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QUALITY AND RISK MANAGEMENT IN INDUSTRIAL PRODUCTION SYSTEMS: A LITERATURE REVIEW

BY

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Abstract. Nowadays quality management and specific tools can represent a challenge in SMEs (small and medium enterprises). To assure the expected quality of the products, SPC (statistical process control) combined with industry 4.0 specifics offer instantaneous responses and triggers for needed actions. Therefore, risk analyses are used as enablers for quality-oriented behaviour, and risk mitigation and identification, together with collected data, represent a comprehensive system that leads enterprises to achieve the expected performance level needed to remain competitive in the market. In addition, risk management and quality management cannot be treated without looking at the maintenance activities and policies which can have a considerable impact on those two. This paper provides a comprehensive literature review of the papers from the quality management sector and articles where risk management and maintenance are seen as facilitators for quality improvement with an impact on the performance level. The main contribution of each paper is listed in the table which simplifies the reader’s access to the work done in the field and the overview presented enables easy access to trends in this field and offers a starting point for future research by presenting the gaps.

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Keywords: maintenance, nonconformities, quality analysis, risk analysis, maintenance methodologies.

1. Introduction

The product quality in high product variety manufacturing environments represents a challenge for engineers and management due to new opportunities and improvements that can be done by using electronic resources (Temponi, 2006).

Nowadays maintenance strategies and approaches represent an important pillar for product reliability and quality. Maintenance data can help technicians in specific activities and minimize response operation time (Ribeiro *et al.*, 2009). Moreover, depending on the maintenance model, production failures and quality issues can be treated as a common ground for maintenance of the production processes and its specific indicators as response operation time, costs, and product quality (Riveira-Gomez *et al.*, 2013; Tambe *et al.*, 2013; Liu *et al.*, 2018; Bokrantz *et al.*, 2020).

Quality control in the manufacturing sector is an important part of non-conforming product management (Durakbasa *et al.*, 1992) and strives to assure the optimum level of quality following market expectations, process capabilities, and enterprise-quality policy. The implementation of different quality control methods can be made considering the cost of quality and their implications, even the ideal scenario is with zero quality issues, moreover, the competitiveness in the market and continuous improvement lead entrepreneurs to cost-related quality decisions (Oh *et al.*, 2019). Production data, by using graphs and SPC specifics, are used to improve efficiency and product quality (Colledani and Tolio, 2006). However big data analysis through the Quality 4.0 concept represents a new challenge for quality leaders (Escobar *et al.*, 2021).

As a part of a quality management system, which represents the sum of methods, procedures and specific responsibilities which define the business process, quality assurance in manufacturing industries represents a mandatory behaviour to check and assure production part conformity and can be used as a basic starting point for quality improvements (Colledani *et al.*, 2014). Lean manufacturing tools such as zero defects (Eger *et al.*, 2018) and quality VSM (value stream mapping) (Haefner *et al.*, 2014) together with industry 4.0 methods (Duong *et al.*, 2021) and AR (augmented reality) with direct implications on shop floor operators can be used to check, prevent, and improve overall quality (Alves *et al.*, 2021).

The quality management and management of nonconformities represent one of the most important aspects in manufacturing industries through the entire product life cycle. The collaboration between quality specifics, such as quality audits, quality control, and assurance, can provide, as a result of their interaction, a full collaborative system for achieving expected product quality

(Shaosha *et al.*, 2006; Cordeiro, 2016). Moreover, quality control, quality assurance, and quality improvements are three sectors where the overall quality and performance are obtained. Quality management integrates all quality aspects providing a comprehensive method for producing conforming parts (Fonesca and Domingues, 2017), even nowadays where the demands for variety and continuous improvement lead manufacturing industries to a flexible and adaptive production environment, with or without documented processes.

Risk assessments in manufacturing industries can be an important factor in reducing non-conforming parts by identifying and isolating the risks related to the manufacturing processes (Karkoszka, 2015). By evaluating the risk of direct influencing factors, product reliability and quality can be managed and assured from concept and product design to the final steps of production (Dumitrescu and Deselnicu, 2018; Moreno-Cabezali *et al.*, 2020). However, the influence of the variation, due to failure appearance, can be identified using risk analysis and minimized by taking systemic preventive actions, following enterprise cost of quality.

With implications for quality assurance and risk mitigation, risk management represents a key factor in developing new processes where issues and nonconformities can be avoided, starting with concept design and the first production line layout (Kayis *et al.*, 2007). Classifying the risk by their typology, the deployment of process control can be facilitated by the efficiency of the feedback in the production and by placing the risk analysis between implied engineers and departments (Bassetto *et al.*, 2011). Alternatively in SMEs, the shop floor's direct influence must be illustrated and revealed in more study cases due to the lack of dates from the micro level in the existing literature. In doing so, the influence of the adaptable and interchangeable equipment and systems, also the direct influence of manual work done by the shop floor technicians can be evaluated and integrated into a comprehensive quality assurance and risk management orientated environment where de interaction still exists, despite of the automation and robotization which are designed to replace human influence.

Therefore, risk and quality management must be implemented together, including quality-related maintenance management aspects. An integrated system, as part of Industry 4.0, where data can be gathered automatically, and artificial intelligence used to evaluate quality issues represents a new approach and a new challenge in the production industry, especially for SMEs. Following this work, researchers start to develop integrated models of risk analysis and maintenance models with quality-related outcomes. Further, the direct correlations between variables in the manufacturing process, such as poka-yoke nests wear, fixture tolerances, manufacturing precisions of the production devices, and product quality or maintenance policy must be studied.

The main contribution of the present paper is a comprehensive review of published papers regarding advances, methods, and practices in quality and risk management in industry, especially with implications in SMEs, including relevant aspects from maintenance management. The most important features, like research topic, limitations, methods, results, and takeaways are tabulated in such a way to facilitate access to the work done. The articles reviewed are from two known databases: Springer and ScienceDirect Elsevier, and for checking the similar work done, Google Scholar was used. The oldest paper cited in the present work (Durakbasa *et al.*, 1920), which considers automated quality control as an enabler for quality management in manual manufacturing sectors, was published in 1992. So, the present review includes papers from 1992 to November 2021, by researching keywords: quality management; quality control; quality assessment; total quality management; quality improvement; nonconformities; process capability; product reliability; quality cost; quality key process indicators; risk assessment; risk analysis; FMEA (failure mode and effects analysis); hazard management; risk management; loss function; maintenance management and quality improvement; lean principles in quality; quality in Industry 4.0. The review papers in which one of the three main aspects, quality, risk, and maintenance, was targeted, with implications in product quality and management.

Table 1

Publications distribution-journals

Number of papers	Journal
44	The International Journal of Advanced Manufacturing Technology
19	Procedia CIRP (International College for Research for Production Engineering)
11	IFAC (International Federation of Automatic Control) Proceedings Volumes
11	Procedia Manufacturing
9	Production Engineering
6	Procedia Engineering
6	Reliability Engineering & System Safety
5	Computers & Industrial Engineering
4	CIRP Annals
4	Journal of The Institution of Engineers (India)
3	Computers in Industry
3	International Journal of Precision Engineering and Manufacturing
3	Journal of Manufacturing Systems
2	International Journal of Production Economics
2	Advanced Engineering Informatics
2	Computers & Chemical Engineering
2	Engineering Failure Analysis
2	IFAC-PapersOnLine
2	International Journal of Production Economics
2	Journal of Industrial Engineering International
2	Journal of Intelligent Manufacturing
2	Journal of Loss Prevention in the Process Industries

Table 1 provides an overview of journals that have published a paper in the field of quality management, quality assurance, and quality control, risk management, maintenance management, most related to industrial production systems and a few related to other domains, which can be easily translated and applied in manufacturing sectors. The presented table lists journals that have published either two or more papers in the field. The International Journal of Advanced Manufacturing Technology has published the highest number of papers in the field which are related to the present review.

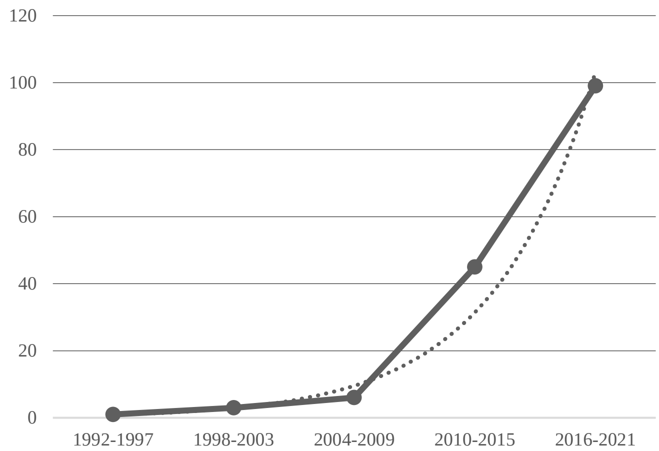

Fig. 1 − Publication distribution years.

Analysing the year of publications, as is shown in Fig. 1, the number of papers published in the field has increased in the years 2010 to 2015 with a steep slope. This trend continued from 2016 to 2021, indicating that quality management and risk management represent a mainstream research topics in manufacturing. Moreover, the tendency of studying integrated quality and risk management with implications of maintenance strategies and quality-related activities on the shopfloor has increased in recent years. However, in SMEs with high product variability, also in prototypes shopfloors still exist gaps in quality management systems related to the high complexity of the existing methods.

Keywords co-occurrence analysis is provided for identifying the frequently used keywords in studies reviewed in the present paper. Fig. 2 shows the whole overview of co-occurrence in the considered topics and can be observed that “control” and “quality” are the most representative keywords for the papers included in this work. Furthermore, “process”, “manufacturing”, “system”, and “management” are words with notable positions to denote the importance of the management for the quality aspects. Moreover, it is observable that "integration", "model-based", "collaborative", "learning", "automation", and "augmented reality" are the keywords that represent state of the art in integrated technologies quality management systems.

Fig. 2 − Keyword co-occurrence

Analysing the review papers' provenance, Fig. 3, can be observed that most of the papers reviewed originated in the manufacturing sector. In addition, the automotive sector takes second place in occurrence followed by the industrial sector. The distinction between manufacturing and industrial is done by the specifics of each case study. Considering the metallurgical sector, diecasting, and moulding as industrial provenance, the assembly lines and activities which include parts producing and assembling operations are catalogued as manufacturing.

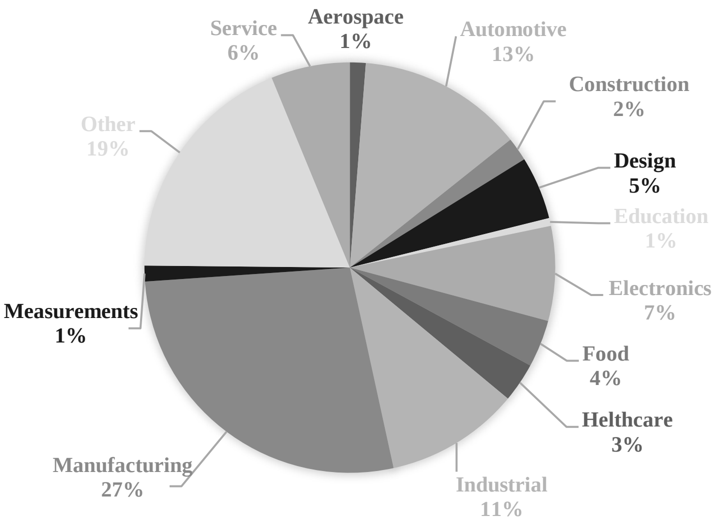

Fig. 3 − Provenance of co-occurrence

The rest of the paper is presented as follows: Section 2, summarizes the papers according to their implications in quality, by targeting four principal aspects: assurance, control, improvement, and management. Section 3 summarizes de advancements in risk assessments and risk management with results in production and product quality. In section 4, maintenance management-related papers are tabulated and presented as enables for quality improvement by using Industry 4.0 methods and quality indicators such as quality cost and rejection cost. Section 5 concludes the article and presents the main areas for future research.

2. Quality management overview and tabulation

Considering quality management and its specifics, the main factor in assuring and increasing product quality in industrial manufacturing sectors, articles related to quality management strategies, quality analysis, quality assurance, quality improvement, quality control, and quality indicators, represent 63.13% of the total reviewed articles. In addition, quality and maintenance management reviewed articles represent 2.5%, and quality and risk management represent 3.75%.

The papers with quality-related concepts are presented in Table 2. which includes quality analysis, maintenance models for quality improvement, predictive analysis, industrial quality control, nonconformities handling methodologies, different correlations between process steps, six sigma, and SPC tools, continuous improvement approaches, quality optimizations, and process modelling, AR methods integration, problem-solving approaches, and lean manufacturing tools.

Table 2

Related concepts: quality

Concept	Paper
Quality analysis	(Teli *et al.*, 2013; Yang *et al.*, 2021)
Quality assurance	(Colledani *et al.*, 2014; Eger *et al.*, 2018; Haefner *et al.*, 2014; Duong *et al.*, 2021; Alves *et al.*, 2021; Alexandru *et al.*, 1998; Osanna *et al.*, 2001; Nikolay, 2016; Ransing *et al.*, 2016; Gewohn *et al.*, 2018; Dantan *et al.*, 2020; Khan *et al.*, 2021)
Quality control	(Durakbasa *et al.*, 1992; Oh *et al.*, 2019; Wu, 2004; Korytkowski *et al.*, 2008; Colledani, 2008; Muthu *et al.*, 2009; Hajji *et al.*, 2012; Villeta *et al.*, 2012; Lv *et al.*, 2012; Jovic *et al.*, 2013; Ordieres-Meré *et al.*, 2013; Achcar *et al.*, 2013; Žapčević and Butala, 2013; Chang and Lee, 2013; Liu *et al.*, 2014; Xia *et al.*, 2014; Dodd *et al.*, 2015; Filho and de Oliveira, 2016; Duffuaa and El Gaaly, 2017; Konstantas *et al.*, 2018; Wang *et al.*, 2018; Hofmann *et al.*, 2019; Guo *et al.*, 2019; Gaikwad *et al.*, 2019; Wang and Wu, 2019; Hamrol *et al.*, 2020; Zimmermann *et al.*, 2021 Lorenz et al., 2021; Verna *et al.*, 2021; Silva *et al.*, 2021; Dutta *et al.*, 2021; Colledani and Tolio, 2006; Escobar *et al.*, 2021; Ou *et al.*, 2014; Shin, 2015; Berger *et al.*, 2018; Qeshmy *et al.*, 2019; Kujawińska and Diering, 2021)
Quality improvement	(Wuest *et al.*, 2014; Haug, 2015; Johansson *et al.*, 2016; Liu and Duan, 2021)
Quality management	(Temponi, 2006; Shaosha *et al.*, 2006; Fonesca and Domingues, 2017; Veen-Dirks, 2005; Gharehgozli *et al.*, 2008; Yazdani and Tavakkoli-Moghaddam, 2012; Singh and Singh, 2012; Kumaravadivel and Natarajan, 2013; Magenheimer *et al.*, 2014; Jain *et al.*, 2014; Helleno *et al.*, 2015; Jaeger and Matyas, 2016; Fujishima *et al.*, 2017; Braglia *et al.*, 2017; Burggräf *et al.*, 2017; Xu *et al.*, 2018; Sahoo and Yadav, 2018; Kumar *et al.*, 2018; Lundgren *et al.*, 2019; Lu *et al.*, 2019; Sim, 2019; Kim and Ryu, 2020; Sanchez-Marquez *et al.*, 2020; Ladinig and Vastag, 2021; Göppert *et al.*, 2021; Verhaelen *et al.*, 2021; Aicha *et al.*, 2021; Cordeiro, 2016; Amiri and Golozari, 2011; Besseris, 2013; Mao *et al.*, 2016; Garcia *et al.*, 2017; Xue *et al.*, 2017; Rouabhia-Essalhi and Amirat, 2017; Haghi *et al.*, 2018; Gupta *et al.*, 2018; Shahi *et al.*, 2020; Sotirelis and Grigoroudis, 2021; Singh and Rawani, 2021; Susilawati, 2021; Kiraz and Açikgöz, 2021; García-Alcaraz *et al.*, 2021; Sariyer *et al.*, 2021)
Quality control and management	(Giannetti and Ransing, 2016)

On the shop floor, the measuring process represents the controlling method used for checking product conformity. In highly automated production lines, measuring and checking systems are integrated to identify the deviations on spot, without taking the product beside the line for analysis. Out-of-line measuring cells (Osanna *et al.*, 2001) can be used as flexible automation of quality assurance and management even so the top managers must consider that all this kind of product measuring leads to increased analysis and reaction time. In addition, out-of-line measuring systems and offline or manual measuring activities were a concern in quality management in small industrial plants for precision mechanics and quality management (Durakbasa *et al.*, 1992).

The signal measure, using integrated measuring systems, can be calculated at least for consecutive process steps. In doing so, the cause and effects of defects can be easily found in this kind of short-term measuring system (Jovic *et al.*, 2013). Similarly, based on the STATIS (Structuration des Tableaux A Trois Indices de la Statistique) method, nonparametric online monitoring of complex batch processes can be done, where many variables are present (Filho and de Oliveira, 2016).

Graphs and control charts are used in quality analysis and evaluation to represent a base for quality decisions. (Alexandru *et al.*, 1998) presents an integrated quality system developed to fulfil strict rules and quality conformance with existing standards. Also, an overview of Control Charts as a method for SPC that can be applied in different systems, considering intermachine buffers, inspection, and dependencies of features between different production systems is presented (Colledani and Tolio, 2006). Alternatively, by analysing the relationship among loss function, process capability indices, and control charts the control limits can be established by considering concept costing (Wu, 2004).

Several lean manufacturing tools are related to quality management and orientated to nonconformities handling. Furthermore, it can be applied in production enterprises, even if the production system is not Lean Manufacturing based. TQM (total quality management) represent a structured and comprehensive methodology to assure the competitiveness and flexibility of enterprises, due to technological advancement and high product variability. Despite customized orders, which are meant to satisfy the customer's needs, the Zero Defects method can be easily used for managing defects that can appear in both production and indirect processes using online data (Eger *et al.*, 2018) or direct input from engineers and managers. VSM used in process definition and analysis can be customized to facilitate the identification of effective testing equipment, testing strategies, and quality control loops, from a quality assurance viewpoint (Haefner *et al.*, 2014). Therefore, FMEA, Ishikawa (Fishbone Diagram) is used as input for process mapping and variability factors identification which is time-consuming and due to manufacturing field dynamics can be annoying among engineers and moderators involved.

The technological progress and the evolution of AR opened a new way of doing things also in manufacturing areas. As a combination of the Go and See, lean methodology with AR (Hofmann *et al.*, 2019), identification of the bottlenecks and root causes in production lines can be done using an Industry 4.0 integrated data acquisition system. By doing so, technical problems and variations can be easily identified in front of workstations. Following this work, due to the high digitization of the work environment, lean manufacturing seems to be undermined. Despite the appearance, if the implementation of tools is well done, lean manufacturing methodologies can widely improve production performance, with implications for product quality.

The high product variability can increase the number of work instructions and documents on the shop floor and workstations. The operators and technicians must know all of them and the lack of attention and distractions can influence the quality of products in SMEs where the lines and workstations present manual or semiautomated process steps, without data collecting integrated system. Nevertheless, AR can be implemented during the operator training process (Qeshmy *et al.*, 2019) and directly on the shop floor where the abnormalities can be identified on the station and the process steps can be followed without checking the work instruction as an additional process step (Alves *et al.*, 2021).

Table 3 presents the main contributions or a short overview of the papers with quality as a principal research domain.

Table 3

Quality: The main contributions/overview

Paper	Contribution/Overview
Teli *et al.*, 2013	An illustration of the best practices like PPM (parts per million) agreement for establishing the minimum standard for the supplied quality.
Yang *et al.*, 2021	Quality analysis model system for collaborative manufacturing. The system can perform automatically model quality checks using shared knowledge.
Colledani *et al.*, 2014	An overview of existing approaches in the manufacturing industry concentrated on quality, and maintenance functions, used as enablers for quality improvement illustrated as a comprehensive paradigm named production quality.
Eger *et al.*, 2018	The zero-Defect approach for smoothing defects in modern manufacturing industries relies on suitable industry 4.0 technologies.
Haefner *et al.*, 2014	Quality VSM is used to facilitate the identification of effective testing equipment, testing strategies and quality control loops.
Duong *et al.*, 2021	A method to compute product quality considering both product path and production batches.

Alves *et al.*, 2021	AR-based quality control system capable of generating virtual content to guide operators by overlaying information in a video stream while performing real-time validation.
Alexandru *et al.*, 1998	A modular structure as a toolkit provides a multitude of procedures for quality analysis and evaluation including graphical representation to facilitate operators' decisions.
Osanna *et al.*, 2001	A quality assurance cell contains a series of devices and components such as a local area network, CNC (Computerized Numerical Control) dimensional measuring equipment, a probe changer, a robot for product manipulation and various measuring and hardware systems.
Nikolay, 2016	A developed practical recommendation for the formation of the corrective action plan. A structured list of steps that must be done to identify and manage nonconformities.
Ranking *et al.*, 2016	A quality correlation algorithm to optimize tolerance limits of process variables across multiple processes.
Gewohn *et al.*, 2018	A combination of hardware and different documentation including assembly instruction, and equipment notes, to improve quality indicators like defects at the quality gate, inline defects, average time for inline problem solving, rework cost, and workers satisfaction.
Dantan *et al.*, 2020	The influence of the tolerance, and time margin, on the effectiveness of the manufacturing system, especially the Performance and Quality Index.
Khan *et al.*, 2021	A multi-objective mixed-integer non-linear programming model is proposed which contains the novel objectives of cost, quality decay, and modular efforts.
Kornas *et al.*, 2019	Multivariate KPI (key performance indicator) based method to identify the quality-relevant cause-effect relationship. The proposed method can be used for monitoring complex process chains as a target-orientated analysis path.
Durakbasa *et al.*, 1992	By integrating automated measuring cells online, the manufacturing process can be easily controlled and integrated into various computer systems.
Oh *et al.*, 2019	Cost-effective support vector machine-based automated quality monitoring, and control system is proposed.
Wu, 2004	Relationship among the loss function, process capability indices and control charts for establishing the goal control limits by extending the target costing concept
Korytkowski *et al.*, 2008	Technological specification of the product by visualizing the entire complex production system. A decision-making method applied to lower, middle, and upper tiers of production process quality control.
Colledani, 2008	Approximate analytical method to estimate the performance of asynchronous production lines monitored by SPC. Corrective actions are triggered by control charts which are modelled.

Muthu *et al.*, 2009	The tolerance allocation problem is formulated as a non-linear integer model by considering both the manufacturing cost of each component by alternate processes and the quality loss of assemblies to minimize the manufacturing cost.
Hajji *et al.*, 2012	A study in a dynamic stochastic context of joint production control, and product specification quality decision making, in a failure-prone multiple parts manufacturing system.
Villeta *et al.*, 2012	A link between continuous improvement and statistical quality control with clear-cut decision rules makes it possible to improve production quality by taking the best decision.
Lv *et al.*, 2012	RFID (Radio Frequency Identification) based Colored Petri Net (CPN) modelling method where the coloured tokens are evolved to colour-tagged tokens carrying the product information of real-time status.
Jovic *et al.*, 2013	A short-term information measuring system is used to discover the causes of deviations and their impact on the rejection rate in production.
Ordieres-Meré *et al.*, 2013	A framework for helping the operators to obtain a better classification of defects based on an analytical comparison of damaged products, after being processed in different facilities.
Achcar *et al.*, 2013	Data analysis in two alternative ways, using two standard Weibull distributions with two parameters, in the presence of a charge point and one covariate, and the second using a mixture of parametrical distributions.
Žapčević and Butala, 2013	The concept of a self-learning autonomous work system (SL.AWS) introduces a learning loop into a manufacturing system composed of data acquisition, data mining (DM), and knowledge-building models.
Chang and Lee, 2013	A web-based statistical process control system with a user-centered design at reduced installation cost and difficulty. The system named PAS.
Liu *et al.*, 2014	Integrated process planning and control method based on intelligent software agents and multi-dimension manufacturing features.
Xia *et al.*, 2014	A modelling method, related to multiple inputs and multiple outputs (MIMO), simultaneously based on the Gaussian process (GP) to optimize the combinations of process parameters and to improve the quality control for multi-objective optimization problems in sheet metal forming.
Dodd *et al.*, 2015	The dynamics of the process mean the problem is investigated and by applying different process means to each rework iteration, the profit can be maximized.
Filho and de Oliveira, 2016	A customized multivariate control chart based on the STATIS method, an exploratory technique for measuring similarities between data matrices.

Duffuaa and El Gaaly, 2017	A realistic multi-objective optimization model that integrates measurement errors in the inspection system and process targeting.
Konstantas *et al.*, 2018	A queuing network model was developed for understanding the way product quality may affect the profitability of production systems.
Wang *et al.*, 2018	A deep model framework to solve the deficiency of automated quality visual inspection.
Hofmann *et al.*, 2019	A combination between lean GO & See method with digitalization due to Industry 4.0 philosophy integration.
Guo *et al.*, 2019	A combined process turtle diagram with a quality control system can improve the overall activity by reducing the quality loss and improving the economic benefits.
Gaikwad *et al.*, 2019	Improvement of the issue of rejection rate in the spring support in a medical device manufacturing industry by using SPC and DMAIC (Define, Measure, Analyze, Improve, Control) approach.
Wang and Wu, 2019	A modified repetitive group sampling plan (RGSP) for variable inspection using the loss-based capability index.
Hamrol *et al.*, 2020	Planning and optimization of quality inspections within a multistage manufacturing process based on quality cost and the value added to the production process by inspections
Zimmermann *et al.*, 2021	Manufacturing scheduling optimization that combines a predictive schedule with a proactive multicriteria decision-making method based on smart batches and their quality prediction capability.
Lorenz *et al.*, 2021	An optical line monitoring system that integrates a combined imaging and triangulation sensor as well as subsequent image processing.
Verna *et al.*, 2021	The effectiveness and cost of inspection strategies assessment. Defect probabilities obtained by prediction models and inspection variables are combined to define a pair of indicators for developing an inspection strategy map.
Silva *et al.*, 2021	A systematic review of Lean Six Sigma considering tools and aspects within metrics in the automotive industry.
Dutta *et al.*, 2021	Digitalization priorities of quality practices of SMEs in perspective of adoption of Industry 4.0 technologies.
Colledani and Tolio, 2006	Control Charts area method for SPC that can be applied in the different systems considering intermachine buffer, inspection, and dependencies of features between different production stages.
Escobar *et al.*, 2021	A 7-step problem-solving strategy was developed to increase the likelihood of developing the Quality 4.0 initiative.
Ou *et al.*, 2014	Online anomaly incipient detection technique toward the cold rolling process of steel sheet, based on condition-based SPC.

Shin, 2015	A dispatching algorithm focusing on the rework processes due to quality issues. A parallel machine scheduling problem with process quality, due date, and sequence-dependent setup times.
Berger *et al.*, 2018	The proposed approach includes the application of non-destructive testing methods that are applied as in-line quality control measures, to determine the defect characteristics of the inspected parts.
Qeshmy *et al.*, 2019	AR is used to identify human errors in the manufacturing process. The applicability of this framework is more suitable for the training period.
Kujawińska and Diering, 2021	The impact on the organization of the visual inspection process, its effectiveness, and the efficiency of the manufacturing process.
Giannetti and Ransing, 2016	An algorithm embeds risk-based thinking in quantifying uncertainty in manufacturing operations during the tolerance synthesis process.
Wuest *et al.*, 2014	The usage of the stage-gate model as a tool for product and process quality improvement.
Haug, 2015	The information quality of work instruction in industrial management contexts. The study can be used as a guideline for industrial managers.
Johansson *et al.*, 2016	Questionnaire-based research where product variability is shown as a key influencing factor in work complexity and quality issues.
Liu and Duan, 2021	A quality characteristics relations model based on the Bayesian network was introduced to optimize the IQC (initial quality characteristic) combinations.
Temponi, 2006	A review of quality management and business process reengineering for establishing new opportunities and improvements can be done by using electronic resources.
Shaosha *et al.*, 2006	A collaborative quality system where the supplier quality management system, manufacturing and service are interconnected.
Fonesca and Domingues, 2017	The correlation between the ability of the organizations to change and the performance and results.
Veen-Dirks, 2005	Quality management methods such as JIT (Just in Time) and TQM (total quality management) in production environments it’s a limitation due to perspective changes of management.
Gharehgozli *et al.*, 2008	A decision-making structure was proposed for incoming orders based on fuzzy AHP (analytical hierarchy process) and TOPSIS (technique for order performance by similarity to ideal solution) methodology.
Yazdani and Tavakkoli-Moghaddam, 2012	An application of brainstorming, fishbone diagrams, and AHP in the decision-making process for obtaining valuable results and achieving organizational goals.

Singh and Singh, 2012	Productivity, quality, and flexibility are quantitatively defined, and their combined effect was evaluated on the manufacturing performance index of the system.
Kumaravadivel and Natarajan, 2013	Primary tools as a process map, cause-and-effect matrix and failure mode and effects analysis, usage. Experimental results were statistically analyzed and modelled through response surface methodology (RSM).
Magenheimer *et al.*, 2014	An approach that increases transparency and ensures objectivity by concentrating on the value stream, revealing weaknesses, detecting their causes, and evaluating the impact on the process according to the philosophy of Lean Management.
Jain *et al.*, 2014	A developed questionnaire is based on the generally accepted principle of instrument design to assess the manufacturing capabilities along with different decision areas for four categorization schemes of manufacturing decision areas.
Helleno *et al.*, 2015	The application of the VSM and discrete events simulation as decision-making tools direct the management to invest in the best option among the available scenarios generated by the simulation system.
Jaeger and Matyas, 2016	OsE (operations excellence) working definition was developed and promotes the enhancement of operation-specific enablers and linked results.
Fujishima *et al.*, 2017	A quality management approach before and after shipment of the smart manufacturing machines using IoT (internet of things) and specific approaches from industry 4.0.
Braglia *et al.*, 2017	A SMED (Single-Minute Exchange of Die) set-up reduction approach, fully integrated with 5-Whys Analysis presented.
Burggräf *et al.*, 2017	Disruption situation in low-volume assemblies is improved using a management methodology aimed at efficient reduction of disruption considering the specific characteristics of the low-volume assembly.
Xu *et al.*, 2018	A method was developed using a multiples algorithm that clusters and analyses the quality problems and presents them in a digitized fishbone diagram.
Sahoo and Yadav, 2018	Key values for TQM were identified as principal behaviors needed to increase the manufacturing performance in Indian SMEs
Kumar *et al.*, 2018	The implementation of the Lean-Kaizen concept in SME for helping managers and practitioners to identify waste hidden in the procedures and processes of their organization.
Lundgren *et al.*, 2019	Digital Process and Quality Planning are presented as important and influencing factors to prevent informational duplicates which can influence the decision-making process and information transfer due to different quality methods used.
Lu *et al.*, 2019	The quality methods impact inter-organizational project performance with limited applicability due to the targeted industry and country.

Sim, 2019	A smart-equipment engineering system (S-EES) construction and big data analysis methodology for manufacturing to increase product yield and quality in a smart factory environment.
Kim and Ryu, 2020	A horizontal collaboration system and process data analysis system designed between companies using IoT platforms.
Sanchez-Marquez *et al.*, 2020	KPIs of the quality management system are illustrated and presented as key factors for the long-term performance of the company.
Ladinig and Vastag, 2021	A structured conceptualization method, concept mapping was applied to visualize the conceptual domain in explicit and tacit quality linkages.
Göppert *et al.*, 2021	An assembly control system based on Google Deep Mind's AlphaZero created, an ANN (Artificial neural networks) is incorporated into the approach that suggests favorable job routing decisions and predicts the value of actions.
Verhaelen *et al.*, 2021	A KPI network for global production networks is presented, which links the key figures of the site level and the corporate level.
Aicha *et al.*, 2021	An approach that combines two main metrics, which are the Quality Index and the Timing index, as criteria while selecting an optimal and feasible disassembly plan.
Cordeiro, 2016	A matrix to support the project manager to plan requirement verifications over project phases, using team skills based on customer needs.
Amiri and Golozari, 2011	An algorithm that considers time as a factor, also the cost, risk, and quality criteria to determine the critical path under a fuzzy environment.
Besseris, 2013	A robust technique for profiling economically complex industrial processes.
Mao *et al.*, 2016	A mechanical assembly accuracy prediction model based on a state-space equation, using a Fuzzy analytical hierarchy process.
Garcia *et al.*, 2017	Determination of the factors and criteria for analysis methodology of industrial project management.
Xue *et al.*, 2017	Optimal quality investment strategies with the reference of quality effect over time. An algorithm to obtain the optimal joint pricing and dynamic quality investment policy for the system
Rouabhia-Essalhi and Amirat, 2017	The importance of traceability implementation in recalls and defective parts identification.
Haghi *et al.*, 2018	An overview of Complain and failure management in SMEs. The gap between data structure and IT systems is presented as a weak point due to limited resources in this type of enterprise.

Gupta *et al.*, 2018	A framework where the overall process was improved by applying the 6-sigma methodology and its specific tools in tire production.
Shahi *et al.*, 2020	Optimization of automotive body assembly ASP (assembly sequence planning) based on product dimensional quality through the development of quantitative criteria.
Sotirelis and Grigoroudis, 2021	A review of linkages between quality management and innovation based on three conceptual frameworks.
Singh and Rawani, 2021	An industry-oriented quality management method with the help of an integrated QFD (Quality Function Deployment)-TOPSIS approach.
Susilawati, 2021	A performance measurement system (PMS) for productivity enhancement of a particularly lean company or organization, is based on multiple indicators decision making (MIDM) and uses the fuzzy analytical hierarchy process (FAHP).
Kiraz and Açikgöz, 2021	The fuzzy EFQM (European Foundation for Quality Management) model was developed to minimize the calculation deviation of expert opinions and to measure the level of institutionalization more consistently.
García-Alcaraz *et al.*, 2021	A framework where a structural equation model relates three critical success factors for TQM with customer satisfaction benefits through six hypotheses presented as enablers for quality improvement.
Sariyer *et al.*, 2021	A three-stage model that classifies products depending on defects (defects or non-defects) and defect type according to their levels. Multilayer Perceptron algorithm developed.

3. Risk management overview and tabulation

Quality assurance and quality improvements cannot be done without a developed risk management culture, implemented from shop floor technicians to high management, due to uncertainties during production processes and decisions which can influence the quality of products. However, by implementing the risk management-specific tools, analysis, and behaviours, and by identifying and mitigating risks, the needed quality-related actions can be easily implemented as preventive actions, despite reactive or corrective ones.

Of the total reviewed articles, risk-related ones, with outcome in quality improvements and assurance, represents 26.86%. Risk management and maintenance (policies and management) related articles are 1.88%, and quality management and risk management issued articles are 3.75% of the total reviewed.

The related risk concepts and the paper's clustering are presented in Table 4. Even though some of them include quality and maintenance aspects, this paper will be reviewed with more impact on risk management.

Table 4

Related concepts: risk

Concept	Paper
Risk assessment	(Karkoszka, 2015; Dumitrescu and Deselnicu, 2018; Gopinath and Johansen, 2016; Moreno-Cabezali *et al.*, 2020; Klöber-Koch *et al.*, 2017; Folch-Calvo *et al.*, 2019)
Risk analysis	(Hietikko *et al.*, 2011; Lo *et al.*, 2019; Macedo and Jones, 2000; Brown, 2007; Mili *et al.*, 2008; Shah *et al.*, 2012; Shah, 2013; Behún *et al.*, 2014; Kremljak and Kafol, 2014; Altinisik and Hugul, 2020; Huang *et al.*, 2020; Wu *et al.*, 2021)
Risk management	(Islam and Tedford, 2012; Karkoszka, 2013; Zetterlund *et al.*, 2016; Ratnayake and Antosz, 2017; Bastchen *et al.*, 2018; Crespo *et al.*, 2018; Shafqat *et al.*, 2019; Johnson and Bogle, 2019; Gorecki *et al.*, 2019 Lamine *et al.*, 2020; Kayis *et al.*, 2007; Bassetto *et al.*, 2011; Bauer *et al.*, 2014 Cube and Schmitt, 2014; Cui *et al.*, 2016; Thekdi and Aven, 2016; Shahtaheri *et al.*, 2017; Tupa *et al.*, 2017; Bevilacqua and Ciarapica, 2018; Oduoza, 2020; Stürmlinger *et al.*, 2020; Wen *et al.*, 2021; Utiyama *et al.*, 2021)
Performance and risk management	(Thekdi and Aven, 2019)
Quality control and risk management	(Kawai, 2013; Bettayeb *et al.*, 2014)
Quality and risk management	(Lundgren *et al.*, 2016; ArunKumar and Dillibabu, 2016; Doshi and Desai, 2017; Colledani *et al.*, 2018)

In SMEs, where manual work represents the principal way to manufacture products, the direct influence of the operators and technician are reflected in product quality. Due to limited time, the necessary efforts which must be done by engineers to implement risk management tools represent a barrier and don't represent a priority in their tasks. High product variability increases the complexity of the risk analysis and the necessary resources that must be consumed. (Oduoza, 2020) presents a risk method affordable and suitable, based on Bayesian Belief Network and Analytical Hierarchical search algorithm. Taking this into account, risk factors that influence the project cost, product quality, cycle and takt time, health and safety can be identified and managed. Furthermore, by conducting risk analyses in shopfloors with the inclusion of the association rules and by highlighting the human factors' impact, risk management can be improved (Bevilacqua and Ciarapica, 2018).

Performance, as a success indicator for an enterprise, is influenced by external factors such as customer behaviour and competitivity of the market. Even so, internal factors are the ones that can be directly influenced by the enterprise employees, from managers to shop floor technicians. The connection between risk management and performance can represent an essential competitive advantage (Thekdi and Aven, 2019). Moreover, the connection between performance and risk can be illustrated at the machine level, starting with the machine development process step (Hietikko *et al.*, 2011). Similarly, the risks related to the industrial manufacturing labour system on the well-being of the employees are interconnected SMSs productivity and performance (Dumitrescu and Deselnicu, 2018). As much as enterprises try to eliminate the human factor from processes by improving the equipment and production lines, with the integration of sensors, robots, and industry 4.0 specifics, humans will still represent the major key influence on product quality. Furthermore, as soon as the processes are manual, semi-automated and with direct involvement of humans, process variation and nonconformity appearance will be related to employee involvement and discipline.

During the process, practitioners can appear a tendency of overestimating the risk, a fact which conducts to high-quality costs, related to high process cost implementations due to increased complexity. As an enabler for decision-making, value and risk-based performance evaluation applied at the industrialization phase of product development can be adopted. Alternative scenarios and simulations output simplify the decision-making process without harming the company and customer interests (Shah *et al.*, 2012). Besides the necessity of highly skilled engineers for developing and implementing simulated and analytical frameworks, the outcome will be considered an enabler for daily jobs.

If a failure occurs, then the product or process quality might be compromised, and the actions needed to be done will be corrective ones. Further, in risk analysis, for preventing on-time failure occurrence, the simulation methods can be used to predict and forecast the outcome before it's too late. By usage of control charts together with the Monte Carlo Markov Chain method (Islam and Tedford, 2012), the values outside the limits are visible whit enough time for taking corrective measures to reduce risk.

Quality assurance, by using control plans all over the process, must be linked with risk analyses. Sensible characteristics are monitored by their specific definition from the control plan and the impact of the failure is estimated during the risk analysis. Scrap reduction during manufacturing processes can be influenced directly by exposure-based quality control planning used as analytical solutions for planning quality control under capacity and quality assurance control (Bettayeb *et al.*, 2014).

FMEA (failure mode and effect analysis), during the last few years, attracted the interest of researchers. The classic calculation method of RPN (risk priority number) was discussed and due to the subjectivity of the practitioners, new approaches were introduced. Multi-criteria group decision-making by integrating the best-worst method was introduced by (Lo *et al.*, 2019) in machine tools production, as an enabler for failure modes prioritizing. Moreover

(Wen *et al.*, 2021) proposed a flexible risk assessment approach by integrating subjective and objective weights under uncertainty and proposed the usage of the hesitant fuzzy linguistic term set instead of a single linguistic term set, in the risk assessment process.

Due to the high applicability in production sectors and by introducing criticality as a factor in failure analyses, FMECA (failure mode and effects critically analysed) can be used as a tool for maintenance of the production equipment improvement (Mili *et al.*, 2008). Following this work, the outcome of the applied risk assessments can be used in the maintenance shop floor as a trigger for maintenance activities. In addition, an overview of failures that occurred in the industry for identifying the key elements for design and manufacturing (Brown, 2007), helps engineers in the risk minimisation and loss prevention.

FTA (fault tree analysis) considering common cause failures, combined with the Bayes formula, and marginal analysis (Cui *et al.*, 2016) represents a method to analyse the risk of quality accidents from the viewpoint of manufacturers. Despite the consumed time for making this kind of analysis, if the practitioners consider the quality cost and cost-benefit methods, the quality issues can be easily avoided by taking systemic actions both preventive and predictive.

Industry 4.0 context, integrated sensors, and online data gathering represent a step forward for improving the reaction time and the on-spot detection of abnormalities. Even so, the industrial network can be seen as an enabler for decentralized information and activities which are needed to sustain a short time response for failure management using shop floor personnel as sensors for notifying the malfunctions and failures (Bauer *et al.*, 2014). In the same context, due to interactions between humans, objects, and systems, new risks and root causes can occur (Tupa *et al.*, 2017). Considering the new interactions, risk analysis must be conducted and risk management for industry 4.0 can represent a necessity in highly automated with integrated data systems, sensors, and enterprises.

Table 5 presents the main contributions or a short overview of the papers with risk as a principal research domain with involvement of quality-related issues and improvements.

Table 5

Risk: the main contribution/overview

Paper	Contribution/Overview
Thekdi and Aven, 2019	The connection between performance and risk management was illustrated as an essential competitive advantage in both the public and private sectors.
Hietikko *et al.*, 2011	A risk estimated method, for a control function of a machine, where the connection between performance level of the control function and cost for manufacturers was identified.

Lo *et al.*, 2019	FMEA model is based on multi-criteria group decision-making by integrating a rough best-worst method, and modified rough technique for order preference including, cost as a risk element.
Macedo and Jones, 2000	An integrated database to optimize the operator activities by synchronizing the working procedures with help of statistical control charts used for monitoring the risk events.
Brown, 2007	An overview of failures that occurred in the industry for identifying the key element for designing, and manufacturing to minimize the risks and prevent loss.
Mili *et al.*, 2008	FMECA is a tool for maintenance of production equipment improvement. This method is based on historical stocked data and periodically database updates.
Mili *et al.*, 2009	A method where FMECA with Computerized Maintenance Management System can be used as an operational tool that is continuously updated by operational events.
Shah *et al.*, 2012	A value/risk-based performance evaluation framework in the context of manufacturing processes at the industrialization phase of product development.
Shah, 2013	A process-oriented risk assessment methodology for improving the decision-making process using a global risk indicator.
Behún *et al.*, 2014	A simplified FMEA method was used in a manufacturing site with small batches due to MTO (Make-to-Order) and ETO (Engineer-to-Order) production system.
Kremljak and Kafol, 2014	A presentation and classification of the risks which arise in decision making. The usage of the RISK tool and its utility.
Altinisik and Hugul, 2020	A seven-step approach for complex and cross-functional diagnosis is based on the first two steps of the universal problem-solving approach.
Huang *et al.*, 2020	A literature review where the traditional risk priority number and FMEA evolution are presented highlighting the most valuable articles and most prolific researchers.
Wu *et al.*, 2021	A framework where the variation of FMEA and risk assessments are analyzed for identifying the need for future work and the need for SMEs and small batch production variability.
Karkoszka, 2015	The methodology of the environmental risk assessment considers the connection between the environmental risk ratio and the occurrence and significance of the environmental impact.
Dumitrescu and Deselnicu, 2018	An overview of the risk generated by the labor system in SMEs and its effects on productivity and performance level.
Gopinath and Johansen, 2016	A novel approach by placing equal emphasis on various participants working within their workspaces.
Moreno-Cabezali *et al.*, 2020	A model as a tool for organizations and academics, to prioritize the risk that is more critical in developing the appropriate response strategies to achieve the success of the projects.

Klöber-Koch *et al.*, 2017	An approach for a production planning system taking a production system's actual risk level into account.
Folch-Calvo *et al.*, 2019	A methodology based on Dynamic Risk Assessment and application of control charts together with the use of the Monte Carlo Markov Chain methods used as the concept of Statistical Risk Control.
Islam and Tedford, 2012	A systematic method of approach to identify and treat potential effects along with an appropriate set of tools.
Karkoszka, 2013	A methodology to identify and manage the organizational risks properly, using practical studies to show the increased quality and quantity of the identified risk.
Zetterlund *et al.*, 2016	A study where the challenges and opportunities for the implementation of sustainability-oriented decision support in product development were identified.
Ratnayake and Antosz, 2017	An assessment where fuzzy logic is used for minimization of suboptimal classification of maintenance tasks.
Bastchen *et al.*, 2018	A framework that identifies 23 relevant articles regarding risk management and its strengths and gap in actual processes.
Crespo *et al.*, 2018	A practical way to implement criticality analysis with examples regarding procedures and concepts using several maintainable items.
Shafqat *et al.*, 2019	A framework in risk management of the Product Development project was the hypothesis that risk management and resilience-based approaches complement each other.
Johnson and Bogle, 2019	A model-based approach to risk analysis combines systematic modelling procedures with Hammersley sampling-based uncertainty analysis and sensitivity analysis used to quantify predicted performance uncertainty and to identify key uncertainty contributions.
Gorecki *et al.*, 2019	A framework of using the Papyrus tool and Model Exchange as integrated risk management, hazard generation, and complexity issues in process modelling with data coming from an industrial context.
Lamine *et al.*, 2020	A Business Process-Risk Integrated Method framework and a dedicated tool named ADOBRPRIM support its efficient application of it.
Kayis *et al.*, 2007	A risk mitigation methodology for new products and processes which can be used in both risk and management of manufacturing projects.
Bassetto *et al.*, 2011	A concept of risk typology and how these typologies and classifications can be used to modify the deployment of a process control organization.
Bauer *et al.*, 2014	Industrial networks as an enabler for decentralized information and activities needed to reduce the time response, and to improve the failure management in the ramp-up process, using humans as sensors for notifying the malfunctions and failures.

Cube and Schmitt, 2014	An overview of the existing risk methodologies which can be implemented in the early steps of the project, especially in rump-up projects.
Cui *et al.*, 2016	A quality accident analysis model which contains FTA considering common cause failures, Bayes formula and marginal analysis is proposed to analyse the risk of quality accidents from the viewpoint of the manufacturers.
Thekdi and Aven, 2016	A framework where uncertainty is a main component of risk and where the improvement of performance management processes can be done by proper risk conceptualization.
Shahtaheri *et al.*, 2017	A link between structural analysis framework aims to predict the performance of various assembly configurations, construction costs, and various types of project risks.
Tupa *et al.*, 2017	A framework that implements risk management for the industry 4.0 concept.
Bevilacqua and Ciarapica, 2018	A conceptual model, based on association rules is proposed to improve risk management by highlighting the human factors' impact.
Oduoza, 2020	A framework for risk management, affordable and suitable for use especially by SMEs in the manufacturing sector using Bayesian Belief Network and Analytical Hierarchical Process search algorithm.
Stürmlinger *et al.*, 2020	A method that supports engineers in the decision-making process on both technical and strategic issues.
Wen *et al.*, 2021	A flexible risk assessment approach integrates subjective and objective weights under uncertainty.
Utiyama *et al.*, 2021	An alternative approach to improve manufacturing setup time and the time between failures with a focus on eliminating outliers.
Kawai, 2013	A system, Quality-HAZOP (Hazard and Operability Analysis) analyzes the scenarios in which manufacturing errors can affect product quality via complex propagation pathways.
Bettayeb *et al.*, 2014	A method that illustrates the link between a control plan and risk analysis as an enabler for scrap reduction during the manufacturing process.
Lundgren *et al.*, 2016	A model-based approach to integrate process planning and quality assurance to provide more efficient support to production engineering processes.
ArunKumar and Dillibabu, 2016	A quality improvement model to enhance software quality without increasing effort, cost, and time. The method is named the Kano Lean Six Sigma model (KLSS).
Doshi and Desai, 2017	A review of the application and benefits along with existing research on Automotive Core Tools with special emphasis on continuous quality improvements.
Colledani *et al.*, 2018	A reference framework for defining strategies to improve manufacturing systems' production quality performance, during the ramp-up phase.

4. Maintenance management overview and tabulation

Despite the high importance of maintenance management and activities in quality assurance, especially for production shop floors, articles included in the present work represent 6.25% of the total reviewed. However, the chosen ones, are directly involved in quality assurance and their results reflect the benefits for product quality and overall quality control and improvements. Table 6 cluster them by related concept with direct implications in quality management and assurance.

Table 6
Related concepts: maintenance

Concept	Paper
Maintenance	(Ribeiro *et al.*, 2009; Bokrantz *et al.*, 2020; Saurin *et al.*, 2012)
Quality and maintenance management	(Riveira-Gomez *et al.*, 2013; Méndez and Rodriguez, 2017)
Risk and maintenance management	(Tambe *et al.*, 2013; Liu *et al.*, 2018; Carpitella *et al.*, 2021)
Quality control and maintenance	(Kurniati *et al.*, 2015; Farahani and Tohidi, 2021)

In Industry 4.0 context, data gathering represents one of the biggest steps in quality development due to integrated sensors and on-line measurement systems. Moreover, in-process data helps engineers and managers to analyse and prevent more rapidly the nonconforming parts apparition, and the trends can be tracked and forecasted using different algorithms. Furthermore, smart maintenance and specific practices can be applied in the manufacturing environment as an improvement in the maintenance field (Bokrantz *et al.*, 2020), with involvement in cost reduction and by improving the quality with direct implications in quality indicators. Considering this, the smart maintenance framework supports industrial managers on long-term strategies by offering clear guidance and perspective.

In maintenance activities, response time is a valuable resource that with an established architecture for collecting maintenance data, will help the technician in preventive and predictive activities. Alarm modules, maintenance task agents and data mining provide a complete solution for maintenance teams (Ribeiro *et al.*, 2009). In addition, by getting an on-time diagnosis, prognostic, forecast and maintenance recommendations, technicians are supported in the decision process for choosing the best timing and intervention activities. Due to embracing the continuous improvement behaviour in more and more companies, reduction of the processing time and being competitive in industrial marketing represents a path chosen by industrial managers. All breakdowns and production disturbances, due to malfunctions of production machines and equipment, can be avoided by having a clear and practical maintenance system.

Nonconforming parts can be directly related to malfunctions and abnormalities which can appear in the process. In the same way, maintenance and quality cannot be segregated from the production processes and inspection can represent a trigger for maintenance activities (Kurniati *et al.*, 2015). The performance of the equipment is essential to assure the production processes' performance.

As a lean manufacturing tool, used to increase productivity and avoid losses, TPM (total productive maintenance) philosophy can be adopted by SMEs or industrial manufacturers to reduce maintenance hours. Well-maintained equipment ensures product quality (Méndez and Rodriguez, 2017). In addition, the poka-yoke philosophy reflected on the designing process of the fixtures and devices used as fixing interfaces on the production equipment, which are used in assessing quality and safety requirements. (Saurin *et al.*, 2012) investigate the design, operations, and maintenance activities of poka-yoke devices by defining fail-safe characteristics and best practices in design, device implementation, and maintenance activities.

Smart manufacturing can be seen as an enabler to the efficiency of the measurement analysis and improvement of machines that can be interconnected using IoT, before and after delivery. By doing so, remote monitoring enables maintenance decisions after shipment (Fujishima *et al.*, 2017).

Risk assessment can be implemented also in maintenance activities and a multi-criteria decision-making process can be adopted for the evaluation of the main risks related to those activities. (Carpitella *et al.*, 2021) used ANP (Analytical Network Process) to select maintenance policy and ELECTRE III (Elimination Et choix Traduisant la Réalité III) method to rank the risk of the selected maintenance policy. Additionally, the maintenance policy choices can be done by including nonconforming parts, abnormalities, and quality issues as deciding factors, besides cost and performance, even though they are quite related. However, the multi-criteria decision-making process can be avoided by practitioners due to the increased time and resources needed. Even if the outcome will be a positive one, the highly analytical tools and methods with mathematical implications needs highly trained and specialized personnel. Nowadays practitioners tend to use more simplified methodologies due to the variability of the products and the high pressure of being competitive in a market where customer demands are customizable enlarges the interest in using quick and easy ways.

The main contributions or the short overview of the review articles related to maintenance activities and topics are presented in Table 7.

Table 7
Maintenance: the main contribution/overview

Paper	Contribution/Overview
Ribeiro *et al.*, 2009	An architecture that collects maintenance data to help technicians in preventive/predictive maintenance activity due to minimizing response operation time.
Bokrantz *et al.*, 2020	A review of the Smart Maintenance method and practices in the manufacturing environment and its involvement in production performance including cost impact and quality indicators.
Saurin *et al.*, 2012	A framework where attributes of poka-yoke devices were analyzed for assessing quality and safety requirements. Best practices are illustrated as evidence for best design, implementation, and maintenance.
Riveira-Gomez *et al.*, 2013	A control model that simultaneously determines the optimal production plan, overhaul, and preventive maintenance strategies as a joint control policy for minimizing the tool cost.
Kurniati *et al.*, 2015	An approach regarding the connection between maintenance and quality cannot be segregated from the production process.
Méndez and Rodriguez, 2017	A framework that provides an application of the TPM philosophy as a systematic means for avoiding losses and increasing productivity, performing root cause analysis based on failure data.
Farahani and Tohidi, 2021	A comprehensive literature review on the papers that optimize decisions for either maintenance and quality or maintenance, quality, and production.
Tambe *et al.*, 2013	An opportunistic maintenance model for a multi-component system to take maintenance decisions with a constraint on available time and system availability requirements.
Liu *et al.*, 2018	A method to optimize the maintenance schedules for a serial-parallel hybrid assembly system is presented to prevent system failures.
Carpitella *et al.*, 2021	A multi-criterion decision-making framework for the evolution of the main risks related to maintenance interventions.

5. Conclusions

In this paper, a comprehensive review was conducted on the papers which put in discussion the quality improvement, by using different methods, and by taking a look on the actual quality management system and it implementation. Also, risk and maintenance management, and its interactions with quality indicators and outcomes, were overviewed to offer o complete framework for practitioners and engineers who are interested in the presented topic. The review includes papers from 1992 to 2021, mentioning that some of them are indirectly related to one of the qualities, risk, and maintenance topics, but we consider that those papers represent some outcomes that can be adopted in those areas as enablers for quality and performance improvement.

Considering the contribution of the reviewed papers, and based on the analysis performed, there are some research gaps in this area and many contributions can be made in the quality and risk management field. Furthermore, a handful of recommendations for future research are presented in the following:

Firstly, there are only a few papers that are based on practical applicability and more study cases must be conducted in the field. Moreover, the analytical character of the proposed methodologies must be tested in production life and based on the outcome the applicability and improvements can be directly quantified.

Secondly, most of the papers use as exemplifiers of the big enterprises and elevated production sectors, where the digitization and the adherence to industry 4.0 philosophy are materialized by automatic data gathering and highly automated production lines with the newest integrated equipment. At the same time, the solution integration and adaptation for SMEs and for manufacturing shop floors where the work is done using manual or semiautomatic lines must be analysed and evaluated.

In addition, the correlation between maintenance characteristics, failure appearance, and quality issues can be studied and analysed using shopfloor and practical scenarios instead of analytical and mathematical simulations and practices.

The region's specifics and behaviours can influence the outcome of the practices. In doing so, the need of having more study cases from different geographical areas is sizable and recommended to enlarge the applicability of methods.

Human interactions and their direct influence on the product and production quality must be highly evaluated. Even though the trend in the manufacturing sector is for digitization and automatization, humans represent the main contributor to value-adding activities in SMEs. Furthermore, the management systems must be developed based on that and quality, risk, and maintenance key influencing factors must include human perceptions and activities.

Finally, a complete solution by integrating the aspects of quality, risk, and maintenance management is needed, both for SMEs and enterprises without highly automated and updated processes. Nonconformities must be prevented and avoided before and during processing using a comprehensive method, easy to be used and embraced by shopfloor technicians and engineers, and helpful and reliable for managers.

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MANAGEMENTUL CALITĂȚII ȘI AL RISCULUI ÎN SISTEMELE DE PRODUCȚIE INDUSTRIALE: O REVIZUIRE A LITERATURII

(Rezumat)

În prezent, managementul calității și instrumentele specifice pot reprezenta o provocare pentru IMM-uri (întreprinderi mici și mijlocii). Pentru a asigura calitatea așteptată a produselor, SPC (controlul statistic al procesului) combinat cu aspecte ale industriei 4.0 oferă răspunsuri instantanee și ajutătoare pentru acțiunile necesare. Prin urmare, analizele de risc sunt utilizate ca factori care contribuie la un comportament orientat spre calitate, iar atenuarea și identificarea riscurilor, împreună cu datele colectate, reprezintă un sistem cuprinzător care conduce întreprinderile către nivelul de performanță așteptat, necesar pentru a rămâne competitive pe piață. În plus, managementul riscului și managementul calității nu pot fi tratate fără a analiza activitățile și politicile de mentenanță care pot avea un impact considerabil asupra celor două. Această lucrare oferă o analiză cuprinzătoare a literaturii de specialitate, a lucrărilor din sectorul managementului calității și a articolelor în care managementul riscului și al mentenanței sunt văzute ca facilitatori pentru îmbunătățirea calității cu impact asupra nivelului de performanță. Contribuția principală a fiecărei lucrări este sub formă tabelară care simplifică accesul cititorului la munca depusă în domeniu, iar imaginea de ansamblu prezentată permite accesul ușor la tendințele în acest domeniu și oferă un punct de plecare pentru cercetările viitoare prin prezentarea lacunelor.