; 2024), electronics, aerospace, and the automotive industry (Costa et al., 2017; Kuhn et al., 2021; Steghöfer et al., 2021), where the life and health of the end user depend on product quality, make the implementation of traceability (tracking) systems a crucial aspect of business operations. For the food industry, traceability is not only required by regulatory agencies and third party audit standards, but it is a key element of risk management and control of safety and quality. Traceability is a collection of complete and chronological information about unique identified products, registered in the course of production processes. Traceability systems make it possible to trace (register) actually every essential step of production. Starting from the raw materials used (their origin, composition), through semi-finished products (what is the end result of passing through a specific work station), technological operations performed (along with process values), to finished products. Systematic recording of production data allows to keep track of the process, check the history of products and, based on the analysis of the recorded data, stop the entry of defective products to further stages of production on time. Traceability facilitates work by automatically recording process data about the product in a database system, allowing for data analysis in an office environment without the need for extensive testing and trials. It enables the extraction of information on where mistakes most frequently occur, the extent of these mistakes, and their root causes, ultimately helping to reduce the risk of product liability. Process transparency translates into improved quality and better production planning, and thus meeting customer expectations as well as applicable standards. In short, traceability systems are designed to determine the properties and parameters of products of individual production stages and compare them with an obligatory specification. According to (Cheshmberah & Beheshtikia, 2020), traceability supports control over whole supply chains. Advanced IT solutions for traceability systems have become very important management information systems within the production companies. They can efficiently control the supply chain, by minimizing the risks of the production process, and helping to enhance the customer reliability on products.

Schuitemaker et al. (2020) conducted a review of terminology, techniques, and technologies related to the implementation of traceability systems in existing manufacturing environments. Similarly, Argilovski et al. (2023) conducted a review providing insights into the role of product traceability in enhancing the digital transformation of manufacturing companies. Their study also offers initial guidance for organizations and researchers exploring the possibilities of implementing or improving traceability systems.

Production Flow Control Systems (PFC) are more than traceability systems. PFC Systems are IT systems that are utilized to register discrete production data in a database at various stages of industrial processes. The data is mainly acquired from PLC controllers and industrial PCs. In this respect PFC Systems perform the function of traceability systems, that enable tracking products and processes. Thanks to designed communication protocols as well as database functions, PFC systems additionally provide automatic blocking (introduce prevention from further processing) of identifiable products, which were incorrectly processed during earlier stages of production or follow wrong technology path. PFC systems require production stations which are PLC/PC controlled or provide other means of communication to acquire process data, for example a PC not integrated with production station's hardware at all. The functioning of a PFC system can be e.g. described as follows:

- already at the first stage, a unique identifier is assigned to the manufactured product and applied by means of a label with a two-dimensional code, next main basic data about the product (e.g. identifier, date of introduction into production) is entered into the IT system (database),
- when the product enters a work station, the employee scans the label and checks whether the system allows for the operation on this product,
- if not – the product automatically gets physically blocked at the station,
- if yes – the part is admitted to the next stage, until the last station, where the employee, after scanning the label, checks whether the product has been made in accordance with the accepted standards,
- if yes – the product goes to the end customer of the supply chain, if not – it returns to production for rework or disassembly (if possible) or becomes waste and at the same time becomes the object that allows to obtain information about what mistake was made, at what stage of the process, which will help to develop a strategy on how to prevent the recurrence of such situations.

Other methods, except a label with a barcode, for identification can be used, i.e. various RFID tags or marking directly on components (DPM - Direct Part Marking). Regarding communication protocols to acquire production data directly from devices, one has to consider nowadays standards like MMQT as well as OPC UA, which enable data exchange independent of the device's manufacturer.

Through PFC System's functionality (checking results of previous technology operation conducted on a product, automatic blocking of defective products (preventing from further processing and shipping to a customer)) it is treated in fact as poka-yoke tool implemented in a production system to prevent from a risk of delivering defective products. Poka-yoke is a Japanese term that means "mistake-proofing". It is a Lean tool that originated from the Toyota Production System. Implementing poka-yoke involves designing a process in such a way that mistakes are avoided entirely or made visible for quick correction.

Another issue is interoperability of systems, which is becoming increasingly valuable across the economy as organizations of all kinds undergo digital transformation and adopt new software. In case of PFC Systems the main challenges could be exchanging data with PLCs of different vendors (i.e. Siemens, Allen-Bradley, Mitsubishi etc.), integration with existing traceability or PFC systems, as well as with higher level analytics tools, like i.e. Palantir Metropolis. In case of PLC, protocol standards like OPC UA can be used.

PFC systems enable the recording of the history of discrete products in the form of individual production steps, including data such as date and time, various numerical values, identifiers (including component identifiers), operation results, and workstation identifiers. Such data fully identifies each production step, enabling analysis and, if necessary, the blocking of defective products to prevent their transfer to the next production step. This mechanism of blocking the product consists in physically preventing an unauthorized person from removing the product from the production station if its defect is detected. A defect may manifest, for example, as product incompleteness, a faulty technological operation, or the presence of multiple products with the same identifier. Defect detection is based on the automatic analysis of registered database content (data from the previous workstation) as well as system configuration, including workstation sequence for a given product type, appropriate components, and alternative workstations. PFC Systems help prevent potential customer complaints or significantly reduce their occurrence. The systems provide manufacturing advantages by lowering the capital required for handling customer complaints and, more importantly, boosting revenue through enhanced customer trust and the ability to attract new clients.

PFC Systems idea is also described in Chrobot (2023), where focus is made on industrial requirements. The 2023 article discusses desired PFC architecture as central one, which means both PFC main application and database implemented on remote server hardware. This architecture integrates rework station, disassembly station as well as remote communication. Example IT solutions for rework and disassembly are discussed. Additionally, remote communication is explained as an integral part of both solutions:

- remote desktop, which shows the PFC main application's user interface,
- a local IT application, installed on a local PC placed at the production station, which shows own communication process with PFC main application as well as with local PLC.

The discussion includes only selected components. This 2025 article expands on this by providing, in later chapters, a preliminary description of a complete PFC system toolset for discrete manufacturing of mechanical products. Chapter 2 explains the concept and novelty of the proposed PFC system toolset, while Chapter 3 details its individual components. Finally the paper ends with conclusions' chapter, which underlines characteristics and advantages of the discussed concept as well as names future works.

2. IDEA OF A PFC SYSTEM TOOLSET

The concept of a complete PFC system toolset for discrete manufacturing of mechanical products is to provide modular functionality, enabling production flow control on the shop floor via a computer network. The idea is based on several years of observation of discrete manufacturing processes as well as gathering and analysis of industrial requirements and expectations regarding a PFC System.

The suggested PFC System's toolset is a new approach, because of:

- proposed automatic blocking of defective products, which means a prevention from delivering defective products (based on internal communication protocols as well as database functions and procedures),
- taking into account most of different types of work stations in the production system, that are PLC/PC controlled or not controlled at all (manual)), by enabling including them into the production flow control chain,
- modularity of the computerized system,
- universality, completeness of the solution dedicated to discrete manufacturing of mechanical products.

Scientific articles describe advanced traceability models and solutions (Kuhn et al., 2021, Steghofer et al., 2021, Mitsiaki et al., 2023). Also on the market there are offered commercial traceability systems by companies like i.a. Dassault Systèmes (DELMIAWorks Track and Trace module) or Xprimer (XPRIMER.TRC). According to its official website the DELMIAWorks Track and Trace module "provides manufacturing traceability, accurate and timely reporting and documentation to meet industry regulations and quality audits and Recall & Analysis". In case of Xprimer system, according to its website, the XPRIMER.TRC (traceability) "enables the recording of the relationships between manufactured and consumed materials in the production process. It also allows necessary parameters to be tracked, such as production date and time, part serial number, operator ID, job identification, operation number, production plant number, recording of process parameters (as required for individual operations), identification of process sequence and BOM recording". The Xprimer system is characterized in more detail, so comparison Xprimer with the proposed PFC System is possible, and one can say, the tracked set of data offered by Xprimer is also possible in case of the proposed PFC System except BOM recording.

In conclusion, scientific publications and market solutions primarily focus on the pure registration and analysis of product and process data based on reporting. Such approaches may result in delays in responding to quality issues. Currently, no published concept addresses the automatic blocking of defective products near the location of the problem, nor is there a commercially available IT solution for this purpose. PFC systems are primarily internal solutions developed by manufacturing companies, but they are often limited to specific company needs. Therefore, a universal and comprehensive approach is required.

3. COMPONENTS OF THE PFC SYSTEM TOOLSET

The suggested PFC System toolset consists of the following basic (necessary) and optional (on demand) software components:

- PFC Database (PFCDB) – At each stage of production (each production station), the PFC system records information in an SQL database composed of tables, functions, and procedures that manage the automatic blocking of defective parts. The PFC Database is a fundamental component.
- Main PFC System Application (MainPSA) – An IT application installed on a single PC that communicates with PFCDB to store and retrieve data, visualize events, inform about product blocking reasons, and interact with production workstation controllers (PLCs, industrial PCs) via a specialized

internal PFC Protocol. MainPSA is a core tool that includes both basic (necessary) and optional functionalities.
- PFC System Protocol (PProto) – this communication protocol is designed for communication over Ethernet network with PLC as well as with PC, which control production stations and is the basis of data exchange and automatic decision taking; PProto is a basic tool.
- Reporting Tool Application (RepoTA) – an IT application installed on single PC station, which is used for retrieving data from PFC Database to establish different production statistics for users; RepoTA is a basic tool.
- Single Station Application (SingSA) – an IT application installed on single PC, which is used to confirm the result (positive or negative) of manufacturing operation, conducted by an operator, at production station which is not PLC- or PC-controlled; SingSA is an optional tool.
- Visualisation Application (VisuA) – is used when MainPSA is installed on a remote central server far from the production facility; it only shows what happens on MainPSA, but does not allow to handle it; VisuSA is an optional tool.
- Process Application (ProcA) – an IT application at a workplace to visualise own process only and data exchange with the MainPSA as well as with station's controller (PLC/PC); ProcA is an optional tool.
- Rework Station Application (RewoSA) – a specialized IT application to support a confirmation of the result (positive/negative) of rework activities, conducted by a workstation operator, as well as printing of a spare identifier of a product (e.g. label with a barcode); RewoSA is an optional tool.
- Disassembly Station Application (DisaSA) – an IT application to support confirmation of the result of disassembly activities, conducted by a workstation operator, to enable reuse of disassembled identifiable component; DisaSA is an optional tool.
- Route Writer Application (RoutWA) – a functionality (an IT module) to support a worker to manually register workplace history, like e.g. setups, breaks, breakdowns, as well as regular production; RoutWA is an optional tool.
- Planning Application (PlannA) – an IT module to edit planned amount of parts to produce, depending on reference (type of product) as well as on a shifts' schedule; the plan is used in SingSA; PlannA is an optional tool.
- External Scanning Application (ExteSA) – single PC application to enable product traceability in case a part of the production process is located outside the factory, not using any remote connection; ExteSA is an optional tool.

The components of the system are shown in Fig. 1. The figure shows components connected via Ethernet network. PFC Database is implemented on a dedicated powerful computer server. Components colored in orange (i.e. SingSA, RewoSA, DisaSA, ExteSA, RepoTA) communicate with PFC Database only by sending queries and receiving query results. Others (like MainPSA, ProcSA) communicate with PLC/PC as well, using the PFC System Protocol (PProto). VisuA communicates directly with MainPSA. Such a structure of a computer system is caused by the needs of the industry, functional expectations, the structure of the production system, which consists of workstations controlled by PLC/PC, as well as uncontrolled, fully manual stations.

3.1. PFC Database (PFCDB)

At each stage of production (each production station, essential from traceability point of view), the PFC System records the information in the SQL database, which is made out of tables, functions and procedures. The database handles data storing as well as automatic blocking of defective products as well.

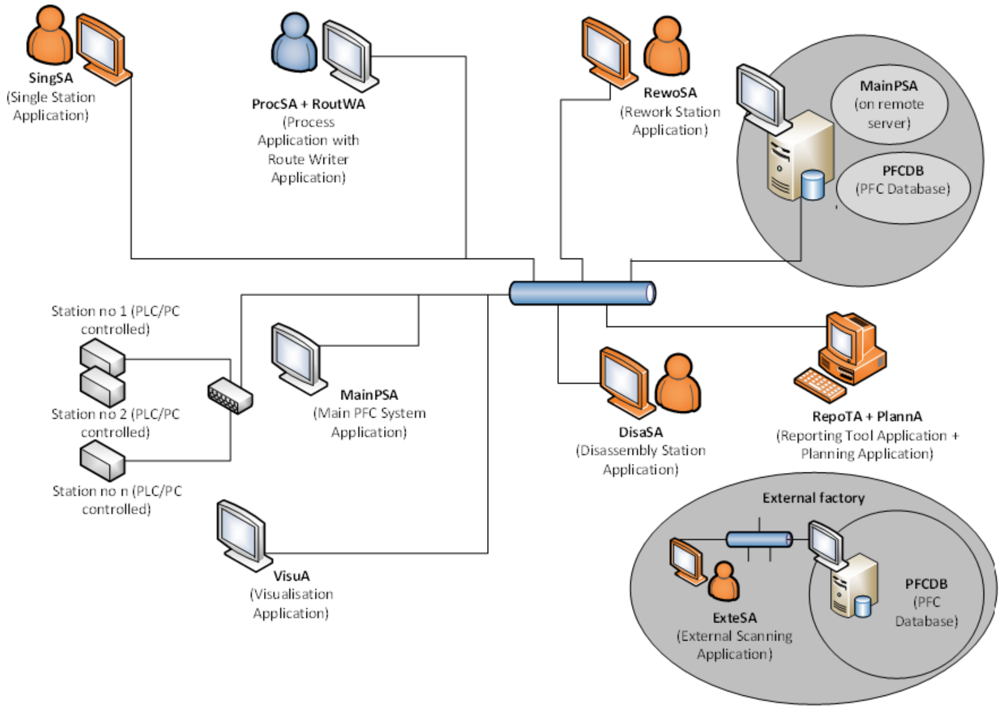

Fig. 1. The idea of PFC system toolset

When the product enters the next production station, the PFC System additionally queries the database, whether the previous operation was successful, whether the product follows the defined technological route, as well as whether a right component is to be assembled into a main product. The query is conducted by internal database functions and procedures, which process the received data. If the answer is negative, the function returns a result value indicating the reason for refusing further processing of the product. Tables store such information as particular technology steps with values (i.a. screwing torque, screwing angle, number of rivets, identifiers of components) together with results (positive, negative). There is stored as well data regarding single products in the manufacturing process together with information about expected next technology step, products already finished etc. Functions and procedures handle analysis of incoming data and stored data in the database. The functions handle queries after a product enters a production station to check the result of previous technology step conducted at previous production station in a technology sequence. Procedures handle queries to store resulting values after technology operation is finished as well. The PFC System shall be optimized according the number of database connections. It means it is highly recommended to ensure a separate database connection channel for every production station. It shall be made to avoid query conflicts in case of an intensive data exchange process when a larger number of production stations take part in the manufacturing process.

3.2. PFC Protocol (PProto)

This communication protocol is designed for communication over Ethernet network with PLC as well as with industrial PC, which control production stations:

– to check if the communicating device is active,
– to get data about product that enters the production station,
– to send information to allow/not allow a product to be further manufactured,
– to get technology operation results when it is finished as well as
– to confirm receiving messages.

The protocol can use OPC UA standard, which ensures interoperability of the PFC system, or own developed algorithm (at the beginning limited to communicate with PLCs of chosen vendors). The protocol requires programming both MainPSA and PLC (with use of a specially designed datablock (DBL)), as well as programming of PC, which control production stations, according to guidelines for programmers. The protocol shall work as a telegram system between a controlling PLC/PC and the MainPSA. The communication network protocol is TCP/IP. Data shall be always prepared inside the PLC/PC and collected by the MainPSA in the

PFC Database. In case of the communication with PLC, every PLC shall have its own area in DBL with all data for a complete traceability. The MainPSA shall establish the communication with the defined IP address and port, read data from the defined DBL and also write back data into the same DBL.

Two different areas are set in DBL:

- the first area is the area (shall never be written by MainPSA), where the PLC writes actual seat information like product identifier, screwing results, etc.,
- the second area is the area where the MainPSA returns an answer after receiving data from the PLC.

In case of the communication with PC, specially formatted text messages shall be exchanged between production station PC and MainPSA. The text massages include all necessary data to register products and results. Figure 2 shows a suggested communication protocol to exchange data with a production station PC.

3.3. Main PFC System Application (MainPSA)

This application runs on a single PC (local – on the shop floor or central – in remote location). The MainPSA is characterized by the following functionality (some functions are basic ones (necessary) and some can be added to extend the application according to requirements as optional ones):

- exchanging data with controlling devices of production stations (PLCs and industrial PCs) over Ethernet network (data received – i.a. product's identifier, components' identifiers, process values, data sent – i.a. confirmation of data receiving, command to allow/not allow to proceed with production); this shall be a basic functionality,

COMMUNICATION SPECIFICATION:
production station PC → ← MainPSA

First scan of product code, when products enters station:

Status query (production station PC → MainPSA):
Q;label_in;line_in;station_in;

Answer (PC ← MainPSA):
Q;status;reference;operation_number_out;

Comments:
1. status=1 means operations allowed,
2. status=0 means operations not allowed

Operation finish:

Finish request (production station PC -> MainPSA):
F;label_in;line_in;station_in;assembling_status_in;assembling_datetime_in;treatment_type_in;operation_number_in;operation_status_in;operator_id_in;final_label_in;{scanned_label_component_in};{control_value_name_in}; {control_value_value_in};{control_value_status_in};

Comments:
1. assembling_status_in - value 1-OK, 0-NOK
2. scanned_label_component_in – labels of possible components shall be put in quotation marks and separated by semicolons, for example {"1234";"5454";"5454"}
3. control_value_value_in - numeric values in floating point format with a dot, separated by a semicolon, for example {12.4;43.2;12.7}, if a value has status only please put as empty, for example {12.4;;12.7}
4. control_value_status_in - value 0-NOK, value 1-OK separated by semicolon, for example {1;1;0}

Answer (production station PC ← MainPSA):
F;status

Comments:
1. status=1 means OK,
2. status=0 means "data storing error"

Fig. 2. The idea of a communication protocol between a production PC and MainPSA

- reading/storing data from/into PFC Database by sending SQL queries – these exchanged data is saved in the PFCDB and is assigned to an unique identifier read either from the product label in the form of a bar code, two-dimensional code (data-matrix code (2D)) or RFID data transponder (tag); this shall a basic functionality,
- blocking strategies – a command to allow (not block)/not allow (block) to proceed depending on identified problem; the following blocking strategies are to be considered: defect produced on previous process, wrong technology path, wrong component, duplicated product, not allowed product's spare

identifier, multiple attempts to proceed with a product on a production station, which already processed the product; this shall a basic functionality,

- working modes – working mode is to be set for every production station included into the MainPSA: "blocking" mode means that defective product is not allowed to be processed; "non-blocking" mode means that products, made as defective at the previous production stage, can be allowed to enter the next production station ("non-blocking" mode shall be used very carefully, mainly during a start-up phase of the production station); this shall a basic functionality,
- auto-blocking – it is used to configure the MainPSA to change the working mode of a production stations automatically, depending of a product type (reference); this shall an optional functionality,
- visualisation of events – allows to visualize the results of technological operations on the production line through a graphical user interface divided into sections; the section of connected stations informs which stations are covered by the PFC System and in what mode they work, as well as whether there is communication active; the telegram (events) section is built in the form of a list/table, in which each row contains the main set of information registered on the production station; the information section provides detailed data in case the user selects a row in the telegram section; the information section provides explanation about the reason of blocking (not allowing) a product for further processing; this shall be a basic functionality,
- filtering of stations – this functionality is used to show events regarding chosen production stations only (it is helpful when the number of stations within the PFC System is too large to recognize events regarding e.g. newly implemented production stations); this shall be an optional functionality,
- sending data to the VisuA tool – it is used when the VisuA tool shall be active (if the functionality is active, the MainPSA, which runs on a remote server, sends data to the VisuA tool to visualize events only); this shall be an optional functionality,
- the logbook – it is used to record and view system events, such as system start, system termination, user login/logout, PFCDB problems, operating modes, reasons for refusal to continue (blocking) the production process etc.; this shall a basic functionality,
- handling of product's spare identifier – it is used when the rework station shall generate (print out) a spare identifier for a product (in case of a loss or a destruction of the original identifier) in the form of e.g. a label with a 1D/2D code or an RFID tag; the PFC System checks whether the production station can allow the product with such an identifier to be manufactured; this shall be an optional functionality,
- validation of product's spare identifier – it is used when the user wants to define an expiry limit of a product's spare identifier, so when a product with such identifier enters a production station, the PFC System checks if the identifier is already up to date; this shall be an optional functionality,
- automatic setup – it enables manual setup (changing PLC program) at first work station only, the rest of stations setups automatically because of storing product's reference code joined with the product's identifier in the PFCDB; this shall be an optional functionality,
- configurability – it is an important feature, because it enables shortening time of implementation of PFC System; an example of configuration is a graphical user interface; in the case of adding a new version/type of the product (a reference), a technological route consisting of a sequence of production stations should be defined for the reference of the product; another way of configuration can be a specially designed xml file, where user can define production stations with network addresses, technology routes for types of products as well as other parameters like allowed working modes, maximal number of reworks allowed etc.; this shall be a basic functionality,
- user management – this functionality allows the system administrator to add and remove authorized users; it should be possible to quickly log into the system using a RFID token, as well as to register a new user (by reading the content stored in this token), in accordance with the established procedure; the user receives access rights to existing functions, depending on the level of access, which is defined and stored in the RFID token (administrator, leader, maintenance, etc.).

3.4. Single Station Application (SingSA)

This application shall run on a single PC at a production station, which is not PLC- or PC-controlled, and is used to confirm manufacturing operation, which was conducted at production station by a worker. The confirmation is sent to PFCDB as a query, which adds this step to a product history. SingSA does not control a production station, but is fully handled by the station operator. The operator scans (e.g. with a handheld scanner) a product identifier from a label and, if it is allowed to proceed (after checking PFCDB by using a query), confirms with assigning a "positive" or "negative" result of manufacturing operation.

3.5. Visualisation Application (VisuA)

This application is used when the MainPSA is installed on a remote central server. It only shows what happens on MainPSA. The MainPSA, which runs on a remote server, sends data to VisuA over Ethernet network to visualize events only. The VisuA has a similar user interface like MainPSA, but very limited, only to show the list of events/telegrams. Another option is to enable visualization of MainPSA over Windows Remote Desktop with possibility for a worker to log in using a RFID token and change working modes of production stations.

3.6. Process Application (ProcA)

This application runs at workplace to visualize own process only and data exchange with the MainPSA. The ProcA, installed on a local PC placed at the production station, first checks the communication with the MainPSA and next waits for a scan of a product's identifier, which is conducted by an employee (operator). Before scanning, the operator has to choose a product reference, which will be currently produced. If the identifier gets scanned, the ProcA communicates with MainPSA to show to the operator if the product is allowed to be further produced. After finishing the production, it sends data regarding production results, which are stored by the MainPSA in the PFCDB. The ProcA can communicate also with production station's PLC, which connects with a scanner or RFID reader, as well as controls the production station. A production plan is loaded and processed by the ProcA (i.e. if the number of parts done is less than the number of parts planned, there is an alert generated by ProcA).

3.7. Reporting Tool Application (RepoTA)

This application shall run on a single PC station (as an external one), which is used for retrieving data from PFCDB only, to establish production statistics. External reporting application has advantage not to overload MainPSA with additional data processing effort. User can generate a report from the PFCDB according to various query criteria. The user can combine search criteria into more complex criteria, such as product identifier and date. It is possible to save the report to an external file for further analysis.

3.8. Rework Station Application (RewoSA)

This is a specialized IT application, installed on a local PC placed at the rework station, to support a confirmation of rework activities, conducted by a workstation operator, by sending a query to PFCDB, as well as printing of a spare identifier of a product. A positive confirmation enables the product to be further processed at next work stations, on the other hand, a negative confirmation blocks the product. An additional functionality is the printing of special/spare identifiers (in case of a loss or a destruction of original identifiers (e.g. printed on labels)). To print a spare identifier label it is necessary:

- first to select the production station at which the PFC System will allow the product with such an identifier to enter the production process (e.g. at the station right after the painting process, which may cause identifier damage),
- next select the product reference number (type) from the list, set the date and time, if required, as well as enter the number of labels to be printed.

3.9. Disassembly Station Application (DisaSA)

This is an IT application to support confirmation of disassembly activities to enable reuse of disassembled components. The example could be manual disassembly of a car seat metal structure to identify and return to a production some components like e.g. electrical seat adjuster. The confirmation, which is conducted by a workstation operator, causes sending a PFCDB query, which stores a permission for a chosen component to be reused. The application communicates with MainSA over PFC Database.

3.10. Route Writer Application (RoutWA)

This IT application shall support a worker to manually register a workplace history, like setups, breaks, breakdowns, as well as regular production. This is a tool to register workplace events, which shall help to evaluate and increase its effectiveness. The specially designed user interface consists of buttons, which mean an event, like i.a. production start, production finish, setup, a failure event (e.g. tool breakdown), management problems (e.g. no material), quality problems (e.g. a corrective action), as well as a planned pause (e.g. setup, planned maintenance, a meeting). An operator at the production station uses the user interface to register the production station's history (event, date, time). Each event is registered in a spreadsheet file in a format suitable for further analyses.

3.11. Planning Application (PlannA)

This application shall support editing of planned amount of products to produce, depending on reference (type of product) as well as a shift period. This tool shall consist of a viewer window and of a specially designed spreadsheet file (to enable the editing to be conducted at the office). At first, spreadsheet file has to be edited, next the file has to be loaded into the viewer application and finally exported to PFCDB. PlannA enables to define the number of parts planned for every day of a week, as well as for every shift. The number of parts is also planned for every reference. The spreadsheet enables to define start and finish times for every break (there are 3 breaks within a shift to consider) within every shift (there are 3 shifts to consider). Each row in the sheet addresses a workstation. So it is possible to define individual calendar for every workstation as well.

3.12. External Scanning Application (ExteSA)

This is a single PC software application to enable product traceability, in case a part of process is located outside the factory, not using any remote connection. This application enables scanning of a product's identifier in a form of a barcode/datamatrix printed on a label. This tool is also used when a component manufactured outside the factory is treated as a final product to be sold. With the application an operator scans product identifier and, after sending a query to PFCDB and receiving a positive response, an additional "OK" identifier is printed in form of a label and gets fixed on the product.

4. CONCLUSIONS

The ability to prepare, maintain, and utilize registered information minimizes the costs associated with withdrawing potentially harmful or unfit goods while also supporting the implementation of preventive measures to eliminate production errors. The implementation of PFC systems can be a crucial element in the functioning of companies, particularly large organizations or those operating in specialized market sectors under strict legal regulations. The article discusses a suggested modular PFC System's toolset, that meets the basic industrial requirements from the area of discrete manufacturing of mechanical products by integrating i.a. rework, disassembly, single non-controlled stations as well as external software applications to communicate with workplace operators. The PFC System's toolset covers first of all a basic (must-have) functionality. Extended functionality can be added by including next system modules (e.g. single stations, reporting workplace). With this article the Author contributes to the knowledge regarding PFC systems and conceptions of a PFC system's functionality. The concept is limited to discrete manufacturing of identifiable mechanical products. The products can consist of identifiable (for example electrical/manual actuators) and non-identifiable components (for example springs, screws, rivets etc.). So, it shall be suitable for companies from industrial sectors, like automotive, aerospace, machinery, heavy equipment, marine as well as medical devices. Additionally, the feature of configurability helps to adapt the system to different manufacturing equipment configurations (i.e. workstation sequence for a product type, appropriate components, alternative workstations). The concept presented in this paper needs practical validation. When ready, software components mentioned will be tested first in laboratory – a larger number of PLC and PC stations will be simulated and database server will be implemented. Various blocking scenarios will be tested, and the system's response time will be examined to assess the effectiveness of the proposed solution. This will be conducted using communication standards such as OPC UA, implemented in commercial modules (e.g., Softing, Kepware), as well as a custom-developed communication protocol. The results of the examination of the basic configuration will be published in a future paper in the form of testing results and case studies.

Conflicts of Interest

The authors declare no conflict of interest.

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